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02220	DEMOLITION
02230	SITE CLEARING
02240	DEWATERING
02255	UNDERPINNING, SUPPORT AND RESTORATION OF STRUCTURES
02260	SUPPORT OF EXCAVATION
02270	MAINTENANCE, SUPPORT AND RESTORATION OF UTILITY FACILITIES
02291	GEOTECHNICAL INSTRUMENTATION
02320	GRADING, EXCAVATING AND BACKFILLING
02410	ROCK TUNNELING
02415	EARTH TUNNELING
02416	EARTH (EPBM) TUNNELING
02417	NATM EXCAVATION
02420	ROCK REINFORCEMENT
02425	PRECAST CONCRETE TUNNEL LINING
02426	NATM SHOTCRETE LINING
02427	NATM CONCRETE LINING
02431	DRILLING AND PRESSURE GROUTING FOR ROCK TUNNELS
02460	PILES
02515	WATER DISTRIBUTION SYSTEM
02535	SANITARY SEWER
02585	UNDERGROUND ELECTRICAL AND COMMUNICATIONS DISTRIBUTION SYSTEMS
02625	SUBWAY DRAINAGE SYSTEM
02635	STORM SEWER

**DIVISION 2 - SITE WORK (CONT.)**

02725-v1	BASE FOR PAVEMENTS (Version 1)
02725-v2	BASE FOR PAVEMENTS (Version 2)
02726	SUB-BALLAST
02727	BALLAST
02740-v1	BITUMINOUS PAVEMENT (Version 1)
02740-v2	BITUMINOUS PAVEMENT (Version 2)
02750-v1	CONCRETE PAVEMENT (Version 1)
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02765	PAVEMENT MARKINGS
02772	CURBS, GUTTERS AND WALKS
02820	FENCING
02845	TRAFFIC CONTROL DEVICES
02872	STATION MEZZANINE ENCLOSURES AND PLATFORM SHELTERS
02890	MARKERS (FORMERLY MONUMENTS AND MARKERS)
02920	TOPSOIL, SEEDING AND SODDING
02930	LANDSCAPING

**END OF SECTION**

## SECTION 02205

### REMOVAL AND RESTORATION OF EXISTING FACILITIES

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies removing, restoring and reinstalling miscellaneous facilities on public and private property which are removed during construction.
- B. Related Work Specified Elsewhere:
  - 1. Demolition: Section 02220.
  - 2. Grading, excavating and backfilling: Section 02320.
  - 3. Base for pavements: Section 02725.
  - 4. Bituminous pavement: Section 02740.
  - 5. Concrete pavement: Section 02750.
  - 6. Curbs, gutters and walks: Section 02772.
  - 7. Fencing: Section 02820.
  - 8. Topsoil, seeding and sodding: Section 02920.
  - 9. Landscaping: Section 02930.
  - 10. Concrete formwork: Section 03100.
  - 11. Concrete reinforcement: Section 03200.
  - 12. Cast-in-place structural concrete: Section 03300.
- C. Definitions:
  - 1. Miscellaneous facilities include, but are not limited to, the following: Store fronts, alarm and sprinkler systems, bay windows, cornices, signs, fire escapes, canopies, awnings, security grilles, heating, cooling and electrical facilities, vaults, entrance walkways, steps, sidewalks, curbs, walls, railings, fences, planter boxes, shrubs, lawns and trees.
  - 2. Definitions pertaining to trees, shrubs and other plants: ANSI Z60.1.
  - 3. .Salvage: To remove and store material and equipment for reuse in this or other Authority contracts.
- D. Salvage:
  - 1. Clean salvaged items of foreign material and store in accordance with the General Requirements at accessible points within right-of-way unless otherwise shown, approved or directed.
  - 2. Repair or replace salvaged items which are damaged or destroyed.
  - 3. Unless otherwise specified items removed but not to be salvaged will become the property of the Contractor.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Working Drawings:
    - a. Complete details of proposed reconstruction of store fronts and shop windows.
    - b. Complete details of temporary signs including method of reinstalling existing permanent signs. Submit prior to removing signs.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ANSI: Z60.1.
  - 3. ASTM: C4.
  - 4. ICNCP (International Commission for the Nomenclature of Cultivated Plants): International Code of Nomenclature for Cultivated Plants.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS:**

- A. Materials for Restoration: New materials, unless otherwise approved, conforming to existing undisturbed materials in quality, color and finish.
- B. Topsoil: Section 02920.
- C. Seeding and Sodding: Section 02920.
- D. Trees, Shrubs and Other Plants: Same species as that removed, unless otherwise specified, and identified in accordance with the International Code of Nomenclature for Cultivated Plants.
- E. Clay Drain Tile: ASTM C4.

## **PART 3 - EXECUTION**

### **3.01 REMOVALS:**

- A. Remove work to extent shown minimizing damage to work which is to remain in place.

### **3.02 STORE FRONTS, BAY WINDOWS AND CORNICES:**

- A. Store Fronts:
  - 1. Rebuild store fronts at or behind building line to match existing fronts insofar as practicable.
  - 2. Complete restoration in accordance with approved working drawings.
- B. Bay Windows:
  - 1. Rebuild bay windows at or behind building line as window walls.
- C. Cornices:
  - 1. Do not replace cornices which have been removed.
  - 2. Parge areas disturbed by removal with cement plaster.

### **3.03 ALARM AND SPRINKLER SYSTEMS AND FIRE ESCAPES:**

- A. Alarm Systems:
  - 1. Maintain existing alarm systems in operating condition. On completion of construction, reinstall components to provide same degree of protection as original system.

- B. Sprinkler Systems:
  - 1. Maintain existing sprinkler systems fully operative in areas temporarily occupied for construction purposes.
  - 2. Protect system from freezing where exposed to open-air conditions.
  - 3. Restore sprinkler system to provide same degree of protection as original system.
- C. Fire Escapes:
  - 1. Relocate fire escapes temporarily and maintain safe egress.
  - 2. Replace fire escapes in original location as soon as practicable.

**3.04 CANOPIES, AWNINGS AND GRILLES:**

- A. Canopies and Awnings:
  - 1. Store canopies and awnings during construction.
  - 2. Reinstall as soon as construction permits.
- B. Grilles:
  - 1. Remove and reinstall security grilles concurrently with building modifications.

**3.05 VAULTS:**

- A. Perform work on vaults as specified in Section 02320.

**3.06 HEATING, COOLING AND ELECTRICAL FACILITIES:**

- A. Heating and Cooling Facilities:
  - 1. Remove and rebuild heating and air-conditioning facilities as necessary to provide service.
- B. Electrical Facilities:
  - 1. Remove and reconstruct electrical facilities to extent necessary to provide electrical service inside building line.

**3.07 SIGNS, FLAGPOLES, RAILINGS AND FENCES:**

- A. Salvage signs, flagpoles, railings and fences where shown.
- B. Provide temporary sign for each permanent sign removed in accordance with approved working drawings. Remove on completion of construction.
- C. Reinstall items in their original locations or in other locations shown. Reinstall or replace chain-link fences in accordance with Section 02820.
- D. Repair existing surfaces, damaged during the work, by cleaning and restoration to match existing.

**3.08 STEPS, WALLS AND COPINGS:**

- A. Salvage steps and copings of wall components where shown and rebuild them to match existing.
- B. Where new reinforcing steel and concrete construction is necessary, provide such items in accordance with Sections 03100, 03200 and 03300 so as to maintain continuity of quality and appearance between existing and new construction.

### **3.09 SIDEWALKS AND CURBS:**

- A. Salvage components of sidewalks and curbs where shown. Dispose of six-inch granite curb. It will not be reused.
- B. Restore sidewalks and curbs to line and grades which existed originally or new lines and grades shown.
- C. Restore asphalt and concrete sidewalks and curbs using new asphalt and concrete of equal quality to existing and to match lines, grades, thickness and construction existing prior to removal. Perform work in accordance with Sections 02725, 02740, 02750 and 02772.

### **3.10 PARKING AREAS AND DRIVEWAY PAVEMENTS:**

- A. Restore parking area and driveway pavements to lines, grades, thickness and construction existing prior to removal. Perform work in accordance with Section 02725, 02740 and 02750.

### **3.11 LANDSCAPING:**

- A. Tree Preservation:
  - 1. Repair injuries, abrasions or other damage to planting by cleanly removing broken members, loose or torn bark and shape edges in order to permit drainage of rain water from wounds. Perform pruning in accordance with Section 02930.
    - a. Where depth of soil over root system of existing plantings is to be modified by final grading, provide the following:
      - 1) Where increase of one foot or more in elevation is shown, spread continuous layer of rock aggregate, graded 1/4 inch to two inches, six inches deep from trunk to drip line of branches prior to installation of fill.
      - 2) Provide proper aeration by installing, within perimeter of spread, system of four-inch clay drain tile, vertically from soil surface into aggregate fill.
      - 3) Construct stone wells around trunks as shown, detailed or as approved. Extend stone work from rock fill layer to final grade, allowing sufficient space for trunk growth.
      - 4) Protect trees, shrubs, groundcovers and features such as landforms, walls, wells, coping and similar items that are to remain. Exercise special precautions and provide treatment for retention and protection of such landscape items in preference to removal.
- B. Tree Removal and Replacement:
  - 1. Where existing trees are to be removed and replaced by others at present locations, use replacement trees of comparable species and size up to four inches maximum caliper, except that the jurisdictional authorities have the right to specify alternate tree species or varieties of comparable size and cost, if such are readily available. Do not replant or relocate trees over 12 inches in caliper, except in cases of historical significance, rarity of type, excellence of form or other special considerations.
  - 2. Replace trees of minimum three-inch caliper, removed by construction, on the basis of diameter inch for diameter inch, up to four-inch maximum caliper, and on total diameter inches removed, so that planting can be complete and uniform throughout.
  - 3. Use replacement trees of prime specimen quality, field selected and seal-tagged. Measure, grade, install and maintain plants in accordance with ANSI Z60.1, except for National Park Service lands where trees are to be measured for diameter by taking the average of two trunk caliper measurements at right angles, six inches

- above the root crown.
4. Replace shrubs removed with same species and varieties and of same size in height or width or substitute at locations designated by the Engineer a number of plants of same species and variety whose total measurements equal measurement of plant or plants to be replaced
- C. Plant maintenance and replacements:
1. For 18 months after completion of plant installation, maintain planting and incidental work by replacing plants, watering, weeding, cultivating, fertilizing, remulching, pruning, controlling insects and diseases, reguying, rewrapping and by performing other maintenance operations for promotion of root growth and plant life so that work is in satisfactory condition at completion of Contract and throughout maintenance period.
  2. Water and weed root system of plants at regular intervals and keep surrounding soil in condition for promotion of root growth and plant life.
  3. Provide planting and planting materials that will be in a condition acceptable to the Engineer at end of maintenance period.
  4. During next planting season, replace trees, ground cover, vines and shrubs which are discovered during and at end of maintenance period to be dead or in unhealthy, unsightly or badly impaired condition. Replace with healthy plants of same kinds and sizes as originally specified.
  5. The Contractor will not be held responsible or liable for damages to plants and planting materials by animals, malicious or careless damage by human agencies over which he has no control, or by fire and storm damage following completion and acceptance of original planting.
- D. Topsoil:
1. Provide and place topsoil in tree spaces and areas to be seeded in accordance with Section 02920.
- E. Grassed Areas:
1. Unless otherwise shown, provide seed in accordance with Section 02920. If sodding is required, provide in accordance with Section 02920.
- F. Replace landscaping, trees and grassed areas, inside and outside limits of work, if removed or damaged.

### **3.12 JOINTS BETWEEN EXISTING AND RESTORED WORK:**

- A. Make joints between existing and restored work as inconspicuous as practicable.
- B. Use saw to cut straight line at joint between existing and new concrete surfaces.
- C. Make joints between existing and restored work at least equal structurally to original undisturbed items.

**END OF SECTION**

## SECTION 02220

### DEMOLITION

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies demolition work.
  - 1. Related Work Specified Elsewhere:
  - 2. Clearing, grubbing, removal and protection of trees and shrubs: Section 02230.
  - 3. Removal of concrete and masonry walls and foundations 12 inches below existing grade: Section 02320.
  - 4. Removal and restoration of miscellaneous facilities: Section 02205.
- B. Definitions:
  - 1. Demolition: Complete removal and disposal of existing facilities from areas to be cleared and grubbed and from other areas shown.
  - 2. Existing facilities include, but are not restricted to, buildings, sheds, streetcar tracks, pavements, sidewalks, curbs and gutters, signs, posts, fences, drainage, sewage and other utility facilities located in the area to be cleared and grubbed.
  - 3. Salvage: Section 02205.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Certification:
    - a. Submit copy of request to utility companies owning or agency controlling services and appurtenances affected by demolition work for discontinuance of services along with certificates of severance.
  - 2. Documentation:
    - a. Demolition permit from the jurisdictional agency or owner.
    - b. Permits and releases from each owner of property where demolition debris will be deposited absolving the Authority of responsibility in connection with such disposal.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.

##### 1.04 JOB CONDITIONS:

- A. Buildings:
  - 1. Demolish buildings in place.
- B. Street and Road Closures:
  - 1. Make arrangements with appropriate jurisdictional agency for temporary closing of public streets or highways to traffic as necessary.
  - 2. Arrange with the appropriate agency for the rerouting of traffic and comply with its regulations.
  - 3. Furnish and maintain temporary signs, barricades, flashing lights and flag persons necessitated by the work and remove same upon completion of work.

- C. Maintenance of Traffic:
  - 1. Construct, maintain and remove on completion of work, temporary canopies and other structures for protection of the public in accordance with applicable codes to ensure continuous safety of traffic.
  - 2. Bridge cuts in traffic areas with steel plates or by other approved means.
  - 3. Keep traffic areas free from debris and spillage of materials.
  - 4. When demolition work interferes with bus loading facilities, provide and maintain surfaced areas at alternative locations or arrange rerouting with appropriate authorities for duration of work.
  
- D. Protection and Restoration:
  - 1. Prevent damage to pipes, conduits, wires, cables and structures above and below ground which are not designated for removal. Repair or replace damaged items.

## **PART 2 - PRODUCTS**

Not Used.

## **PART 3 - EXECUTION**

### **3.01 PRESERVATION OF REFERENCES:**

- A. Prior to removal, record location and designation of survey markers and monuments located within demolition area. Store markers and monuments during period of work. Restore survey markers and monuments upon completion of work.

### **3.02 BUILDING DEMOLITION:**

- A. Undertake rodent control and extermination program in demolition areas.
- B. Take possession of building materials, fixtures and equipment in, attached to or belonging to, buildings and structures.
- C. Proceed with demolition of building or structure and appurtenances.
- D. Party Walls:
  - 1. Where building wall being demolished is a party wall with another building not to be demolished, prevent damage to other building and avoid interference with its occupants.
  - 2. Restore and waterproof exposed party walls in accordance with applicable building code for exterior walls of particular type of construction involved.
  - 3. Should party wall become unsafe or dangerous because of demolition, effect remedial measures for anchoring, bracing or buttressing. If such work does not correct unsafe or dangerous conditions, remove and replace wall and perform necessary work to properly enclose structure that is to remain standing, at no cost to the owner of such property.
- E. Cellars and Foundation Walls:
  - 1. Break concrete and masonry cellar floors into pieces not exceeding four cubic feet in volume or, where approved, punch holes of not less than one-square-foot area through full thickness of floor approximately at 10-foot centers.
  - 2. Remove wooden cellar floors.
  - 3. Remove foundation and cellar walls 12 inches minimum below final grade.

4. After breaking or removing cellar floors, fill cellar spaces with durable free-draining fill material, consisting of particles no one of which exceeds eight inches in its greatest dimension. Use masonry rubble obtained from demolition work if it meets this requirement. Place fill material in layers each of 12-inch maximum thickness, compact each layer and fill voids in each lift with approved coarse sand.
5. Correct subsidence in filled areas by placing and compacting additional fill.
6. The Engineer may waive the requirement to fill cellar voids where cellar structures will be subsequently excavated for construction.

### **3.03 REMOVAL OF STREETCAR TRACKS, PAVEMENTS, SIDEWALK, CURBS AND GUTTERS:**

- A. Removal of Streetcar Tracks:
  1. Regardless of depth, totally remove and dispose of rails, slot rails, yokes, switches, turnouts, ties, manholes, concrete and masonry encasements, cables, insulators and other related parts and accessories of track installation located within boundaries drawn two feet outside outer rails. Remove materials within such boundaries horizontally and from existing street grade to yoke encasement subgrade, vertically. In double track installations, remove materials in intervening space between inner rails of each track.
  2. Known locations of streetcar tracks are shown.
  3. Remove streetcar tracks as necessitated by the work and as directed, whether tracks are shown or encountered during excavation.
  4. Transport from the site removed or excavated track accessories or parts thereof which will become the property of the Contractor.
  5. Methods of removal and disposal will be at the Contractor's option, subject to approval and meeting the requirements of the Construction Sequence and Maintenance of Traffic Schedule.
- B. Demolish pavement, sidewalks, curbs and gutters within demolition area shown to underside of pavement and dispose of resulting debris. Remove and salvage stone curbing where shown. Dispose of six-inch granite curb.
- C. Fill resulting excavations, holes and depressions to existing grade or alternative grade as shown, using fill material conforming to requirements of Section 02320.
- D. Adequately drain resulting surfaces.

### **3.04 DISPOSAL:**

- A. Remove debris resulting from demolition work to locations outside Authority's right-of-way.
- B. Dispose of debris off site only with permission of property owner where such debris is to be deposited and in accordance with codes and regulations of the jurisdictional authorities.
- C. Do not burn debris at demolition site.

**END OF SECTION**

## SECTION 02230

### SITE CLEARING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This Section includes the following:
  - 1. Protecting existing trees and vegetation to remain.
  - 2. Removing trees and other vegetation.
  - 3. Clearing and grubbing.
  - 4. Topsoil stripping.
  - 5. Removing above-grade site improvements.
  - 6. Disconnecting, capping or sealing, and abandoning site facilities in place.
  - 7. Disconnecting, capping or sealing, and removing site facilities.
  
- B. Related Sections include the following:
  - 1. Demolition: Section 02220.
  - 2. Topsoil, seeding and sodding: Section 02920.
  - 3. Landscaping: Section 02930.
  - 4. Construction Facilities and Temporary Controls- Div 1
  
- C. Definitions
  - 1. Topsoil: Natural or cultivated surface-soil layer containing organic matter and sand, silt, and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2 *inches* in diameter; and free of weeds, roots, and other deleterious materials.
  - 2. Facility: Utility structures and system components belonging to utility company including service lines which are used to provide service to utility's customers and product which these facilities convey.
  - 3. Utility: Company, agency, owner or operator of facility concerned.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Documentation:
    - a. Permits and releases from each owner of property where debris will be deposited absolving the Authority of responsibility in connection with such disposal.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.

#### PART 2 - PRODUCTS

##### 2.01 MATERIALS:

- A. Requirements for satisfactory soil materials are specified in Division 2 Section "Earthwork."

1. Obtain approved borrow soil materials off-site when satisfactory soil materials are not available on-site.
- B. Standard Wood Tree Guards: As shown on W.M.A.T.A. Standard Drawing ST-C-16, consisting of the following:
  1. Wood posts: Two inches square.
  2. Wood stringers: Two inches by four inches.
- C. Standard Chain-Link Tree Guards: As shown on W.M.A.T.A. Standard Drawing ST-C-16, consisting of the following:
  1. Chain-link fencing: Nine gauge, two-inch mesh.
  2. Posts: 2.7 lbs. per foot "H" or 1-1/2 inches inside diameter.
  3. Brace rails: 1-5/8 inches outside diameter.
  4. Stretcher bars: 1/4-inch by 3/4-inch.
- D. Temporary Enclosures and Wrapping: Contractor's option.
- E. Tree Wound Paint: Standard bituminous product.

### **PART 3 - EXECUTION**

#### **3.01 PREPARATION**

- A. Protect and maintain benchmarks and survey control points from disturbance during construction.
- B. Provide erosion-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways
- C. Locate and clearly flag trees and vegetation to remain or to be relocated.
- D. Protect existing site improvements to remain from damage during construction.
  1. Restore damaged improvements to their original condition, as acceptable to Owner.

#### **3.02 TREE PROTECTION**

- A. Erect and maintain temporary enclosures or wrappings around drip line of individual trees or around perimeter drip line of groups of trees to remain. Remove enclosures or wrapping when construction is complete.
  1. Do not store construction materials, debris, or excavated material within drip line of remaining trees.
  2. Do not permit vehicles, equipment, or foot traffic within drip line of remaining trees.
- B. Protect trees shown on the drawing with standard wood or chain link tree guards.
- C. Nurture protected and replaced trees, shrubs and plants during the period of this Contract.
- D. Do not excavate within drip line of trees, unless otherwise indicated.

- E. Where excavation for new construction is required within drip line of trees, hand clear and excavate to minimize damage to root systems. Use narrow-tine spading forks, comb soil to expose roots, and cleanly cut roots as close to excavation as possible.
  - 1. Cover exposed roots with burlap and water regularly.
  - 2. Temporarily support and protect roots from damage until they are permanently relocated and covered with soil.
  - 3. Coat cut faces of roots more than 1-1/2 inches in diameter with an emulsified asphalt or other approved coating formulated for use on damaged plant tissues.
  - 4. Cover exposed roots with wet burlap to prevent roots from drying out. Backfill with soil as soon as possible.
- F. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations, in a manner approved by Architect.
  - 1. Employ a qualified arborist, licensed in jurisdiction where Project is located, to submit details of proposed repairs and to repair damage to trees and shrubs.
  - 2. Replace trees that cannot be repaired and restored to full-growth status, as determined by the qualified arborist.

### **3.03 UTILITY FACILITIES**

- A. Locate, identify, disconnect, and seal or cap off facilities indicated to be removed.
  - 1. Owner will arrange to shut off indicated facilities when requested by Contractor.
- B. Existing Facilities: Do not interrupt facility service to building connections occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
  - 1. Notify Engineer not less than two days in advance of proposed facility interruptions.
  - 2. Do not proceed with facilities interruptions without Engineer's written permission.
- C. Excavate for and remove underground facilities indicated to be removed.

### **3.04 CLEARING AND GRUBBING**

- A. Remove obstructions, trees, shrubs, grass, and other vegetation to permit installation of new construction. Removal includes digging out stumps and obstructions and grubbing roots.
  - 1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
  - 2. Cut minor roots and branches of trees indicated to remain in a clean and careful manner where such roots and branches obstruct installation of new construction.
  - 3. Completely remove stumps, roots, obstructions, and debris extending to a depth of 18 inches below exposed subgrade.
  - 4. Use only hand methods for grubbing within drip line of remaining trees.
- B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material, unless further excavation or earthwork is indicated
  - 1. Place fill material in horizontal layers not exceeding 8-inch loose depth, and compact each layer to a density equal to adjacent original ground.

### **3.05 TOPSOIL STRIPPING**

- A. Remove sod and grass before stripping topsoil.

- B. Strip topsoil to whatever depths are encountered in a manner to prevent intermingling with underlying subsoil or other waste materials.
  - 1. Strip surface soil of unsuitable topsoil, including trash, debris, weeds, roots, and other waste materials.
- C. Stockpile topsoil materials away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust.
  - 1. Limit height of topsoil stockpiles to 72 inches.
  - 2. Do not stockpile topsoil within drip line of remaining trees.
  - 3. Stockpile surplus topsoil and allow for respreading deeper topsoil.

**3.06 REMOVAL OF TREE BRANCHES:**

- A. Remove tree branches which extend over structure neat lines and are less than 20 feet above top of rail or existing surface whichever is higher.
- B. Remove tree branches which create a hazardous condition.
- C. Remove branches so as to present balanced appearance of tree.
- D. Treat scars resulting from removal of tree branches with heavy coat of tree wound paint

**3.07 SITE IMPROVEMENTS**

- A. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction.
- B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.
  - 1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut length of existing pavement to remain before removing existing pavement. Saw-cut faces vertically.

**3.08 DISPOSAL**

- A. Disposal: Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials, including trash and debris, and legally dispose of them off Owner's property.
- B. Dispose of debris off site only with permission of property owner where such debris is to be deposited and in accordance with codes and regulations of the jurisdictional authorities.
- C. Burning and burying debris on site is prohibited.

**END OF SECTION**

## SECTION 02240

### DEWATERING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies general dewatering systems for control of groundwater and removal of surface water during construction.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ASTM:
    - a. D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
    - b. D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
    - c. D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
    - d.
- B. Qualifications:
  - 1. For mined earth tunnels, have the design, implementation, evaluation, and maintenance of the dewatering system under the supervision of a specialist with a minimum of five years experience in responsible control of work similar to that proposed.
- C. Design Criteria:
  - 1. Provide dewatering system which will reduce hydrostatic pressure and lower groundwater levels below excavation levels excluding mined tunnels, as necessary for safe and proper prosecution of the work and which will result in obtaining stable, substantially dry subgrade for prosecution of subsequent operations.
  - 2. For mined earth tunnels, provide dewatering system which will reduce hydrostatic pressure and control groundwater in soil surrounding each tunnel to prevent the following:
    - a. Heaving of the invert, hazardous seepage, and flow of soil in tunnel face.
    - b. Loss of ground and surface subsidence.
  - 3. For mined earth tunnels in pervious soils, lower groundwater to two feet below invert or reduce hydrostatic pressure to a point where tunneling proceeds without groundwater related delay and loss of ground.
  - 4. For mined earth tunnels where impervious soils extend above invert, lower groundwater level to two feet above top of lowest impervious soil layer or reduce hydrostatic pressure to a point where tunneling proceeds without groundwater related delay and loss of ground.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Working Drawings:
    - a. Type of dewatering system proposed, showing arrangement, location and depths of proposed system, complete description of equipment and materials to be used, installation procedure, well and piezometer

development procedures, maintenance plan for dewatering system and piezometers, standby equipment and standby power supply (if required), and proposed location of points of discharge of water and settlement measuring procedure.

- b. Obtain approval of jurisdictional agencies prior to installation of system.
2. Documentation:
- a. Observe and record average flow rate and time of operation of each pump used in dewatering system. Provide appropriate devices, such as totalizing flow meters for observing flow rates. Provide interior dewatering well drop tube and exterior filter piezometer to observe and record operating levels and filter levels. Submit data on approved form and in approved format during period dewatering system is in operation.
  - b. Observe and record elevation of groundwater in the piezometers, including those previously installed, on approved form and in approved format, during the period that dewatering system is in operation. Sound depth to bottom of each piezometer monthly to ensure that soil particles are not building up in standpipe. Submit observation records promptly, regularly and as directed.
  - c. During dewatering, make observations daily. After dewatering levels have stabilized, observations frequency may be reduced as approved.
  - d. Submit maintenance schedule for piezometers and dewatering system. Record and submit maintenance records for each piezometer and dewatering well or dewatering system component weekly or as approved
  - e. Provide drill logs and installation details of all dewatering system components, and piezometers, 24-hours after installation.

### **1.03 JOB CONDITIONS:**

- A. Subsurface Conditions:
  1. Reports of subsurface investigations are available as listed in the General Requirements.
- B. Permits:
  1. Prior to discharging water, obtain permit from jurisdictional agency.
  2. Control discharge of water in accordance with the General Requirements, if specified.
- C. Responsibilities:
  1. Design and install dewatering system to accomplish groundwater control as specified.
  2. Monitor, and report as required, discharge from dewatering system to determine if water quality meets the requirements of jurisdictional agency. Modify dewatering system as necessary to meet the requirements of jurisdictional agency.
  3. Measure to determine if movement occurs in adjacent areas by dewatering operations; take approved measures to minimize movement and prevent damage to affected properties, buildings, structures, utilities or facilities. Establish criteria for acceptable tolerances.
  4. Take measures to prevent damage to properties, buildings, structures, utilities and facilities resulting from groundwater pumping.
  5. Modify system if it causes, or threatens to cause, damage to properties, buildings, structures, utilities or facilities.
  6. Repair as approved, damage, disruption or interference to properties, buildings, structures, utilities or facilities resulting from dewatering operations.
  7. Contract Drawings may designate locations where lowering of groundwater will not be permitted.

8. Locations of dewatering system elements and piezometers may be adjusted in field to suit job conditions, as approved.
  9. Operate dewatering system without interruption until directed otherwise.
- D. Coordination with Other Contractors:
1. The Contract Specifications govern requirements for access to areas outside Contract limits.
  2. Coordinate installation and operation of dewatering system and piezometers with others concerned and with other Authority contractors if applicable.
  3. If an adjoining Authority contract requires installation of portions of the adjoining contract dewatering system or piezometers within Contract limits, allow access for installation.

## **PART 2- PRODUCTS**

### **2.01 PIEZOMETERS:**

- A. See Soil & Geological Standard Drawing Piezometer Details as shown.
- B. Piezometer construction shall use ASTM-specified materials and procedures (D2466, D1785, and D2564) .

## **PART 3 - EXECUTION**

### **3.01 SURFACE DRAINAGE:**

- A. Intercept and divert surface drainage away from excavations, piezometers and dewatering wells by use of dikes, curb walls, ditches, pipes, sumps or other means.
- B. Design surface drainage systems to prevent erosion.
- C. Remove surface drainage system when no longer required.
- D. Remove debris and restore site to original conditions.

### **3.02 DRAINAGE OF EXCAVATED AREAS:**

- A. Provide and maintain ditches of adequate size to collect surface and subsurface water and divert it into sump for draining or pumping into channels or storm sewers, as approved.
- B. Install settling basins, tanks or other approved apparatus as necessary to bring the discharge into compliance with permit requirements.
- C. When no longer necessary, backfill and seal drainage ditches, sumps and settling basins with approved material.

### **3.03 DEWATERING:**

- A. Coordinate dewatering installation to prevent conflict with other construction activities.
- B. Install dewatering system in accordance with approved drawings and procedures. If site conditions require modification of the dewatering system, implement modifications to achieve specified design criteria prior to excavation.

- C. Demonstrate by approved methods that discharged sand content from each well meets the design criteria specified above under Quality Assurance.
- D. Discharge subsurface water clear of the work area.
- E. Maintain continuous and complete effectiveness of the installation through regularly scheduled maintenance of well screens, pumps, piezometers, electrical and piping systems.
- F. Maintain water level so that no damage to structure can occur.
- G. During backfill operations, the extent of dewatering may be reduced when approved, provided water level does not result in uplift pressure in excess of 80 percent of downward pressure produced by weight of structure and backfill in place.
- H. At locations of piezometers in mined earth tunnel sections, reduce water level to specified criteria at least 48 hours in advance of tunnel excavation.
- I. Maintain dewatering operations until permanent tunnel lining has been installed.

**3.04 PIEZOMETERS:**

- A. Prior to dewatering operations, install piezometers at locations shown or as approved and to the depths shown or approved.
- B. Verify installed piezometer tip elevation. Reinstall piezometers which do not comply with requirements at no additional cost to the Authority.
- C. 48 hours after completion of each piezometer installation, prove proper functioning of piezometer by performing Falling Head Tests. Submit test records within 24 hours of test completion.
- D. While dewatering system is in operation, prove continued proper functioning of each piezometer by performing rising head tests. Submit test records within 24 hours of test completion.
- E. Take static water level readings prior to energizing dewatering system. Submit water level readings within 24 hours of observation.
- F. Operate dewatering system so that groundwater level in piezometers is maintained continuously within prescribed limits.
- G. Protect and maintain piezometers in good operating condition until completion of Contract.
- H. Replace promptly any piezometer or dewatering well that is damaged or destroyed.
- I. Terminate piezometer readings when approved.

**3.05 PORTIONS OF SYSTEM TO BE LEFT IN PLACE:**

- A. When specified, leave portions of dewatering system in place.

**3.06 PORTIONS OF SYSTEM TO BE REMOVED:**

- A. Upon completion of Contract, remove piezometers and well casings, unless otherwise specified, to a depth of two feet minimum below ground surface.

- B. Backfill voids, well and piezometer casings with bentonite-cement grout.
- C. Backfill remaining space with compacted earth and restore ground surface to its original condition.

**END OF SECTION**

## SECTION 02255

### UNDERPINNING, SUPPORT AND RESTORATION OF STRUCTURES

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies underpinning, supporting and restoring of structures.
- B. Definitions:
  - 1. Underpinning: Permanent supporting structure designed to transmit foundation loads to lower bearing levels necessary to securely maintain structure being underpinned. Also includes temporary support necessary to safely perform underpinning work and restoration of structure upon completion of work.
    - a. Temporary support: Construction required and designed to support structures during underpinning or other construction work.
    - b. Restoration: Correction by repair or replacement of structure which is damaged, removed or altered by the Contractor in furtherance of his operation equivalent to condition existing prior to start of Contract work unless otherwise shown or specified.
  - 2. Structure categories:
    - a. Category 1 structures: Structures for which underpinning is necessary and has been designed.
    - b. Category 2 structures: Structures which, because they are likely to be affected by construction operations, the Contractor has the option of supporting temporarily, underpinning or both. The decision rests solely with the Contractor who is entirely responsible for results.
- C. Related Work Specified Elsewhere:
  - 1. Grading, excavation and backfilling: Section 02320.
  - 2. Dewatering: Section 02240.
  - 3. Support of excavation: Section 02260.
  - 4. Decking: Section 01530.
  - 5. Piles: Section 02460.
  - 6. Concrete work: Sections 03100, 03200 and 03300.
  - 7. Structural steel: Section 05120.
  - 8. Geotechnical instrumentation: Section 02291.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ASTM: D1056, D1149, D1692.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Working Drawings:
    - a. Verify by field investigation foundation loads, locations, sizes and conditions of existing structures and footings requiring underpinning and temporary protection.

- b. Prepare working drawings showing method, staging and necessary details, including computations for construction of underpinning and temporary support of each structure on which work is to be accomplished as well as method of transferring structural load to piles.
  - c. Have drawings and computations certified by a registered professional engineer who is licensed to practice in the jurisdiction where the work is to be performed and who is qualified to substantiate extent and design of underpinning work.
2. Documentation:
    - a. Submit written understandings with each structure owner with owner's signature signifying his agreement.

#### **1.04 JOB CONDITIONS:**

- A. Consents, Permits and Approvals:
  1. The Authority will obtain necessary rights from owner for Contractor to occupy construction areas for Category 1 Structures as shown.
  2. The Contractor is responsible for obtaining in his own name, other agreements, rights, permits and consents necessary to effect underpinning work, which are to provide for and constitute agreement as to interdependent unitized system of underpinning support, when such system is feasible in the Contractors' opinion. Obtain permits required by jurisdictional agencies. Permits to name property owner and the Authority as co-applicants, when applicable, and the Contractor as their agent. Transmit copies of these instruments to the Engineer before starting work on each affected structure.
  3. Additional requirements for permits, consents and approvals are contained in the General Provisions. Where plans for existing structures are available, they may be reviewed as specified in the General Requirements.
- B. Responsibilities:
  1. Maintain safety, stability and integrity of structures of whatever nature regardless of location which may be affected by the work.
  2. Repair damage to structures caused by work necessary to restore structures to condition existing prior to start of work.
  3. Perform underpinning operations in accordance with applicable codes and regulations of the jurisdictional agencies.
  4. Perform underpinning operations with qualified personnel under continuous supervision of a registered professional engineer experienced in such work.
- C. Coordination with Structure Owners:
  1. Prior to starting work on structure, confer with owner or his authorized representative and obtain concurrence with underpinning procedures and sequence of operations including:
    - a. Means of access to the construction area.
    - b. Permitted areas of operations.
    - c. Time restrictions for performance of work which may disturb occupants.
    - d. Scheduling of time and durations of outages of utilities and other services to premises as well as of operation of systems within premises.
  2. Notify the Engineer three days prior to intended conferences with owner.

## **PART 2 - PRODUCTS**

### **2.01 PRODUCTS AND MATERIALS:**

- A. Piling: Section 02460.
- B. Concrete: Section 03300, Class 3500 or better.
- C. Reinforcement: Section 03200.
- D. Structural Steel: Section 05120.
- E. Vibration-Isolation Materials:
  - 1. Closed-cell neoprene isolation board conforming to ASTM D1056, Grade 2C5.
  - 2. Self-extinguishing when tested in accordance with ASTM D1692.
  - 3. No cracks after exposure to air containing 100 ppm of ozone for 100 hours at 104F with samples under 20 percent strain tested in accordance with ASTM D1149.
  - 4. Water absorption: Not exceeding one percent by weight.
- F. Bonding Adhesive: As recommended by the vibration-isolation material manufacturer.

## **PART 3 - EXECUTION**

### **3.01 DETECTION OF MOVEMENT:**

- A. In accordance with the General Requirements, provide, install and maintain monitoring equipment to detect horizontal or vertical movement of structures as specified in Section 02291.
- B. Inscribe or firmly affix on each column, pile cap, or wall to be underpinned or supported and at additional locations directed by the Engineer, visual methods of determining movements. Method used is optional but to be capable of being read to within 0.005 foot.
- C. Take readings daily or more often if necessary during progress of underpinning or support operations and for a period of four weeks after completion of such operations. Frequency of readings may be reduced at specific location(s) with prior approval.

### **3.02 TEMPORARY PARTITIONS AND CLOSURES:**

- A. Build where shown and as required by property owner, closed, dustproof, weatherproof and burglarproof temporary partitions and closures of suitable materials to isolate work site from remainder of the structure. Comply with local building code requirements.
- B. Provide emergency exits, with appropriate hardware.
- C. Provide temporary protection against dust and damage from underpinning operations.
- D. Remove temporary protective installations upon completion of work and restore area to original condition.

### **3.03 INSTALLATION:**

- A. Excavation:
  - 1. Excavate underpinning pits in accordance with Section 02320.
  - 2. Support excavated surfaces in accordance with Section 02260.
  - 3. Provide and maintain protective fencing and decking in accordance with Section 01530.
  - 4. Dewatering: In accordance with Section 02240.
- B. Underpinning:

1. Perform needling, shoring, cribbing and posting as necessary to ensure that movements damaging to the structure do not occur prior to and during underpinning operations.
  2. Place dry pack mortar, concrete and reinforcing steel in accordance with Sections 03100, 03200 and 03300.
  3. Install structural steel shapes in accordance with Section 05120.
  4. Install piling where shown in accordance with Section 02460.
  5. When jacking piles, establish adequate controls to detect movement of structure being underpinned. Maintain suitable equipment and methods continuously available to contain movement should it occur.
  6. Remove obstructions encountered when installing steel shell piling by drilling or spudding. Blasting is prohibited.
  7. Test installed piling where shown and take remedial action necessary to obtain loading.
  8. Use underpinning piles for underpinning purposes only, unless approved.
  9. Transfer structural load to piles in accordance with approved procedures.
  10. When transfer of loading has been completed and approved, clean pits of foreign matter.
- C. Vibration Isolation:
1. Place vibration-isolation material where shown using boards supplied in lengths sufficient for one-piece installation. Apply bonding adhesive at rate recommended by manufacturer of board.
- D. Backfill:
1. Place concrete backfill to limits shown.
  2. Place and compact earth backfill in accordance with Section 02320.
- E. Restore ground and building surfaces to their original condition.
- F. Remove debris and construction materials. Leave site in a neat presentable condition.

**END OF SECTION**

## SECTION 02260

### SUPPORT OF EXCAVATION

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies support for cut-and-cover, open-cut excavation, trench excavation and shafts.
- B. Related Work Specified Elsewhere:
  - 1. Grading, excavating and backfilling: Section 02320.
  - 2. Maintenance, support and restoration of utility facilities: Section 02270.
  - 3. Decking: Section 01530.
  - 4. Rock reinforcement: Section 02420.
  - 5. Drilling: Section 02431.
  - 6. Concrete reinforcement: Section 03200.
  - 7. Cast-in-place structural concrete: Section 03300.
  - 8. Steel bars, steel strand, anchorages, couplings for ground anchors, grout: Section 03415.
  - 9. Structural steel: Section 05120.
  - 10. Grounding and bonding of soldier piles: Section 16060.
  - 11. Geotechnical instrumentation: Section 02291.
- C. Contractor's Options:
  - 1. System of support to consist of soldier piles and lagging, sheet-piling or slurry-trench concrete walls, secured in place by means of bracing members such as wales, struts, shores and ground anchors. Other methods of support permitted only when approved.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standard and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. API: 13A, 13B-1.
  - 3. ASTM: A36, A709, A722.
  - 4. EPA.
- B. Design Criteria:
  - 1. Design support of excavation in accordance with design criteria shown and specified. Criteria are the minimum acceptable.
  - 2. Design component members of system to support temporary decking system, earth and rock pressures, unrelieved hydrostatic pressures, utility loads, applicable traffic and construction loads and other surcharge loads. Use loading combinations shown. Prepare design for staged removal of bracing to suit sequence of concrete placement.
  - 3. Design support system for nonpenetration of station and entrance surfaces visible to public. Temporary penetration permitted only where location of penetration is eventually to be hidden by elements such as acoustical panels or similar items

4. Design sheeting and bracing for sides of excavations for underground structures in a manner permitting safe and expeditious construction of permanent structures, minimizing movement or settlement of the ground and preventing damage to adjacent buildings, structures and utility facilities. Locate and design the bracing system such that it will not interfere with the reinforcement and construction of the permanent structure.
5. For support systems in which struts are installed between opposite sides of the excavation, design and construct support of both sides to obtain comparable rigidity.
6. Choose location of soldier piles to allow for expected deviations from true line during driving procedure without encroaching on future permanent structures.
7. Approval of Contractor's plans and methods of construction does not relieve the Contractor of the responsibility for adequacy of support.

## 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  1. Working Drawings:
    - a. Details, arrangement and method of assembly of proposed system, including construction sequence.
    - b. Method of preloading and bracing.
    - c. Elevations and sections showing full excavation depth from top grade to bottom of soldier piles or subgrade, whichever is deeper.
    - d. Loads for various stages of bracing removal and concrete placement.
    - e. Anticipated equipment load.
    - f. Maximum design load to be carried by various members of support system and preloads.
    - g. Depths below main excavation to which support system will be installed.
    - h. Methods of resolving difficulties arising from misalignment of soldier piles exposed during excavation and criteria for implementation of those procedures.
    - i. Methods of controlling and monitoring vibrations caused by driving of soldier piles to prevent damage to structures and utility facilities.
    - j. If proposed support system includes tieback anchors, show geologic profile or section for which each anchor is intended, design load for full depth of the excavation, maximum design and proof load and criteria proposed for deformations under proof loads.
    - k. Ground anchors and rock bolts:
      - 1) Prior to starting work, submit support system tieback and rock bolt details including design calculations, installation and load test procedures, grouting materials, grouting methods and detailed working drawings of the proposed rock bolt system.
      - 2) Show geologic profile or section for which each ground anchor or rock bolt is intended and design load of ground anchor and rock bolt for full excavation condition.
    - l. Include design calculations and maximum theoretical deflections of support members.
      - 1) The maximum allowable deflections of support members are as follows:
 

Soldier beams	1/2-inch
Walers	1/4-inch

This does not include the movement of support due to creep in tieback.
    - m. Include existing utility facilities. After checking their locations by field investigations, revise drawings to show actual locations of facilities, location of excavation supports, interference with proposed work and measures proposed to overcome such interferences.

2. Documentation:
  - a. Where proposed system of tieback anchors or rock bolts projects beyond vertical projection of property lines shown onto adjoining property, obtain permission of owner in writing.
  - b. Submit copies of permits with drawings.
  - c. Calculations:
    - 1) Design calculations as applicable.
    - 2) Do not proceed with work prior to approval.

#### **1.04 JOB CONDITIONS:**

- A. Provision for Contingencies:
  1. Monitor performance of components of support system, both vertical and horizontal movement in accordance with Section 02291, at regular intervals not to exceed three days.
  2. Provide contingency plan or alternative procedures to be implemented if unfavorable performance is evidenced.
  3. Keep on hand materials and equipment necessary to implement contingency plan.
- B. Proceed with caution in areas of utility facilities; expose them by hand excavation or other methods acceptable to utility owner.
- C. If existing utility facilities interfere with proposed method of support, modify or relocate such facilities with the approval of the appropriate utility owner. If relocation of the utility is not possible, obtain Engineer's approval for field changes to the approved support scheme of the excavation.
- D. Do not splice elements of support system unless approved.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS:**

- A. Steel Sheet Piles: Continuous interlocking type with cross section selected for intended use.
- B. Cast-In-Place Structural Concrete: Section 03300, Class 3500 unless otherwise shown.
- C. Timber Lagging: Structural grade, minimum allowable flexural stress of 1,100 psi.
- D. Concrete Reinforcement: Section 03200.
- E. Structural Steel: Section 05120; ASTM A36 or ASTM A709, Grade 36, minimum.
- F. Rock Bolts: Section 02420.
- G. Ground Anchors:
  1. Steel bars: ASTM A722 and Section 03415.
  2. Steel strand: Section 03415.
- H. Anchorages and Couplings for Ground Anchors: Section 03415.
- I. Grout: Section 03415.
- J. Bentonite Powder: API 13A.

- K. Other Materials: Those best suited for intended use, and as approved.

## **2.02 MIXES:**

- A. Lean Concrete: Portland cement and mineral or soil aggregate proportioned so that concrete retains its shape during excavation operations.
- B. Concrete for Slurry Trench Walls:
1. Tremie concrete of 3500 psi strength or higher if necessitated by design, with the following additional requirements:
    - a. Minimum cement factor: Seven bags per cubic yard.
    - b. Water-cement ratio: As necessary for strength and durability.
    - c. Sand proportion: As necessary to produce optimum results.
    - d. Rounded gravel aggregate: 1-1/2 inch maximum.
    - e. Slump: Six inches plus-or-minus one inch.
    - f. With water-reducing or fluidizing agents as necessary.
  2. Submit mix design for approval.
- C. Bentonite Slurry:
1. Stable suspension of powdered bentonite, or equal, and natural silts and clays in water.
  2. Density: 64 pcf minimum, 85 pcf maximum.
  3. Marsh funnel flow rate: 40 seconds minimum, 80 seconds maximum viscosity.
  4. Fluid loss: 25-cc maximum in 30 minutes.
  5. pH: 7.0 to 11.0
  6. Shear strength:
    - a. By shearometer: 1.4 to 10 N/M.
    - b. By fan viscometer: 4.0 to 400 N/M.

## **PART 3 - EXECUTION**

### **3.01 SHEETING, SHORING AND PILING:**

- A. Install soldier piles by driving, preboring or other pre-excavation methods. Drive soldier piles only in those areas where shown or approved. Install piles vertically within tolerance of one foot per each 100 feet for full depth of each pile.
- B. Where piles are installed by preboring or other pre-excavation methods, take appropriate measures to stabilize excavation to preclude loss of ground.
- C. Provide prebored holes for soldier piles adequate to accommodate pile section shown on approved working drawings. Extend hole to necessary depth below top of subgrade.
- D. Carry bottom of support system to depth below main excavation, adequate to prevent lateral movement. In areas where additional excavation is required below main excavation subgrade, make provisions to prevent movement of main excavation supports.
- E. Multiple-Layered Horizontal Bracing:
1. At locations where top of weathered bedrock is above the subgrade of main excavation, install soldier piles so that tips are at least two feet below top of subgrade.
  2. At locations where top of weathered bedrock is five feet or more below subgrade of main excavation, install soldier piles so that lower tip is at least five feet below bottom of excavation.

3. If weathered bedrock is encountered at elevation between subgrade elevation and five feet below subgrade, install soldier piles so that lower tip is five feet below subgrade or two feet into rock, whichever is higher.
- F. After seating soldier piles in pre-excavated holes, encase piles with Class 3500 concrete up to lowest point of excavation adjacent to pile location. Fill remainder of hole with lean concrete, completely encasing pile.
  - G. Use timber lagging, steel sheeting or precast reinforced concrete members secured in place for sheeting of excavations.
  - H. Follow excavation closely with placement of sheeting and lagging. Do not allow maximum height of unsheeted or unlagged face of excavation to exceed five feet in rock or predominantly clayey soils and three feet in sandy soils.
  - I. Do not permit height of unlagged face to exceed 15 inches if water flows from face of excavation or if soil in face moves toward excavation area.
  - J. Carefully perform excavation for installation of sheeting to minimize formation of voids. Separate sheeting members only to extent necessary to permit packing behind them.
  - K. Pack behind sheeting as installation progresses to establish tight contact between excavation face and sheeting. Pack openings between sheeting members with straw or other suitable material to allow free drainage of water without loss of soil or sand packing.
  - L. If unstable material is encountered during excavation, take suitable measures to contain it in place and prevent ground displacement which may cause damage.
  - M. Maintain sufficient quantity of material on hand for sheeting, shoring, bracing and other operations for protection of work and for use in case of accident or emergency.
  - N. Support System For Vertical Shafts Which Penetrate Soil/Rock Interface:
    1. Soldier piles:
      - a. If shaft excavation is supported by soldier piles, locate piling at least five feet in a horizontal direction from outer face of shaft wall. Install lower tip of piling at least ten feet below top of unweathered bedrock.
      - b. Procedure for establishing tip elevations:
        - 1) Make three pilot core borings at equal spacing along soldier pile line. Borings may be washed through overburden, but must be cored through bedrock to a depth of 20 feet into unweathered rock as determined by the Engineer. Advance holes in rock by rotary drilling methods and recover 2-1/8 inch diameter (NX) size rock cores using Series M double-tube core barrel. Drill in conformance to applicable portions of Section 02431. Place cores in wooden boxes as specified in Section 02431 and deliver to storage site as directed.
        - 2) Install soldier piles to obtain tip elevations established by the Engineer's examination of coring results.
        - 3) For shafts where pilot core borings indicate top of unweathered bedrock varies by more than three feet in elevation, set tips of soldier piles at least ten feet below lowest point of top of unweathered bedrock.
        - 4) In drilling soldier pile holes, use equipment capable of penetrating hard igneous and metamorphic rock that has an average unconfined compressive strength of six to eight kips per square inch and that may reach even greater values in some locations.

2. Ring beams and lagging or liner plate:
  - a. If shaft excavation is supported by ring beams or liner plates, install rings or liner plate to at least ten feet below average elevation of top of unweathered bedrock, which will be determined by the Engineer from examination of the rock in the advancing excavation.

### **3.02 SLURRY WALLS:**

- A. Slurry Trench Equipment:
  1. Use equipment capable of removing from trench foreign materials embedded in soil as well as natural materials, including boulders, where necessary. Arrange equipment to permit free vertical passage of slurry within trench and to prevent development of suction or pressure.
  2. Furnish trench inspection tools adequate to ensure that trench has been excavated to dimensions shown on approved working drawings and that cuttings and foreign material have been removed.
  3. Use slurry mixing equipment capable of producing, with mechanical agitation, a stable suspension of bentonite and water. Transport slurry to panels by temporary pipe line or other approved methods.
  4. Furnish slurry circulation equipment to provide circulation and agitation of the slurry throughout full depth of excavated panels. Do not agitate slurry by air
  5. Use slurry reclaiming equipment which will remove detrimental quantities of excavated material from slurry to ensure use of clean slurry in trenches. Recirculate reclaimed slurry to trenches in a continuous operation regardless of slurry density. Monitor slurry and control its capability of retaining solid particles in suspension.
- B. Field Quality Control:
  1. Make tests on samples of in-place slurry to determine density, viscosity, filtration and sand content in accordance with API 13B-1.
  2. Maintain quality of bentonite slurry compatible with soil characteristics of trench walls.
- C. Construction:
  1. Perform preparatory work to discover, protect, maintain, relocate and restore utility facilities and other obstructions in vicinity of slurry walls.
  2. Construct slurry trench walls by displacement of bentonite slurry with tremie concrete.
  3. Construct walls of reinforced concrete or plain concrete embedded with structural steel. Where soldier piles are used in construction of walls, it is permissible to consider piles as reinforcement.
  4. Provide sufficient embedment of walls below subgrade of excavation to prevent loss of ground due to piping under wall or lateral movement of wall.
  5. Use construction methods ensuring that slurry materials employed during trench excavation and placing of tremie concrete are contained and controlled to prevent leakage and spillage of slurry and excavated materials into basements, vaults, utilities and other facilities.
  6. Excavate slurry wall trenches in panels of width and depth shown on approved working drawings with maximum panel length of 18 feet. Reduce panel length when excavating adjacent to facilities sensitive to settlement.
  7. Maintain level of slurry in panels no more than five feet below top of trench during excavation operations and until tremie placement is essentially completed.
  8. Progress construction with no less than one unexcavated panel and one tremie-filled panel with concrete cured at least 72 hours, between two slurry panels under active excavation.
  9. Keep slurry circulated or agitated during drilling and excavating and immediately prior to concreting. Continuously maintain slurry requirements even during

nonworking periods and stoppages. If stoppage occurs in the operation causing slurry in panel to remain uncirculated and unagitated for more than 24 hours, backfill panel until operation can be resumed.

10. Place concrete by tremie methods either by gravity flow or by pumping. As soon as possible after placement of concrete is commenced, position bottom of pipe not less than five feet below upper surface of concrete being placed and maintain it in this position throughout operation. Equip tremie pipe with bottom valve or other device to prevent mixing of slurry with concrete inside tremie pipe. Aluminum pipe is prohibited.
11. Inspect trenching in the presence of the Engineer prior to concreting. Ensure that settled cuttings and excavated material have been removed.
12. Start placement of concrete in panels within 12 hours after completion of panel excavation and proceed continuously until concreting is completed.
13. When wales are used, obtain tight bearing between wales and wall and ample bearing area with wedges and dry pack for load transfer.
14. Preload braces at each level to computed maximum compressive force to be encountered at that level. Base calculations of this computed force upon pressure diagrams shown. Take into consideration increased strut loads that may develop because of removal of bracing as structure is built.
15. Accomplish preloading by approved procedures. Transfer load by jacking applied symmetrically to braces without introducing eccentricity.
16. Introduce jacking load into braces immediately after each tier of braces has been installed and before excavation has progressed more than two feet below bottom of bracing tier. Make provision to fix preload into each brace by shim plates, wedges, blocking or other approved device.
17. After concrete invert slab has been placed and attains sufficient strength to receive loads from slurry walls, remove tiers of bracing above invert level, provided the following conditions exist:
  - a. Remaining tiers are capable of resisting total load calculated from trapezoidal pressure diagrams shown.
  - b. Calculated deflection of the walls between tiers of bracing, assuming forces indicated by the trapezoidal pressure diagrams, does not exceed 1/2 inch.
18. Construct tight joints between adjacent pours of concrete in slurry wall to minimize loss of fines from retained earth. Take necessary care to accomplish this in terms of properly excavating trench and cleaning abutting face of hardened concrete or surfaces of structural members if used. Provide approved method of water stopping.
19. Seal leaks encountered in walls as excavation progresses, if leaks are of sufficient size to permit penetration of fines and loss of ground. Procedures may include grouting outside or through wall.
20. Dispose of unsuitable excavated material and debris in accordance with Section 02320.
21. Dispose of slurry waste offsite by means of sealed tanks and in accordance with EPA regulations.

### **3.03 PRIMARY SUPPORT:**

- A. Use wales, struts, tieback anchors and rock anchors as necessary to provide primary support of excavation faces retained by soldier piles, sheeting, sheet piles or concrete slurry walls. For excavation depths greater than eight feet, primary support or supports are required.
- B. Provide struts with intermediate bracing as needed to enable them to carry maximum design load without distortion or buckling.
- C. Provide diagonal bracing as needed to maintain stability of system.

- D. Include web stiffeners, plates or angles as needed to prevent rotation, crippling or buckling of connections and points of bearing between structural steel members. Allow for eccentricities caused by field fabrication and assembly.
- E. Install and maintain primary support members in tight contact with each other and with surface being supported.
- F. Design primary support members to support maximum loads occurring during excavation or removal stages.
- G. Preloading:
  1. Except for ground anchors and slurry wall bracing, preload primary bracing members including struts, shores, wales carrying axial load, and similar members at installation to 50 percent of design load, which for this purpose is maximum load that bracing member will have to carry. Preload tiebacks and slurry walls as specified for those installations.
  2. Use procedures that produce uniform loading of bracing member without appreciable eccentricities or overstressing and distortion of members of wall system.
  3. Make provisions for permanently fixing load in each member using steel shims or wedges welded into place.
  4. Accomplish preloading by jacking support in place against soldier piles or wales.
  5. Do not use wooden wedges to preload bracing member.
  6. Include in preloading system means to determine within five percent amount of preload induced into bracing members.
- H. If decking beams are not required or if decking beams are not designed for support of excavation loads, install uppermost tier of bracing at vertical distance of not more than six feet below top of excavation.
- I. Install tiers of primary support with no greater vertical distance between them than 16 feet
- J. Reduce maximum vertical distance to 12 feet at locations where ground movement and settlement must be minimized to prevent damage, where shown and as directed.
- K. Excavate to no more than two feet below point of support about to be placed. Install support and preload immediately after installation and prior to continuing excavation.

#### **3.04 SUPPORT SYSTEM WITH TIEBACKS:**

- A. Install tieback system in accordance with approved working drawings. Install anchorage in soil no closer than a plane extending upward at an angle of 45 degrees to the horizontal from outer limit of lowest depth of excavation.
- B. Stress tiebacks to proof loads equal to 140 percent of maximum design load and maintain proof load for 30 minutes prior to reducing to design load. Reject tiebacks which lose more than five percent of proof load during 30-minute period.
- C. Apply proof loads in increments of five tons at one-minute intervals and provide means to measure load application within accuracy of plus-or-minus five percent.
- D. After reducing tieback load to design load, encase anchors in grout maintaining design load until anchors are fixed in place.
- E. In transfer of loads from jacks to support system, use fixation method which will limit load loss to no more than five percent of design load.

- F. Provide and maintain convenient access and appropriate means to accomplish these observations.
- G. Preliminary And Creep Tests On Tiebacks:
  - 1. Reapply proof loads equal to 140 percent of design load at each level of support in excavation on first installation on each side of excavation at horizontal intervals not exceeding 500 feet and wherever there is significant difference in soil in which tiebacks are installed.
  - 2. As specified for proof loading, apply proof loads in increments of five tons at one-minute intervals. Provide means to measure load applications with an accuracy of plus-or-minus five percent of design load. Maintain proof load for 24 hours prior to reducing it to design load.
  - 3. Make records of axial movement with incremental applications of load as well as amount and time of load fall-off with no pumping of jack or axial movement during 24-hour period that proof load on tieback is maintained. If during 24-hour period axial deformation of tieback system exceeds 0.02 inch or decrease in jack pressure without pumping is more than five percent after correcting for temperature changes during the test period, redesign tieback system to satisfy requirements.
- H. Rock Bolts:
  - 1. Tension rock bolts to their design load as approved to permit checking of each loading by the Engineer.
  - 2. If grouted rock bolts are used, after loading has been approved, pressure-grout each permanent rock bolt in place using methods and equipment which will ensure elimination of air from bolt hole.
  - 3. If fully resin-encapsulated bolts are used, use slow-setting resin to allow Engineer sufficient time to approve loading prior to gelation.
- I. Vertical Support System With Tiebacks:
  - 1. Install piles or other vertical support system members incorporated in a system utilizing tiebacks so that they are capable of resisting vertical components of tieback loads without significant settlement during excavation and construction.
  - 2. Install vertical support members so that settlements will not be caused by construction. In general, install members to be end bearing in stratum below maximum depth of excavation and capable of carrying total vertical loads without assistance of skin friction at depth of excavation.

### **3.05 LAGGING:**

- A. Unless otherwise shown or specified, provide timber lagging of three inches minimum thickness where it spans soldier piles placed at distances five to seven feet on centers and for excavation depths up to 25 feet. Increase minimum lagging thickness to four inches for excavation below 25 feet in depth.
- B. For other conditions and types of lagging, submit design details for approval.

### **3.06 TRENCH EXCAVATION:**

- A. Perform sheeting, shoring and bracing for trench excavation for utility facilities and other purposes in accordance with specified safety requirements.
- B. Provide sheeting, shoring and bracing for trench excavation in subgrade of subway excavation to prevent movement of main excavation support system.

### **3.07 SUPPORT OF EXCAVATION AT INTERFACES:**

- A. Design, construct, maintain and remove all or parts of support system at limits of the Contract at interface with the Authority's adjacent contracts, as may be necessitated by construction schedules and sequence of operations of respective contracts.
- B. In the event excavation is commenced at an interface prior to the commencement of excavation on adjacent contract, design, construct and maintain end support system making provisions as follows:
  - 1. Install near face of cofferdam on line separating contracts. Allow no part of support system to project into the next contract except thickness of supporting wall, e.g. soldier piles and lagging, and tiebacks if approved.
  - 2. Provide support system adequate to support backfill and restoration loads with installation of a reasonable bracing system by adjacent contractor during excavation for his contract.
  - 3. Design and construct support system so that it will be supported against vertical settlement when adjacent contractor removes lower portion of the cofferdam to effect connection of structures at juncture of two contracts.
- C. If excavation has commenced on adjacent contract at interface prior to excavation on this Contract, make provisions as follows:
  - 1. Coordinate removal of such portions of cofferdam which have been installed in adjacent contract and support and maintain remainder as necessary to effect juncture of contracts.

**3.08 FIELD QUALITY CONTROL:**

- A. Tests:
  - 1. Where system of tiebacks or rock bolts is proposed in conjunction with or in lieu of struts, bracing and shores, undertake approved number of on-site tests to demonstrate adequacy of tiebacks or rock bolts for typical subsurface conditions.
  - 2. Conduct tests and obtain approval prior to use of tieback system for excavation support.
  - 3. The Engineer may furnish and install certain instruments to monitor performance of tieback or rock-bolt system.
- B. Remove components of support system which inadvertently penetrate or encroach on permanent structure without endangering stability of support.
- C. Welding: In accordance with Section 05120.

**3.09 REMOVAL OF SUPPORTING SYSTEM:**

- A. When removing support of excavation system, wholly or in part, do not disturb or damage adjacent buildings, structures, construction or utility facilities. Fill voids immediately with lean concrete or with approved backfill compacted to density specified in Section 02320.
- B. During strut removal stages, design soldier piles or slurry walls for increased vertical spacing of supports. For the removal of the first level support immediately above the invert slab, the slab can be considered a support for the soldier piles or slurry walls if it is poured directly against the sheeting and shoring and the invert slab is in place for at least 48 hours and is adequate to safely support the support of excavation, adjacent structures and the works. Leave support immediately above top of intermediate structure element, such as walls, slabs, or other horizontal members, until they are placed and are in place for at least seven days and are adequate to carry the loads from the support of excavation and other loads imposed on them. Leave support immediately above top of roof slabs of structure in place for at least seven days after placement of roof slab concrete.

- C. Remove other supports above roof structure only after backfill has been placed and compacted to required density to within three feet of bottom of support.
- D. Except as specified below, remove supporting system to a depth of six feet below surface. Remove supporting systems of intersections of streets and at temporary access ramps to a depth of eight feet.
- E. Where top of Authority structure extends into six-foot or eight-foot limit, remove adjacent supporting systems to a depth flush with top of the Authority structure or one-foot below surface, whichever is greater. Increase removal depths where necessary to accomplish work in this Contract.
- F. Remove material of supporting system from site immediately.

**END OF SECTION**

## SECTION 02270

### MAINTENANCE, SUPPORT AND RESTORATION OF UTILITY FACILITIES

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies protecting, supporting, maintaining and reconstructing existing utility facilities affected by construction, including but not limited to the following:
1. Storm, sanitary and combined sewer facilities.
  2. Water distribution and service
  3. Gas distribution and services.
  4. Electric light and power facilities and services.
  5. Telephone, telegraph and GSA communication facilities and services.
  6. Police and fire alarm systems.
  7. Traffic signals and street lighting, temporary and permanent.
  8. Steam distribution facilities.
  9. Parking meter installations.
- B. Related Work Specified Elsewhere:
- |  |                           |
|--|---------------------------|
| 1. Selective Demolition:                           | Section 02220.            |
| 2. Grading, excavating and backfilling:            | Section 02320.            |
| 3. Dewatering:                                     | Section 02240.            |
| 4. Support of excavation:                          | Section 02260.            |
| 5. Sanitary Sewer:                                 | Section 02535.            |
| 6. Storm Sewer:                                    | Section 02635             |
| 7. Water distribution system:                      | Section 02515.            |
| 8. Ducts, manholes and handholes:                  | Section 02585.            |
| 9. Removal and restoration of existing facilities: | Section 02205.            |
| 10. Concrete reinforcement:                        | Section 03200.            |
| 11. Concrete:                                      | Sections 03100 and 03300. |
| 12. Decking:                                       | Section 01530.            |
- C. Work by Others:
1. Gas distribution and services: Gas company will do its own work.
- D. Definitions:
1. Facility: Utility structures and system components belonging to utility company including service lines which are used to provide service to utility's customers and product which these facilities convey.
  2. Utility: Company, agency, owner or operator of facility concerned.
  3. Abandoned: Use of facilities shown as existing has been discontinued by the owners and operators. Demolish or remove such facilities to extent they conflict with proposed work.
  4. To be abandoned: Particular facility will be removed from operation and/ or replaced by other facilities after written notice has been received that service is no longer required. Maintain service for as long as required, including temporary support, rerouting, substitution of temporary facility or other measures, as directed by the Engineer. Demolish or remove such facilities to extent they conflict with proposed work.
  5. Maintenance: Ensuring continuous and satisfactory service during construction.
  6. Proposed facility:
    - a. New facility constructed and, if necessary, temporarily supported in place, by the Contractor.
    - b. Temporary facility constructed, supported in place and ultimately removed and new facility constructed, by the Contractor.
    - c. New facility constructed as part of rapid transit construction.

7. Temporary facility: Facility provided by the Contractor in lieu of existing or proposed facility, to ensure continuity of service.
8. Maintain complete-in-place: Support and maintenance in serviceable condition, of existing facilities during construction, which may include constructing permanent support, temporary support or other measures necessary to maintain continuous service of existing facility.
9. Expose and maintain existing cables and replace ducts and manholes: Remove existing duct and manhole structures, construct temporary manholes, place existing cables in split conduits and replace spare ducts with whole conduit. Maintain this system during construction. Reconstruct permanent concrete manholes and encase conduits in concrete as specified. Cables for electric power and telephone facilities shall be exposed, separated and supported under supervision of electric power and telephone companies.
10. Maintain service and replace:
  - a. Construct new facility in same location and support it in place.
  - b. Provide temporary facility and ultimately remove it, and construct permanent replacement facility in its original location.
  - c. Temporarily support original facility and ultimately replace it with new facility.
11. Remove and replace: Remove existing facility without providing temporary replacement and reconstruct new facility in same location during execution of contract.
12. Local Jurisdictional Authority: Agency responsible for acceptance and approval of work on storm, sanitary and water distribution facilities.
13. Salvage: Remove and store material and equipment for reuse in this or other Authority contracts.

## **1.02 SUBMITTALS**

- A. Schedule of Work on Utility Facilities:
  1. Submit to the Utilities and the Engineer a detailed sequence of work, with starting and ending dates for each interruption of utility services, and method of coordination for shutoff, capping and continuation of utility services.
  2. Give notice at least two weeks prior to date of intended commencement of operations to parties having surface, subsurface or overhead structures in the construction area. Provide copies of notices to the Engineer.
  3. Do not commence work until written approval has been received from the Utility and the Engineer.
- B. Record Documents:
  1. Show actual location of existing facilities, interference which these facilities present to new work, proposed method of proceeding with actual construction and details of proposed support systems.
  2. Show actual location of settlement measurement points for facilities as indicated on the drawings. Submit copies of readings and measurements within 24 hours after such readings are taken.
  3. Prior to construction, submit two copies of records of inspection of sewers, one copy to local jurisdictional authority and one copy to the Engineer. On completion of tunneling and cut-and-cover and prior to paving or other construction over sewers, submit to local jurisdictional authority and the Engineer one copy each of the inspection records of sewers, including video-tape records of television inspections and coordinated logs, photographs and other records as specified by local jurisdictional authority for visual walk-through inspections. Obtain and submit a written approval and acceptance from local jurisdictional authority of the inspection records of preconstruction and post-construction conditions of affected storm and sanitary sewers.

## **1.03 QUALITY ASSURANCE:**

- A. Codes, Regulations, and Standards: Comply with codes and regulations of the jurisdictional authorities, published standards of owning utility agency, and ASTM: C136.

- B. Inspection Of Sewers:
  - 1. Employ a sewer inspection company which has been regularly engaged in television sewer inspections and which is acceptable to local jurisdictional authority to perform preconstruction and post-construction inspections of sewers 36 inches and smaller in diameter. Submit to Local jurisdictional authority for prior approval one sample of the cassettes to be used.
  - 2. Conduct preconstruction and post-construction inspections under conditions as nearly identical as practical and using the same company.

#### **1.04 DELIVERY, STORAGE, AND HANDLING**

- A. Coordinate with utilities who are furnishing materials for the work to determine availability, locations and required methods of storage and care of materials prior to incorporation into the work.
- B. Transport store and handle materials in accordance with the requirements of the utilities.

#### **1.05 PROJECT CONDITIONS:**

- A. Existing Facilities:
  - 1. Locations of existing facilities shown are plotted from available records; however, these locations are not guaranteed.
  - 2. Verify by field investigation and "Miss Utility" utility locating service, locations of facilities within and adjacent to limits of project which may be affected by construction operations. Avoid damage or disruption of facilities during operation.
  - 3. Upon encountering existing facility which is not shown or upon ascertaining that facility differs from that shown, determine ownership, use and disposition of such facility and proceed as follows:
    - a. If facility is abandoned or is to be abandoned, perform necessary work for either condition as specified.
    - b. If facility is to remain in service, perform support and restoration work in accordance with these Specifications and the CHANGES article of the General Provisions.
- B. Temporary Service:
  - 1. Do not interrupt facility service to building connections unless permitted in writing by Engineer, and then only after arranging to provide temporary service as required..
  - 2. Notify the Engineer and the Utility of damage to facilities caused by construction operations. Repair such damage, except that damaged cables will be repaired or replaced only by the Utility.
  - 3. Provide access for inspection of facilities and for emergencies involving utility services as specified in Section 01530.
  - 4. Permit free and clear access to utility personnel for purposes of inspection, maintenance, providing additional service and construction of new facilities.
  - 5. When approved working or shop drawings show temporary facility provided for the Contractor's benefit, supply necessary materials and perform necessary work.
  - 6. Pay utility directly if, as an aid to the Contractor's construction, the utility performs work not shown.
  - 7. Items supplied by the utility companies are as listed and as shown.

#### **1.06 Coordination:**

- A. Establish through the Engineer direct and continuous contact with respective utilities and cooperate with them in all phases of the work.
- B. Contact utility early enough to allow them sufficient time to accomplish the work. Give special consideration to lead times required for cable work. Provide schedule of utility relocation to the utility to permit coordination with Authority's construction sequence.

- C. To locate buried telephone cables, call the local telephone company's Buried Cable Location Service at least 48 hours prior to starting excavation.
- D. Comply with printed standards and practices of utilities available from the Engineer.
- E. Aerial facilities shown to be relocated by others will be relocated by facility owner. The Contractor is responsible for coordinating relocation work with utility owner as far as possible in advance of required time of relocation. A minimum three-month lead time is required by utility owner when facility serves only one utility. When facility to be relocated is shared by more than one utility agency or when a street light is included in the relocation, a minimum four-month lead time is required

**PART - PRODUCTS**

**2.01 MATERIALS:**

- A. Refer to individual Division 2 Storm, Combined And Sanitary Sewer, Water Distribution and Services, Ducts and Manholes Sections for pipe, tubing, fittings and appurtenances, and for joining and installation methods.
- B. Refer to individual Division 3 Concrete and Reinforcement Sections for materials and installation methods.
- C. Sand Backfill Around High Voltage Conduits And Pipes:
  - 1. Thermal Resistivity Value (RHO) of not more than 70 and the following sieve analysis when tested in accordance with ASTM C136:

Sieve Size	Percent Passing
4	94 - 100
8	80 - 90
16	60 - 80
30	35 - 60
50	31 - 35
100	3 - 13
200	1 - 5

- 2. The power company, through the Engineer, will inform the Contractor of approved sources for this material.

**PART 3 - EXECUTION**

**3.01 Salvage:**

- A. Salvage and clean material shown to be salvaged.
- B. Maintain adequate records and storage facilities for salvaged items as specified in the General Requirements. Make available for inspection a detailed record including signed vouchers and receipts.
- C. Reuse salvaged items after inspection and approval for reuse has been given by the Utility
- D. Return salvaged materials which are not reused to the Utility.

### **3.02 SETTLEMENT OR MOVEMENT:**

- A. Where settlement or movement monitoring system is shown, comply with the following:
  - 1. Provide series of settlement measurement points along each facility and make regular readings to detect movements.
  - 2. Use approved painted marks, metal marker plugs or pins as settlement measurement points.
  - 3. Prior to subsurface work, make initial survey to establish elevations of installed settlement measurement points utilizing permanent, established bench marks outside 100-foot line.
  - 4. Take readings weekly on settlement points until completion of this Contract. Take readings daily during work which may affect facilities.
  - 5. Make readings to an accuracy of 0.01 foot.
  - 6. Take immediate remedial measures to correct conditions causing settlement or other movement and to repair damages thus caused.

### **3.03 EXCAVATION AND BACKFILLING OF UTILITY TRENCHES:**

- A. Excavate and backfill utility facility trenches in accordance with Sections 02320, 02240 and 02260.
- B. Proceed with caution in areas of utility facilities; expose them by hand excavation or other methods acceptable to facility owner.

### **3.04 SURFACE RESTORATION:**

- A. Remove pavements, sidewalks, lawns, landscaping, curbs and gutters where necessitated by utility trenches in accordance with Section 02220.
- B. Replace pavements, sidewalks, curbs and gutters in accordance with Section 02205.
- C. Place temporary pavements where necessitated by sequence of operations.
- D. Replace lawns and landscaping in accordance with Sections 02920 and 02930.
- E. Provide erosion control measures to prevent erosion or displacement of soils and discharge of sediment bearing water or airborne dust from the site.

### **3.05 UNSAFE AND UNSUITABLE UTILITY STRUCTURES:**

- A. General Requirements:
  - 1. If upon exposure, condition or location of facility to be supported in place is found to be unsafe for maintenance or support, replace or reconstruct facility as required after receiving prior approval of the Engineer and Utility Owner.
  - 2. Maintain continuity of existing utility facilities. Protect, support, relocate and reconstruct such facilities, regardless of jurisdictional control.
- B. Electric, Communication and Similar Type Facilities:
  - 1. If structures containing electrical, communication and similar types of cables shown to be maintained complete in place are found upon exposure to be incapable of being maintained in place because of condition, location or both, replace such structures with timber enclosures or split ducts after prior approval of the Engineer and the utility owner.
  - 2. When service box, manhole or conduit structure containing electrical or communication cables is broken away, replace it immediately with temporary structure having facilities for racking and supporting cables equivalent to existing facilities.

3. Exercise care when working in vicinity of telephone structures containing coaxial cable which cannot withstand movement.
  4. Give timber enclosures one interior and one exterior coat of fire-retardant paint of type specified by owners and operators.
  5. Replace temporary timber enclosures with permanent structures in accordance with details shown and restore facilities to the satisfaction of the Engineer and utilities prior to completion of work. Remove materials of temporary nature after completion of permanent installation.
- C. Procedures for payment of costs of work on unsafe and unsuitable utility structures are governed by the CHANGES article of the General Provisions.

**END OF SECTION**

## SECTION 02291

### GEOTECHNICAL INSTRUMENTATION

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies the design, installation, maintenance, and removal of geotechnical instrumentation to monitor soil, rock, and structure movements during construction. This section also includes specifications for reading, analyzing, and reporting instrumentation monitoring results.
- B. Design Criteria:
  - 1. Provide a system of geotechnical instrumentation which will allow monitoring of soil, rock, and excavation support elements, as well as adjacent structures and utilities to ensure safety and stability, confirm design assumptions, and provide a basis for establishing compliance with Contract requirements.
- C. Definitions:
  - 1. Geotechnical Instrumentation - Any device designed to determine change in the position or state of stress of soil, rock, and structures.
  - 2. Instrument Monitoring - The procurement of data obtained from the repeated optical, mechanical, or electronic observations of geotechnical instruments.
  - 3. Frequency of Monitoring - The number of readings obtained from a geotechnical instrument with respect to time.
  - 4. Initial reading- The first stable reading set obtained after instrument installation, but prior to excavation, to which all subsequent readings will be compared.
  - 5. Threshold Limit Values Level 1 and Level 2 - Designer-specified limits for geotechnical instrumentation which if exceeded require (1) notification of the Authority and increased monitoring frequency and (2) implementation of the contingency plan.

##### 1.02 QUALITY ASSURANCE:

- A. Comply with codes and regulations of the jurisdictional authorities.
- B. Permits - Prior to instrumentation installation obtain any permits from the responsible jurisdiction and pay permit costs and any associated fees at no additional cost to the Authority.
- C. Qualifications of Personnel:
  - 1. Instrumentation Selection, Design, Layout, and Data Analysis shall be performed by a registered Professional Engineer specializing in geotechnical engineering with 5 years experience in soil stability and geotechnical design
  - 2. Instrumentation installation shall be performed under the supervision of qualified technicians with at least one year experience in the installation of instruments of the type specified.
  - 3. Instrumentation monitoring shall be performed by qualified technicians with at least one year experience in the reading of instruments of the type specified.
- D. Continuously maintain all geotechnical instrumentation in proper working condition and within manufacturer's specifications. Immediately repair or replace malfunctioning equipment. All instrumentation readout devices to be periodically tested and recalibrated within schedule as recommended by the instrument manufacturer or as approved by the Authority..

### 1.03 SUBMITTALS:

- A. Submit the following for approval prior to proceeding with work:
  - 1. Type of instrumentation system proposed, showing arrangement, location and depths of proposed system.
  - 2. Manufacturer's literature including descriptions and installation recommendations for all instruments, software, and read-out devices proposed for use.
  - 3. Instrumentation installation schedule and monitoring schedule.
  - 4. Resumes listing the qualifications of the Professional Engineer and Technicians specified in 1.02.C.
  
- B. Instrument Installation Data:
  - 1. Record of installation details including date and time of installation, general soil condition at instrument site, adjacent construction activities, and remarks of unusual conditions observed during installation.
  - 2. As-built location and elevation of installed instruments including coordinates and distance referenced to Outbound track centerline. Supply location data within 48 hours of instrument installation.
  
- C. Instrumentation Monitoring Data:
  - 1. Analyzed data to be submitted on forms approved by the Authority within 48 hours after instrument monitoring. Supply copies of field notes if requested.
  - 2. Immediately report to the Authority movements exceeding Level 1 limits.
  - 3. Shift Reports of Construction Activities:
    - a. For each shift in which work is taking place, submit a report within 24 hours containing the following:
      - 1) Detailed excavation and tunneling status at time of instrument reading.
      - 2) Excavation subgrade elevation and tunnel face station at time of instrument reading.
      - 3) Incidents of ground loss, groundwater flow, excavation support instability, or any other unusual event.
      - 4) General construction activity in the vicinity of the instruments.
      - 5) Duration and cause of delays to construction activities.
      - 6) Weather conditions.
  
- D. Contingency Plans:
  - 1. Submit contingency plans to stabilize soil, rock, and structures affected by adverse movements detected by instrumentation. Submit contingency plans at least one month prior to start of excavation or tunneling. At a minimum, include the following:
    - a. Names, telephone numbers, and locations of persons responsible for implementation of contingency plans.
    - b. Materials and equipment required to implement contingency plans.
    - c. Location onsite of all required materials and equipment to implement contingency plans.
    - d. Step-by-step procedure for performing work involved in implementation of the contingency plans.
    - e. Threshold limit Level 1 and Level 2 values for all instruments.
    - f. Clear identification of objectives of contingency plans and methods to measure plan success.

### 1.04 JOB CONDITIONS:

- A. Do not disclose to third parties or publish monitoring data without the approval of the Authority.

- B. The Authority may monitor any geotechnical instrument at any time. Provide and facilitate access to instruments for the Authority.
- C. The instrumentation monitoring data shall be continuously reviewed and interpreted by the responsible instrumentation specialist.
- D. During construction, additional instrumentation may be required beyond that proposed in the initial design. Modifications to the instrumentation plan, including proposed instrument locations, may be required due to site conditions and instrumentation results.
- E. Ensure that all instrumentation installations are continuously protected and are not damaged by construction activities, including blasting. Replace or repair as necessary any instrument damaged by construction activities or adverse soil, rock, or structure movement.

## **PART 2- PRODUCTS**

### **2.01 INSTRUMENT TYPES:**

- A. Specify instrument types and locations in accordance with design criteria indicated in Section 1.01 B.1. and as approved by the Authority.

## **PART 3 - EXECUTION**

### **3.01 INSTRUMENT INSTALLATION SCHEDULE:**

- A. Install and obtain initial readings for all surface instrumentation prior to excavation, chemical grout operations, or dewatering activities, in accordance with approved schedule. In areas to receive chemical grout, delay installation of instruments which might be damaged by chemical grout until completion of this activity.
- B. For all instrumentation located within excavated areas, install and obtain initial reading as soon as practical after excavation or passage of tunnel heading in accordance with approved schedule.

### **3.02 INSTRUMENT LOCATIONS:**

- A. Install instruments as close as practical to locations submitted and approved. Actual conditions in field may require location adjustment. Obtain Authority approval for location adjustments.
- B. After instrument installation, submit reports showing location and installation details of each instrument as specified in Section 1.03.B.
- C. Ensure that all proposed instrument locations will not result in damage to utilities or other structures. Coordinate proposed instrument locations with Miss Utility and any other affected owners prior to instrument installation.

### **3.03 INSTRUMENTATION MONITORING:**

- A. Initial Reading:
  - 1. At time of initial reading, verify that instrument is functioning and has been installed in accordance with contract specifications and manufacturer's recommendations.
  - 2. Replace at no additional cost to the Authority any instrument which does not meet specification requirements.

3. Obtain at least three separate and complete sets of initial readings on each instrument which yield consistent results.
  4. Should inconsistent initial readings be obtained on any instrument, reread until correct and repeatable readings are obtained.
- B. Monitoring Frequency:
1. Monitoring frequency to be in accordance with schedule submitted and approved as specified in Section 1.3 A.3.
  2. Instrument readings which show significant change from previous readings shall be reread immediately.
- C. Instrumentation Monitoring Threshold Values:
1. Instrumentation system design shall establish threshold limit values for each instrument.
    - a. Level 1 Limit values if exceeded require notification of the Authority within 24 hours and notification of individuals listed within the contingency plan. Monitoring frequency of affected instruments which exceed Level 1 limit will be increased to frequency as approved within the contingency plan.
    - b. Level 2 limit values if exceeded require immediate notification of the Authority and implementation of the contingency plan. Instruments which exceed Level II limits will be monitored continuously until stability is achieved.

#### **3.04 INSTRUMENT PROTECTION, MAINTENANCE, AND REPLACEMENT:**

- A. Protect and maintain instruments. Divert surface water from instrument covers. Flush debris from instrument installations. Maintain access to all instruments.
- B. Provide barriers as required to protect instrument.
- C. Install and maintain instruments and instrument access covers in a manner which protects workers and ensures public safety.
- D. Repair or replace damaged instruments within 5 days at no additional cost to the Authority.

#### **3.05 REMOVAL OF INSTRUMENTS:**

- A. Prior to final acceptance of work and subject to Authority approval, remove and dispose of all instrumentation.
  1. Remove surface instrument installations to 2 feet below ground surface. Backfill voids and casing with cement grout.
  2. Restore ground surface to original condition.
- B. Fill holes in masonry with portland cement mortar. Restore structure surfaces to original condition.

**SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY THE DESIGNER.**

#### **ENDNOTES:**

1. The Designer must specify the level 1 and 2 threshold values before finalizing the contract-specific specifications.

**END OF SECTION**

## SECTION 02320

### GRADING, EXCAVATING AND BACKFILLING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies grading, excavating and backfilling for structures and utility facilities.
- B. Related Work Specified Elsewhere:
  - 1. Removal of existing construction and facilities: Section 02220.
  - 2. Clearing and grubbing: Section 02230.
  - 3. Dewatering: Section 02240.
  - 4. Support of excavation: Section 02260.
  - 5. Underpinning, support and restoration of structures: Section 02255.
  - 6. Maintenance, support and restoration of utility facilities: Section 02270.
  - 7. Rock tunneling: Section 02410.
  - 8. Earth tunneling: Section 02415.
  - 9. Rock reinforcement: Section 02420.
- C. Definitions:
  - 1. Grading: Shaping earth and rock through the removal or filling of earth and rock materials.
  - 2. Earth Excavation: Excavation of materials of whatever nature, except rock as defined below.
  - 3. Rock Excavation: Excavation of material in place which cannot be loosened or broken down by ripping using earth excavating equipment and which requires blasting or rock excavating equipment for its removal.
  - 4. Approved Material: Earth which meets specified measurable requirements for use as embankment, fill or backfill.
  - 5. Surplus Excavated Material: Approved excavated material which is not used in embankments or as fill on site.
  - 6. Unsuitable Material: Material which does not meet specified requirements for use in situ or as embankment, fill or backfill and is prohibited for use in the work.
  - 7. Authorized Excavation: Excavating to neat lines and limits shown and specified; excavating unsuitable material.
  - 8. Unauthorized Excavation: Excavating materials which would otherwise be left in place; excavation which is not specified as authorized excavation, such as excavation beyond neat lines and bottoms of footings as shown.
  - 9. Excess Excavation: Excavating materials beyond or below cross section shown, as well as unavoidable over breakage in rock.
  - 10. Controlled Low Strength Materials (CLSM): Fill.
- B. Salvage:
  - 1. Materials shown to be salvaged in accordance with Section 02205 and the General Requirements.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and the additional requirements as specified for each:
  - 1. Samples:
    - a. Submit sample 21 days in advance of desired date of approval. Two one-cubic-foot samples are required of each material proposed for fill, backfill and embankments.

- b. Obtain, identify and ship soil and aggregate samples in accordance with ASTM D75.
  - 2. Documentation:
    - a. Permits for disposal of excavated material:
      - 1) Obtain written permits and releases from owners of property where material will be deposited.
      - 2) Each permit and release from each property owner will absolve the Authority from responsibility in connection with such disposal of the material.
    - b. Blasting plan:
      - 1) Submit a blasting plan in accordance with Section 02410.
    - c. Plan for tunneling or jacking of utility facilities:
      - 1) Prior to tunneling, submit a tunneling plan.
        - (a) Include in the plan the location of the facility, the method of construction, the types of equipment and the procedures proposed.
        - (b) Procedure for field determination of soil bearing capacity, including description of the equipment to be used, and any calibration curves for the various soil types to be encountered, details of field test procedures, forms for reporting of test data/results and details of minimum number of tests required for each footing/base area
  - 3. Certification:
    - a. With samples of materials proposed for fill, backfill and embankment, submit certified test reports of tests performed by an approved Independent Testing Agency for all tests required to demonstrate compliance with specified requirements.

### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. AASHTO: M147.
  - 3. ASTM: C33, D75 , D698, D2487, D2922, D3017, D4318.

### 1.04 JOB CONDITIONS:

- B. Existing Drainage:
  - 1. Preserve, protect and maintain existing operable drains and sewers during grading operations.
  - 2. Keep excavations dry.
- C. Blasting:
  - 1. Control blasting in accordance with Section 02410.
  - 2. Exercise care in drilling and blasting operations so that the remaining rock remains stable and overbreak is minimized. Use controlled blasting in areas where concrete for walls and arches of structures is to be placed against rock.
- D. Accident Prevention and Safety:
  - 1. Perform work in accordance with specified safety requirements and PROTECTIVE DEVICES article of the General Requirements.
- E. Location of Underground Facilities and Structures:
  - 1. Locations shown for utility facilities are approximate.
  - 2. Utility facility locations and site investigations are listed in the General Requirements.
  - 3. Contact Miss Utility to have utilities located before beginning excavation.

- F. Toxic and Combustible Substances:
1. During excavation, provide detection and testing equipment and carry out necessary tests to detect the presence of toxic and combustible substances.
  2. Take action to safeguard persons and property in accordance with the rules and regulations of the jurisdictional agencies and utility owners.
  3. Promptly notify utility owners when problems concerning their facilities become apparent.
- G. Ramps:
1. Construct temporary ramps as necessary to provide access to work area.
  2. Locate such access ramps in Contractor's storage, operations and access areas or within excavation for subway structure and maintain traffic as specified.
  3. Support ramp excavation in accordance with Section 02260.
  4. When ramps are in use, station flag persons equipped with red flags at ramp entrances to keep unauthorized vehicles or persons from entering work area.
  5. When work necessitating entrance or exit of vehicles via ramps is not being performed, protect entrances and exits of ramps by warning signs, barricades and fences in accordance with the General Requirements.
  6. Upon completion of the work needing ramps, remove the ramps in accordance with Section 02260; backfill excavated ramp areas, if necessary.
- H. Excavation Near Buildings:
1. Control excavation in areas near buildings or structures to maintain stability of buildings or structures. If underpinning is necessary, perform excavation work in accordance with Section 02255, so that condition of surrounding area remains unimpaired.

## **PART 2 - PRODUCTS:**

### **2.01 MATERIALS:**

- A. Embankment, Fill or Backfill Materials:
1. Composition:
    - a. Well-graded soil-aggregate mixture, as defined by ASTM D2487, comprised of stone, gravel, sand, silt, clay or combinations of such materials.
    - b. Prohibited material: Organic matter, debris, cinders and frozen material.
  2. Additional requirements:
    - a. Particle size: Four inches maximum, but not exceeding one inch within one foot of finished grade.
    - b. Liquid limit: Forty maximum, determined in accordance with ASTM D4318.
    - c. Plasticity index: Ten maximum, determined in accordance with ASTM D4318.
    - d. Maximum dry density: Not less than 100 pounds per cubic foot.
- B. Select Material: AASHTO M147, with the following gradation requirements:

THIS SPACE NOT USED.

Sieve Designation	Percentage Passing By Weight
Two inch	100
One inch	70 - 95
3/8 inch	35 - 75
Size 4	25 - 60
Size 10	15 - 45
Size 40	10 - 30
Size 200	0 - 15

- C. Pervious Material:
1. Natural, clean, free draining sand conforming to the requirements of ASTM C33 except the following:
    - a. Material passing Size 100 sieve not to exceed eight percent.
    - b. Material passing Size 200 sieve not to exceed five percent.
  2. Drainage Material: Clean, crushed, rock, gravel, with 1-1/2 inch maximum particle size and maximum two percent by weight passing Size 4 sieve.
  3. Below concrete walks and slabs: ASTM C33, Size No. 67, except maximum two percent by weight passing Size 4 sieve.
- D. Impervious Material:
1. Silt-clay material minimum 35 percent by weight passing Size 200 sieve.
  2. Plasticity index: 11 minimum, determined in accordance with ASTM D4318

## 2.02 SOURCE OF MATERIALS:

- A. Use materials for embankment, fill or backfill from this Contract if they meet specified requirements. If sufficient material meeting these requirements is not available from this Contract, obtain material meeting specified requirements.
- B. Use only material whose quality, source and zone of placement in the fill have been approved.
- C. Dress and shape borrow areas provided by the Authority to ensure positive drainage when borrow operations are completed.

## PART 3 - EXECUTION

### 3.01 EQUIPMENT:

- A. Use appropriate equipment in sufficient quantity and sizes to perform the work as specified and shown.

### 3.02 EARTH EXCAVATION:

- A. Excavate in sequences and stages as specified, and in a manner which will not impair permanent or temporary structures, installations or surfaces.
- B. Excavate to neat lines or set back lines for mixed face conditions and grades shown. If approved, slopes may be flattened as a matter of expediency.

- C. Support sides of excavation as specified in Section 02260.
- D. Protect, support and maintain utility facilities as specified in Section 02270.
- E. Proceed with caution in areas of utility facilities; expose them by hand excavation or other methods acceptable to the facility owner.
- F. Control runoff so that water does not run through excavation area. Keep excavation free of water.
- G. Remove excavated materials to fill, embankment, stockpile or disposal locations. Keep haul routes clean in accordance with the General Requirements.
- H. Fill excess excavations with approved materials and compact as specified.
- I. Unauthorized excavation for the purpose of obtaining materials for resale or for use at another job site is prohibited unless otherwise approved by the Engineer.

### **3.03 ROCK EXCAVATION:**

- A. Perform rock excavation to neat lines shown and so as to produce surfaces free of loose rock.
- B. Install rock reinforcement in accordance with Section 02420.
- C. Remove loose, semi-detached and unsound fragments from blasted surfaces. Remove standing water, debris, oil and other objectionable coatings from surfaces of rock upon or against which concrete or porous fill material is to be placed.
- D. Repair shattered or loosened rock surfaces outside neat lines shown, which in the opinion of the Engineer would be detrimental to subway structure or would adversely affect subway drainage system.
- E. Where directed, grout rock surfaces which have not been shattered but are naturally permeable.
- F. Remove excavated rock to approved fill locations or disposal locations.
- G. Fill excess excavation with concrete or other approved material.
- H. If flowing or seeping water is encountered during excavation, install approved drainage system in accordance with Section 02240.

### **3.04 REMOVAL OF SUBSURFACE OBSTRUCTIONS:**

- A. Permanent Closure walls:
- B. Prior to removal of parts of vaults or areaways which extend into Contract limits, build permanent closure walls where shown in such vaults or areaways to separate areas to be left intact from areas to be removed.
  - 1. Obtain the Engineer's approval of permanent closure wall design prior to its installation.
- C. Remove vaults, areaways and foundation walls as shown.

### **3.05 EMBANKMENT, FILL AND BACKFILL:**

- A. Place embankment, fill and backfill in eight-inch loose layers, unless otherwise shown, for entire width so that each layer can be uniformly and properly compacted.
- B. Avoid accumulation of large pieces of material at one location. Fill voids and interstices with finer materials.
- C. In confined areas, use approved power-actuated compactors to achieve required density.
- D. Prior to compaction, adjust moisture content of material within required limits by drying or watering either at material source or on fill.
- E. Leave struts, braces, lagging and timber sheathing in place as long as needed to support excavation and adjacent facilities and structures.
- F. Where utility facilities and structures are supported in place, use special equipment and techniques as required to achieve specified compaction under and around them.
- G. Do not place backfill on subway structures until requirements for curing and waterproofing have been complied with and, if required, until test cylinders for particular structure indicate that concrete has attained specified compressive strength.
- H. When backfilling against structures, place material approximately simultaneously on both sides of structures to equalize opposing horizontal pressures.
- I. When backfilling on tops of structures, place material in six-inch lifts over full area.
- J. Under concrete floor and other slabs on grade, place drainage material directly on prepared subgrade which meets density and elevation requirements. Compact with hand-operated plate-type vibratory compactor.
- K. Prior to placing embankment against slope greater than one vertical to four horizontal, cut benches into existing slope. Height of bench not to exceed two feet unless otherwise approved.
- L. Maintain embankment, fill and backfill in stable, well-drained condition.
- M. Where approved, dispose of surplus excavated material by widening embankments and flattening slopes.
- N. Where pervious material will be exposed to erosion, cover it with 12-inch layer of approved impervious material compacted in place.

**3.06 COMPACTION ADJACENT TO STRUCTURES:**

- A. Compact embankment, fill or backfill materials within five feet of retaining walls, abutments or other structures using lightweight compactors.
- B. Do not overstress structures.
- C. Backfilling against new structures without approval is prohibited.

**3.07 EXCAVATION OF UNSUITABLE MATERIALS:**

- A. Remove unsuitable materials from the site.
- B. Replace unsuitable material with approved material and compact as specified.

### **3.08 PREPARATION OF GROUND AS SUBGRADE:**

- A. Where the subgrade is on original ground or in cut or where embankment or fill is less than one foot, fulfill compaction requirement for 12 inches minimum below final subgrade.
- B. If necessary, scarify original ground and adjust moisture content prior to compacting.

### **3.09 FIELD QUALITY CONTROL:**

- A. Allowable Tolerances:
  - 1. Construct finished subgrade to vary not more than 0.05-foot above or 0.10-foot below elevation shown.
  - 2. Complete embankment slopes to plus-or-minus 0.5 foot of slope line shown.
  - 3. Maintain moisture content of embankment, fill or backfill material within plus-or-minus three percent of optimum moisture content of material.
  - 4. Compact each layer of embankment, fill or backfill to 95 percent of maximum dry density as determined in accordance with ASTM D698, at moisture content within tolerance specified, except the following:
    - a. From upper surface of fill or backfill to a plane 12 inches below subbase level of vehicular pavement, sidewalks, trackbeds and structural foundations to 100 percent of maximum dry density at moisture content within tolerance specified.
    - b. In areas of 95-percent compaction where utility facilities are located in fill and are not supported on concrete cradles, compact material for a depth of one foot directly below bottom of facility to 100 percent of maximum dry density at moisture content within tolerance specified.
- B. Test Method:
  - 1. Determine the maximum dry density and the optimum moisture content in accordance with ASTM D698.
  - 2. Determine in-place density and moisture content in accordance with ASTM D2922 and ASTM D3017 respectively, or other test methods acceptable to the Engineer.

### **3.10 TUNNELING FOR OR JACKING OF UTILITY FACILITIES:**

- A. Location of facility, method of construction, type of equipment and procedures: As approved.

### **3.11 FINISHING:**

- A. On completion of work, clean ditches and channels.
- B. Slope and shape borrow areas to provide positive drainage.
- C. Remove unsuitable and surplus excavated materials to locations outside the Authority's right-of-way.
- D. Leave site in neat, presentable condition.

**END OF SECTION**

## SECTION 02410

### ROCK TUNNELING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies the following:
1. Rock tunneling for running sections, stations, pilot drifts through stations, side drifts, crossover and transition sections, vaults, adits, auxiliary tunnels, escalator ways and cross-passages.
  2. Tunnel linings.
- B. Related Work Specified Elsewhere:
1. Grading, excavating and backfilling: Section 02320.
  2. Dewatering: Section 02240.
  3. Subway drainage system: Section 02625.
  4. Earth tunneling: Section 02415.
  5. Rock reinforcement: Section 02420.
  6. Drilling and pressure grouting for rock tunnels: Section 02431.
  7. NATM excavation (rock): Section 02411.
  8. Concrete work: Sections 03100, 03200 and 03300.
  9. Shotcrete: Section 03370.
  10. Structural steel: Section 05120.
  11. Epoxy injection: Section 07125.
  12. Bentonite slurry: Section 07170.
  13. Piping systems: Section 15205. \*1
- C. Definitions:
1. Rock tunneling: Excavation of natural rock, which requires use of rock excavation methods, such as drilling and blasting, channeling, wedging or barring, or rock tunneling machines.
  2. Controlled blasting: Excavation of rock in which the various elements of the blast, i.e., hole size, depth, spacing, burden, charge size, distribution, delay sequence, are carefully balanced and controlled to provide a distribution of charge which will excavate rock to required contours with smooth surface to minimize overbreak, stressing and fracturing of the rock beyond the contour line. Smooth-wall blasting, presplitting, cushion blasting and line drilling are examples of operations included in the term controlled blasting.
  3. Initial support:
    - a. Elements designed, furnished and installed by the Contractor for stability and safety during construction and not shown.
    - b. To the extent elements of permanent lining shown are effective in providing initial support, such elements may be utilized to provide initial support. If permanent lining must be augmented by initial support to ensure stability and safety during construction, provide elements of such initial support.
    - c. Elements of initial support may be in the form of additional rock bolts, shotcrete, plain concrete, reinforced concrete, timber or steel members which may be temporary or permanent if compatible with permanent lining shown. Plain or reinforced concrete may consist of elements such as wall girders, carrier beams or supplementary foot blocks for temporary posting. Timber may consist of elements such as posts, struts and cross beams. Steel members may consist of such elements as steel sets, straps, spiling,

crown bars, carrier beams, girders, brackets, posts, struts, shores or needle beams. Design and provide these or other alternative elements, singly or in combination, to ensure stability and safety during construction. Install initial support to transfer loads to rock so as to ensure stability and safety during construction.

4. Permanent lining: Tunnel lining elements and support as shown.

## 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  1. Comply with codes and regulations of the jurisdictional authorities.
  2. Appendix G of the General Requirements: Geotechnical Design Report.
  3. MS: MIL-P-26915 (USAF).
  4. ASTM: C171, D638, D1304. \*<sup>2</sup>
  5. ASTM: C171, D638, D1304, D1785, D2464, D2564. \*<sup>3</sup>
- B. Blasting Consultant:
  1. Engage the services of approved, qualified independent, professional blasting consultant to design, review, evaluate and modify blasting operations.
- C. Allowable Tolerances:
  1. Steel rib bending tolerance:
    - a. Conformance to true template:
      - 1) Wide-flange sections up to 14 inches deep weighing 150 pounds per foot: Rib segments to conform to true template at butt plates; intermediate points may depart from true template up to 3/8 inch, providing no point departs more than 1/8 inch from three-foot template section.
      - 2) Wide flange sections heavier than 150 pounds per foot: Intermediate departure not exceeding 5/8 inch from true template; deviation from three-foot template section not exceeding 3/16 inch.
    - b. Bending curvature uniform.
    - c. After bending:
      - 1) Outer flange will be permitted to droop 1/8-inch maximum toward inner flange for radii of bend equal to or greater than 14 times rib depth; 1/4-inch maximum droop will be permitted for radii of bend which are less than 14 times rib depth.
      - 2) Rib depth at not less than theoretical depth minus 1/4 inch.
  2. Steel rib fabrication tolerances:
    - a. Chord, out-to-out of butt, foot plates or both measured on centerline of rib: Theoretical length plus-or-minus 1/16 inch.
    - b. Face of butt or foot plates: Within plus-or-minus 1/16 inch of theoretical plane.
    - c. Gap between ends of ribs and butt or foot plates prior to welding not exceeding 1/16 inch for at least 75 percent of cross sectional area of rib. Where gaps are in excess of 1/16 inch, fill by additional steel-shim welding.
    - d. Tie rod holes in rib webs: Within plus-or-minus 3/8 inch of locations shown on approved shop drawings.
    - e. Width or length of sheared plates: Within theoretical dimension plus-or-minus 1/8 inch.
    - f. Center-to-center of bolt hole dimensions on butt or splice plates: Theoretical dimension plus-or-minus 3/64 inch.

- g. Bolt hole groups in butt or splice plates after fabrication: Within plus-or-minus 1/16 inch of theoretical location regardless of variations in rib resulting from other tolerances.
- h. Holes in butt plates welded to ribs: Within plus-or-minus 1/16 inch of theoretical location.
- 3. Precast-concrete segment tolerances: As shown.
- 4. Watertightness criteria: Section 03300.

### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Working Drawings:
    - a. Prior to using tunneling machines, submit drawings showing design, specification, method of operation and other pertinent data.
      - 1) Drawings and pertinent data for shielded tunnel-boring machine (TBM). Show dust-suppression system. If precast-concrete tunnel-lining segments are used, show the following:
        - (a) That machine can develop forward thrust independently of installed precast-concrete tunnel lining, if this lining is to be used.
        - (b) That machine is equipped to handle and erect precast-concrete segments behind cutter head within tail shield, including auxiliary equipment necessary for erection.
        - (c) Descriptions, data or calculations of proposed facilities, equipment to be utilized and method of construction. Items include, but are not limited to, the following: Hoisting plant, tunnel ventilation, lighting and drainage; groundwater-control methods; temporary shafts, cuts, ramps and tunnels; breakouts; cross passages; bulkheads; details of initial support; details of placing concrete and erection procedures for the installation of precast-concrete tunnel lining.
    - b. For excavation of tunnels and stations, submit drawings, calculations, descriptions and specifications for the following:
      - 1) Number, size, location, orientation and direction of excavation of drifts and benches including those excavated previously and temporary drifts.
      - 2) Sequence and timing of excavating drifts and benches including stagger of advance of heading in adjacent drifts or benches and anticipated rate of advance.
      - 3) Blasting program including length of round and charge distribution for each drift.
      - 4) Initial support elements, including when and where they will be installed in relation to excavation plan and sequence and design calculation and assumptions.
      - 5) Permanent lining elements relationship to initial support elements and to the plan and sequence of excavation and support.
      - 6) Construction equipment and capacities.
      - 7) Assumptions used in arriving at above items, including:
        - (a) Thickness and condition of various zones of rock, decomposed rock and overburden.
        - (b) Incidence, orientation and extent of rock discontinuities including foliation, joints, shears, fractures, faulting, folding,

- depth and degree of weathering, condition of discontinuities (open, tightly closed, gouge-filled).
    - (c) Relationship of excavation and initial support to rock discontinuities.
    - (d) Design load conditions and design mechanical properties of rock and discontinuities used for determining initial support requirements.
    - (e) Stability of sidewall and vertical rock faces with respect to excavation dimensions, sequence and rock discontinuities.
    - (f) Groundwater.
- 2. Certification:
  - a. Certified test report of properties of electrical insulative coating.
- 3. Documentation:
  - a. Blasting plan:
    - 1) Not less than 30 days prior to starting a new phase of work, submit the following data concerning proposed blasting operations:
    - 2) Location, depth, area, anticipated neat lines and relationship to adjacent excavations and structures.
    - 3) Diameter, spacing, burden, depth, pattern and inclination of blast holes.
    - 4) Type, strength, amount in terms of weight and cartridges of explosives to be used in each hole, on each delay and total for each blast.
    - 5) Distribution of charge in each hole and priming of each hole.
    - 6) Type, sequence and number of delays, delay pattern; wiring diagram for blast; size and type of hookup lines, and lead lines; type and capacity of firing source; type, size and location of safety switches, lightning gaps.
    - 7) Scaled range or distance used to calculate scaled range if blast will exceed vibration limits.
    - 8) Stemming of holes and matting or covering of blast area.
    - 9) Qualifications of person directly responsible for supervising loading of shot and for firing it.
    - 10) Complete, maintain and submit permanent blast reports including logs of each blast. Complete reports after each blast to include the following:
      - (a) Date, time and limits of blast by station.
      - (b) Amount of explosives used by weight and number of cartridges.
      - (c) Total number of delays used and number of holes used for each delay period.
      - (d) On a diagram of approved blast pattern indicate each hole not drilled, drilled but not loaded, changes in spacing or in pattern of delays or in loading of holes.
      - (e) Total number of holes, maximum charge per hole and corresponding delay number.
      - (f) Evaluation of blast indicating tight spots, areas of significant overbreak and recommended adjustments for next blast.
  - b. Permits for disposal of excavated material:
    - 1) Arrange for disposal of excavated materials at locations outside the Authority's right-of-way, and obtain written permits from owners of property where excavated material will be deposited.

- 2) Submit each permit and release from each property owner absolving the Authority from responsibility in connection with disposal of such material.
- 3) Details of temporary ventilation:
- 4) In the event it is planned to use equipment not covered by the SAFETY REQUIREMENTS article of the General Requirements, submit details of such equipment.
- 5) Approval of the use of alternative equipment will depend on submitted research information concerning performance in accordance with applicable standards in common use.
  - a. Air-quality reports:
  - b. Daily reports of tests for dust, toxic and hazardous gases and other atmospheric impurities in the working environment during construction.
  - c. Leak repair work plan:
    - 1) Include proposed application methods, equipment details and schedule, as well as complete manufacturer's literature, data, instructions and recommendations.
    - 2) Submit prior to beginning leak repair work.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS:**

- A. Formwork: Section 03100.
- B. Reinforcing Steel: Section 03200.
- C. Concrete: Section 03300, Class 3500; Class 2500 concrete backfill where specified for rock trench for track drain.
- D. Contact Grouting: Section 02431.
- E. Structural Steel, Ribs, Beams, Channels and Plates: Section 05120.
- F. Bolts: ASTM A325, unless otherwise shown or specified.
- G. Timber for Blocking, Lagging, Foot Blocks and Cribbing: Sound, well-seasoned, hardwood timber of rectangular cross section.
- H. Track Drainage: Section 02625.
- I. Porous Subgrade Material: Section 02625.
- J. Pea Gravel: Smooth, rounded pieces of gravel, clean and free from objectionable materials such as soft particles, coal and lignite particles or friable particles, graded from 1/4 to 3/8 inch in size.
- K. Sand: Section 03300, fine aggregate, except 100-percent passing U.S. Standard Sieve Size 16.
- L. Precast Concrete Tunnel Lining Segments: Section 02425.
- M. Impervious Membrane: Polyethylene, ASTM C171, clear or opaque, 0.006-inch thickness.

- N. Epoxy Injection Material: Section 07125.
- O. Bentonite Slurry for Repair of Leaks: Section 07170.
- P. Epoxy Mortar:
  - 1. Two-component, solventless epoxy-resin system, with 100-percent solids, workable in temperature range of 50F to 60F when mixed with sand in specified proportions.
  - 2. Epoxy-resin system: FX-775, Fox Industries, Incorporated; Sikadur 31, Hi-Mod Gel, Sika Chemical Corporation or approved equal.
  - 3. Sand for use with epoxy resin: Three parts No. 16 sand to one part No. 90 sand. High-silica type, dry and bagged.
  - 4. Add sand to epoxy paste as necessary to provide best workability characteristics up to one part sand per one part epoxy.
- Q. Electrical Insulative Coating: Approved moisture-insensitive coating, 100-percent solids, containing no solvents for use on dry or damp concrete or steel surfaces, with the following additional requirements:
  - 1. Properties:
    - a. Minimum tensile strength: ASTM D638, 5,000 psi in 14 days.
    - b. Dielectric strength: ASTM D1304, 440-465 volts per mil.
    - c. Dielectric constant: ASTM D1304 as follows:
      - 1) 60 Hertz: 3.4-3.5.
      - 2) 1,000 Hertz: 3.3-3.4.
    - d. Power factor: ASTM D1304 as follows:
      - 1) 60 Hertz: 0.006-0.007.
      - 2) 1,000 Hertz: 0.03-0.04.
    - e. Viscosity: 6,000 centipoises plus-or-minus 1,000 centipoises, as determined by Brookfield Viscometer using No. 6 spindle at 50 rpm.
  - 2. Primer: Zinc-rich primer, MS MIL-P-26915 (USAF) Type 1, Class B.
- R. Hydrostatic-Pressure Relief System: \*4
  - 1. Plastic pipe: PVC, Schedule 40, ASTM D1785.
  - 2. Plastic fittings: PVC, Schedule 40, ASTM D2464.
  - 3. Solvent cement: ASTM D2564.
  - 4. Galvanized steel pipe and fittings: Section 15205.

## 2.02 FABRICATION:

- A. Fabricate steel supports in accordance with Section 05120.
- B. The following operations are not required:
  - 1. Portions of bearing members such as butt and foot plates, straightened, planed and connected after fabrication.
  - 2. Grinding to remove nicks resulting from flame-cutting.
  - 3. Planing and facing of sheared edges or bearing surfaces.
  - 4. Subpunching or subdrilling of bolt holes.
  - 5. Inspection of groove and fillet welds by other than visual inspection.

## PART 3 - EXECUTION

### 3.01 TEMPORARY VENTILATION:

- A. Provide, operate and maintain for duration of project temporary ventilation system which conforms to specified safety requirements and those of jurisdictional authorities. Remove system from site when work is completed.

### **3.02 SAFETY REQUIREMENTS:**

- A. Perform work so as to minimize safety hazards and exposure of men and equipment to hazardous and potentially hazardous conditions in accordance with specified safety requirements.
- B. In case of emergency or work stoppage likely to endanger excavation or adjacent structures, continuously maintain full work force 24 hours per day including weekends and holidays until emergency or hazardous conditions no longer jeopardize stability and safety of the work.

### **3.03 DISTANCE BETWEEN HEADINGS:**

- A. Maintain longitudinal distance of no less than 150 feet between two adjacent tunnel faces being simultaneously excavated unless otherwise shown or approved in writing.
- B. Where tunnel heading is being advanced adjacent to previously excavated tunnel, ensure that initial support in first tunnel is completely installed and is adequate to withstand construction of second tunnel.

### **3.04 DETECTION OF MOVEMENT:**

- A. In accordance with the General Requirements and as shown, install, maintain and make observations of a system of detection of vertical and horizontal movement of ground, tunnel support, permanent lining and utilities adjacent to the work.
- B. Special Instruments:
  - 1. Provide instrumentation as specified and where shown.
  - 2. Provide such facilities as directed for monitoring these instruments and take appropriate action to arrest movement revealed by resulting observations.

### **3.05 FIELD QUALITY CONTROL:**

- A. Allowable Tolerances:
  - 1. Excavate to accommodate tunnel cross section and minimum thickness of lining selected to within one inch of alignment and grade shown.
  - 2. When steel ribs are used for initial support, do not permit any portion of lagging except clips or bolts used to attach lagging to ribs to extend into tunnel within concrete design line as shown nor any portion of steel rib including bracing to extend further than three inches into concrete design line.
  - 3. Place cast-in-place tunnel concrete to the following tolerances:
    - a. Tunnel lining:
      - 1) Departure of tunnel from line or grade shown as measured from working point of tunnel: One inch.
      - 2) Variation in thickness of lining at any point: Minus zero inch.
      - 3) Variation in internal diameter at any point: One inch.
    - b. Invert: As specified in Section 03300.
    - c. Safety walk: As specified in Section 03300.
  - 4. Install precast concrete segment lining to tolerances shown.

### **3.06 EXCAVATION:**

- A. Excavate to lines, grades, dimensions and tolerances as shown and specified to accommodate initial support and permanent lining.

- B. Tunneling Machine:
1. When excavating with tunneling machine, use equipment which includes dust-control system with spray system and dust shroud. Keep intake end of fan suction line as close to machine as possible without interfering with other operations.
  2. Use equipment which permits installation of initial support no further than ten feet from tail. Use hood if necessary. Install initial support in accordance with approved working drawings.
  3. In order to exercise option for using circular permanent lining comprised of precast segments, excavate tunnel and erect the segments by means of TBM. If, during machine boring, material is encountered in reaches of tunnel that cannot be excavated satisfactorily by TBM, excavate such reaches by other approved methods. Provide necessary initial support and cast-in-place concrete permanent lining as shown for such conditions.
- C. Air Quality:
1. Perform drilling and tunneling operations by methods and with equipment which will positively control dust, fumes, vapors, gases, fibers, fogs, mists or other atmospheric impurities in accordance with specified safety requirements.
  2. Provide approved instruments for testing quality of tunnel atmosphere; take samples under working conditions at prescribed intervals. Submit results of the quality tests.
- D. Drilling and Blasting:
1. Perform blasting in accordance with the General Requirements and approved blasting plan.
  2. Have the blasting consultant design initial blasts as well as supervise and conduct test blasts, if required, until regular production controlled blast patterns are developed that produce desired rate of excavation while meeting requirements for vibration and air-blast control. Have consultant periodically, or when requested by the Engineer, review blasting operations and direct such changes in blasting operations as necessary to produce a controlled blasting operation meeting specified requirements.
    - a. Before blasting within 50 feet of cured concrete, except shotcrete, submit and obtain approval of plan showing relative positions of concrete, area to be blasted and blasting technique to be employed.
    - b. Protect concrete work and structures in vicinity of blasting by limiting size of blasts, by covering blasts and by other means until it is certain that there is no danger of damage by shock waves or flying rock.
    - c. Use controlled blasting techniques. Modify blasting round as necessary to achieve best obtainable results and to keep vibrations and noise within limits specified.
    - d. As excavation proceeds and immediately after each blast, test the roofs and walls; scale loose and shattered rock which is likely to fall. Carry out similar checks on previously excavated sections at least every 48 hours; recheck support system and tighten, lagging, blocking and rock bolts as necessary.
    - e. When so directed, drill feeler or pilot holes no less than 1-1/2 inch diameter ahead of excavation to predetermine nature and condition of materials to be excavated. Number of holes, location, direction and length, minimum 15 feet and maximum 30 feet: As directed.
    - f. Install initial support in accordance with approved working drawings.
- E. Vibration and Air-Blast Control:
1. Control operations in accordance with the following:
    - a. Peak particle velocity:

- 1) Not to exceed two inches per second (ips) measured in or at any adjacent existing structure outside limits of construction site.
- 2) Peak particle velocity at structural concrete not to exceed the following limits dependent on age of freshly-placed concrete and powder charge per delay:

Concrete Age	Maximum Peak Particle Velocity (ips)
Less than three days	0.2
Between three and seven days	2.0
Over seven days	4.0

- 3) Calculate values of maximum powder charge per delay permissible at specified intervals of distance between point of detonation and critical structure and submit for approval.
  - 4) exceed 140-dB peak sound-pressure level measured at edges of shafts or portals of tunnels.
2. Peak particle velocity is defined as maximum of three velocity components of a vibration measured at any point in three mutually perpendicular directions by an appropriate instrument.
  3. Peak sound-pressure level is the peak level measured on the A-scale of a standard sound-level meter at slow response.
  4. The Engineer may make measurements to determine if the Contractor's operations are exceeding such requirements. This data will be available to the Contractor.
  5. If data indicates that specified requirements are not being met, take necessary measures including reducing size of charge, covering or matting blasts to reduce noise and vibrations to acceptable levels.
- F. Dispose of excavated materials as specified.
- G. Drain excavated areas as necessary in accordance with requirements of Section 02240.
- H. If initial support is necessary, keep its installation within three feet of excavated face; do not leave tunnel unsupported without full initial support for longer than three hours after excavation. Stabilize face if necessary.

**3.07 STRUCTURAL STEEL SUPPORT FOR PERMANENT LINING:**

- A. Install structural steel supports true to lines and grades, blocked, braced and wedged against rock surface or against initial layers of shotcrete placed on rock surface.
- B. Install supports as soon as possible after initial layers of shotcrete are placed or as soon as possible after exposing rock by excavation and as close to headings as work will permit.
- C. For support at base of steel ribs, use steel foot plates resting on smooth bearing surface formed by precast concrete or low slump, dry-packed concrete.

- D. Position joints to facilitate steel-rib installation as necessary and as approved.
- E. Wedge and brace blocking and cribbing solidly between rock surface or initial shotcrete layer and steel supports. Check blocking and cribbing and retighten after every blast or more frequently as necessary to maintain it in a secure condition.
- F. Use no greater amount of wedging, blocking, timber lagging and cribbing than necessary to support ground safely and to distribute load to structural-steel supports.
- G. Do not cover more than 25 percent of rock surface above spring line with wedging, blocking, timber lagging and cribbing nor more than 25 percent of projected rock surface of walls below spring line. 25-percent criterion applies along any 10 feet of horizontal underground excavation and between any two adjacent steel ribs placed less than 10 feet on center.
- H. Limit spacing of blocking and wedging points on outside flange of steel set to 48 inches maximum, unless otherwise shown.
- I. Steel lagging may be used in any amount in any underground excavation providing it permits ready placement of shotcrete and flow of concrete around it.
- J. Place wedging, blocking, lagging and cribbing in an open arrangement to permit ready placement of shotcrete and flow of concrete through and around them.
- K. Repair or replace structural steel supports placed improperly or damaged.

**3.08 PERMANENT LINING:**

- A. Cast-In-Place Concrete:
  - 1. Invert:
    - a. Prior to installing drainage system and constructing invert slab, clean off loose material.
    - b. Install drainage pipes and place porous subgrade material as shown and in accordance with Section 02625.
    - c. Place impervious membrane over subgrade layer and extend it continuously up sides of invert and above top of expansion-joint material, taking care to prevent puncturing and tearing it. Tape laps and repair tears or punctures in membrane with material recommended by membrane manufacturer.
  - 2. Permanent lining: In accordance with Sections 03100, 03200 and 03300 and as follows:
    - a. Prior to placement of concrete, remove timber blocks or wedges extending into concrete design line by such means as to not endanger stability of surrounding ground.
    - b. Place concrete for lining upper portion of tunnel by mechanical or pneumatic methods through pipes which discharge as nearly as practicable to highest point of structure. Do not use pneumatic equipment with high-velocity delivery, unless it has velocity-discharge control and unless its discharge line is continuously embedded at least four feet in fresh concrete
    - c. Fill spaces around posts, ribs and lagging beyond limits of concrete lining. Use concrete, grout or mortar as best suited to conditions at particular locations.
    - d. Fill enlargements of tunnel excavation beyond dimensions shown with concrete or grouted prepacking.
    - e. Force concrete into contact with lagging and ribs

- f. After concrete has attained its design strength, perform contact grouting to fill voids in accordance with Section 02431.
- g. For sections in which permanent lining includes steel ribs, comply with sequence of operations and details shown.
- h. Starter walls:
  - 1) Construction of starter walls, 18 inches minimum height, permitted as separate pour after supporting concrete has attained strength to support starter wall forms.
- i. Tolerances for cast-in-place permanent tunnel lining are based on design alignment, not on actual alignment. Locate initial support with sufficient allowance for permanent lining without violating clearance requirements.

B. Precast-Concrete Tunnel Lining:

1. Install tunnel lining so as to prevent damage to lining and coating. Use taper rings on curves.
2. When installing segments ensure that edges are clean and free from materials that could interfere with proper bearing of segments.
3. Place invert segment over properly shaped bed of pea gravel providing full and even bearing.
4. Alternate erection of side segments to prevent shifting of invert segment.
5. Erect precast-concrete segments immediately behind tunneling-machine cutter head and inside tail shield of TBM.
6. Complete ring of precast-concrete segments, without dislodging or damaging gasket. Lubricate gasket of last segment of each ring prior to its installation.
7. Backpack solidly each completed ring of precast-concrete segments with pea gravel and grout. Place pea gravel so as to ensure complete filling of space between lining and excavated surface of tunnel. Do not install more than two completed rings without filling space between lining and excavated surface of tunnel. Proceed with backfill grouting from bottom holes to top holes of completed rings. Use bulkheads as necessary to complete filling of space behind segments. Grouting pressure: 20-psi minimum, 30-psi maximum.
8. Continuously hold last six completed rings from heading by sufficient force to prevent separation of rings. Gap between adjacent rings not to exceed 1/8 inch.
9. Perform necessary remedial work. Damaged precast-concrete segments may be removed, repaired and reinstalled if approved.
10. Fill grout holes with portland-cement grout after backfill grouting is completed for each ring.

C. Hydrostatic-Pressure Relief System. \*5

1. Install hydrostatic-pressure relief system as shown.

**3.09 INSTALLATION OF ELECTRICAL INSULATIVE COATING:**

- A. Apply coating prior to placement of invert and safety-walk concrete on precast segmented lining. Do not apply in tunnels where full circumference water proofing membrane is shown or specified.
- B. Surface Preparation:
  1. Remove dirt, grease and heavy laitance by wet sandblasting, water blasting or wire brushing.
- C. Application:
  1. Apply in two coats of equal thickness totaling 20 mils minimum dry-film thickness (DFT) in accordance with recommendations of coating manufacturer.

### **3.10 TUNNEL CONNECTIONS AND TERMINATIONS AND TEMPORARY BULKHEADS:**

- A. Connect new tunnels to existing structures by removing existing bulkheads and constructing junction as shown.
- B. By means of temporary bulkheads, seal terminations of tunnels which are not connected to existing structures.
- C. Design temporary waterproof bulkheads where and when necessary, capable of resisting lateral pressures and capable of removal without damaging permanent lining. Obtain approval of design prior to construction.

### **3.11 TEMPORARY WORKSHAFTS AND OTHER OPENINGS:**

- A. Excavate and support temporary workshafts and other openings in accordance with Sections 02320 and 02260.
- B. Seal such openings when no longer necessary.
- C. Form and place Class 2500 concrete, two feet thick, in shafts over tunnels to prevent damage to tunnel shape. When concrete has attained design strength, backfill remaining void in accordance with Section 02320.

### **3.12 DEFECTIVE LINING:**

- A. Precast concrete segmented tunnel lining will be considered defective unless it is watertight, properly finished and within specified tolerances and has undamaged edges and joints.
- B. Watertightness Criteria: Section 03300.

### **3.13 CORRECTIVE WORK:**

- A. Repair of Concrete Segments: Repair segments which have minor chipping of edges and corners, using epoxy mortar having surface color and texture closely matching adjacent concrete surfaces. As directed, repair or replace with new segments those cracked segments which the Engineer determines will impair structural integrity of tunnel lining.
  - 1. Ensure that surfaces to be repaired are clean, dry, free from dirt, dust, oil, water and other contaminants.
  - 2. Mix and place epoxy mortar as recommended by manufacturer of epoxy resin. Grind rough or raised projections smooth and flush with adjacent surfaces.

### **3.14 LEAK REMEDIATION:**

- A. If water leakage into tunnel exceeds specified allowable limit, undertake remedial measures such as injection of epoxy, bentonite slurry, chemical grout, cement or a combination thereof in accordance with Sections 07125 and 07170.
- B. Prior to beginning work, submit leak-remediation plan.
- C. If possible, use existing grout holes for injecting material.
- D. Establish injection pressure by means of on-site demonstration; do not exceed structural capacity of lining.

**SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.**

- \*1. Add Article 1.1 B.13. for contracts where hydrostatic-pressure relief system work is directed to be performed.
- \*2. For contracts where hydrostatic-pressure relief systems work is not directed to be performed.
- \*3. Modification for contracts where hydrostatic-pressure relief systems work is directed to be performed.
- \*4. Add 2.1 R. including 1.-4. for contracts where hydrostatic-pressure relief system work is directed to be performed.
- \*5. Add 3.8 C. including 1. for contracts where hydrostatic-pressure relief system work is directed to be performed.

**END OF SECTION**

## SECTION 02415

### EARTH TUNNELING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies the following:
1. Earth tunneling for running sections, side drifts, adits and auxiliary tunnels.
  2. Installing tunnel linings.
  3. Concrete filled voids.
  4. The references in this section to steel ribs and lagging are restricted to the following:
    - a. Misalignment correction.
    - b. Stabilizing excessive deformations occurring in the precast segments.
- B. Related Work Specified Elsewhere:
1. Grading, excavating and backfilling: Section 02320.
  2. Dewatering: Section 02240.
  3. Support of excavation: Section 02260.
  4. Underpinning, support and restoration of structures: Section 02255.
  5. Subway drainage system: Section 02625.
  6. Rock tunneling: Section 02410.
  7. Earth (EPBM) tunneling: Section 02416.
  8. Precast-concrete tunnel-lining: Section 02425.
  9. Concrete work: Sections 03100, 03200 and 03300.
  10. Membrane waterproofing: Section 07125.
  11. Bentonite waterproofing: Section 07170.
  12. Tunnel waterproofing (two-pass system): Section 07137.
- C. Definitions:
1. Earth tunneling: Mined excavation in earth. The following, among others, are classified as excavation in earth: Mixed-face, filled ground including rock fill, boulders, concrete or stone masonry, buried trees, timbers or plankings, conduits, pipes or drains, wood, concrete or steel piles and sheeting and soft decomposed or disintegrated rock.
  2. Mixed-face tunneling: Mined excavation of earth and rock materials both in the same heading at the same time.
  3. Initial support: Elements designed, furnished and installed by the Contractor for stability and safety during construction preparatory to the construction of permanent lining.
  4. Permanent lining:
    - a. For single-pass system precast concrete tunnel lining elements as shown.
    - b. For the two-pass system there are two layers of linings, the initial and the final. The initial lining consists of precast concrete segments which are either jacked in place and retained by dutchmen and filled with concrete or grout to form the ring, or gasketed and bolted segments to form the ring. Final liner is a cast-in-place concrete liner.
      - 1) Concrete filled voids: Voids or chimneys which develop as the result of run-in of soil into the tunnel and which extend entirely or partially to the surface. These voids are then filled with lean concrete.

## 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications.
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. Geotechnical Design Summary Report (GDSR) included as Appendix G to the General Requirements.
  - 3. AASHTO: M33, SDMS.
  - 4. MS: MIL-P-26915.
  - 5. FS: TT-S-230, TT-W-261.
  - 6. ASTM: A36, A325, A709, C109, C144, C150, D638, D1056, D1304, D2240.
  - 7. FGCC: Standards and Specifications for Geodetic Control Networks.
  - 8. OSHA: Standard 1926.800(k)(2) AND (3), CFR 1910720, CFR 1926.800.
  
- B. Watertightness Criteria: Section 03300.
  - 1. Survey Control:
    - a. Provide qualified survey personnel in accordance with the General Requirements pertaining to Layout of Work.
  - 2. Establish a secondary survey control system consisting of horizontal and vertical reference points for driving the tunnels and placing concrete lining. Install horizontal control points either as a brass disc or lead and tack. Install vertical control points either as a brass disc or a 1/2-inch diameter by minimum three-inch long anchor bolt with nut and washer.
    - a. Employ survey procedures and equipment in accordance with FGCC Standards and Specifications for Geodetic Control Networks, using Second Order, Class 1 specifications for horizontal control work and Second Order, Class 1 specifications for vertical control work.
    - b. Make tunnel horizontal transverses closed loops and adjusted by the least squares method. Make tunnel vertical traverses closed loops and adjusted by distributing the error of closure equally through the turning points. Provide the Engineer with traverse adjustment results within 24 hours.
    - c. Advance and verify underground tunnel control after each 500 feet of tunnel lining placement.
    - d. Install vertical control points maximum 300 feet on center throughout tunnel.
    - e. Install inter-visible theodolite instrument platform mounting brackets in the shotcrete lining, at or below the springline, at maximum intervals of 500 feet on center throughout the tunnel, for the purpose of maintaining the secondary horizontal control system. Install additional platform mounting brackets where tunnel alignment curvature does not allow for intervisibility between instrument locations.
    - f. See Part 2 - Products for bracket and surveyor platform specifications.
    - g. Survey Data Collection:
      - 1) Provide and maintain equipment and software necessary to record secondary survey control measurement observations. Assemble measurement observations in digital data collection files and provide data to the Engineer in a format that is compatible and in accordance with the AASHTO Survey Data Management System (SDMS) technical specification for survey data.
      - 2) Survey data collection files transmitted to the Engineer are to contain a time and date stamp for each observation, original field measurements, and the correctly computed coordinates/elevations in addition to the survey data tags necessary to recompute the file if required.
      - 3) Preserve original unedited data collection files and provide one copy of each file to the Engineer.

- h. Survey Equipment Adjustment and Calibration:
- 1) Adjust instrument for collimation error every six months or whenever difference between direct and reverse readings of theodolite depart from 180 degrees by more than 15 seconds. Readjust cross hairs and level bubble whenever their misalignments affect instrument reading by amount of least count.
  - 2) The National Geodetic Survey (NGS) has established specific calibration baselines for the purpose of comparing survey equipment to known monumentation to verify correct instrument operation and verification of compliance with manufacturer's specifications. Service every six months and check frequently the electronic distance measuring instruments (EDMI's) and retroreflectors over lines of known distance at an approved NGS baseline. Recalibrate an EDM I if physical damage is incurred.
  - 3) Compute calibration results using procedures in NOS NGS-10 Use of Calibration Base Lines. Record actual measurements, apply atmospheric corrections and then adjust by least squares to compute a constant, as well as a relative correction factor (scale correction). Calibrate prisms at the same facility.
  - 4) Forward results of this calibration to the Engineer. Post correction factors in Contractor's office for computing area and apply them as required to maintain specified accuracy.
  - 5) Immediately remove and repair, or replace instruments found to be in disrepair or misalignment.
  - 6) Provide a certification of adjustment to the Engineer for instruments to be utilized before commencement of survey work.
  - 7) Provide and maintain the ability in-house to check and adjust tribrachs for eccentricity. Perform adjustment checks at least once a week. Keep a record of adjustments to tribrachs current and made available to the Engineer monthly or upon request. Number and tag each tribrach with date of last adjustment.

### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings:
    - a. Design, specifications, method of operation and other data pertaining to tunnel shields and tunnel machine.
    - b. Manufacturers' printed literature for the products, equipment and instrumentation proposed for use in the work, annotated clearly to indicate exact items to be used
  2. Working Drawings:
    - 1) Detailed description, data or calculations of proposed facilities, equipment to be utilized and method of construction, including but not limited to, the following: Method of operation and other data pertaining to tunnel shields and tunnel machine, hoisting plant, tunnel ventilation, lighting and drainage; ground water control methods; pre-support (chemical) grouting methods; temporary shafts, cuts, ramps and tunnels; breakouts; cross passages; bulkheads; initial support; method of construction including details of installation of initial support and permanent lining; method of controlling line and grade of shield and lining; details of rib and segment ring movement measurement; details of method and procedure for the expansion of initial lining including jack pressures

- and test for completion of expansion; details of method and procedure for preventing the expansion jacks and dutchmen from dropping out from construction induced loads or vibrations; details of method procedure for filling expansion gaps with concrete and grout behind the initial tunnel support system.
- b. Have drawings and computations certified by a professional engineer experienced in earth tunneling and registered in the jurisdiction in which the work is to be performed.
  - c. Details of temporary ventilation:
    - 1) In the event it is planned to use equipment not covered by Section 101, Article VII.A., Safety Requirements, submit details of such equipment.
    - 2) Approval of the use of alternative equipment will depend on submitted research information concerning performance in accordance with applicable standards in common use.
  - d. Leak-remediation plan:
    - 1) Include proposed application method, equipment details and schedule, as well as complete manufacturer's literature, data, instructions and recommendations.
    - 2) Submit prior to beginning leak-remediation work.
  - e. Tunnel shield guidance system: Equipment and software details and operation. Include specific information concerning the method of controlling line and grade of Tunnel Boring Machine.
  - f. Contingency expansion or installation plans for initial lining: Submit in anticipation of the possibility that initial lining expansion or installation procedure is not successful.
  - g. Survey Control:
    - 1) Type and location of horizontal and vertical control monuments to be set.
    - 2) Survey procedures and equipment.
    - 3) Design and location of theodolite instrument platform mounting bracket, bracing support hardware, method of attachment to initial liner, brass mounting screw and standing platform underneath instrument mounting bracket.
    - 4) Survey data collection equipment and software; and traverse reduction and adjustment software.
    - 5) Survey equipment certification of adjustment; and calibration results of electronic distance measuring instruments (EDMI's) and prisms.
    - 6) Tribrach adjustment method and equipment.
3. Certification: Certified test report from the independent testing agency verifying that properties of concrete or non-shrink cement grout are as specified.
  4. Documentation:
    - a. Permits for disposal of excavated material: Each permit and release from each property owner where excavated materials will be deposited absolving the Authority from responsibility in connection with the disposal of such materials.
    - b. Air quality reports: Reports of tests for dust, toxic and hazardous gases and other atmospheric impurities in working environment.
    - c. Qualifications of the following:
      - 1) Survey personnel.
      - 2) Specialists in responsible charge of groundwater control.

- 3) Operators in responsible charge of operating the shield or the tunnel machine.
  - 4) Specialists in responsible charge of pre-support (chemical) grouting program.
  - 5) Independent testing agency.
5. Samples:
- a. Premolded circumferential filler: Two, each two feet square.
  - b. Asphalt-saturated felt filler: Two, each two feet square.

**1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Maintain an adequate supply of straight and tapered precast concrete segments for tunnel lining on site.
- B. Avoid damage to surfaces and undue strain on segments during handling.
- C. Chemical Grout: Transport, store and handle chemical grout, catalysts, inhibitors, additives and buffers in accordance with manufacturer's instructions.

**1.05 JOB CONDITIONS:**

- A. Groundwater Control:
  - 1. Control groundwater along the tunnel alignment and within the tunnel heading to prevent the following:
    - a. Heaving of invert, boiling conditions, hazardous seepage and sudden inflow of soil at the tunnel face and at the tail of the tunnel shield.
    - b. Loss of ground and surface subsidence.
  - 2. Accomplish groundwater control by, but not limited to, the following:
    - a. Lower the water table in accordance with Section 02240.
    - b. Underpin and support structures in accordance with Section 02255.

**PART 2 - PRODUCTS**

**2.01 MATERIALS:**

- A. Precast-Concrete Tunnel Lining Segments: Section 02425.
- B. Reinforcing Steel: Section 03200.
- C. Concrete: Section 03300.
- D. Track Drainage: Section 02625.
- E. Grout: Ingredients that are compatible, noncorrosive to steel and free from calcium chloride.
  - 1. Cement: ASTM C150, Type I.
  - 2. Sand: ASTM C144.
  - 3. Water: Potable.
  - 4. Admixtures and additives: Fly ash or other pozzolanic materials; fluidifiers; accelerating, retarding, and water-reducing agents; and bentonite may be used if approved.
- F. Non-Shrink Cement Grout:
- G. Chemical Grout: Gel-type as follows:

1. Self-supporting gel grout using a soluble polyacrylamide, producing no toxic hazard and which can be mixed in such proportions that dilute aqueous solutions, when properly catalyzed, will form stiff gels and yield true solutions at concentrations sufficiently high to accomplish soil solidification.
  2. Polymer solution mixed using formulations and procedures to provide variable gel times in accordance with the manufacturer's recommendations.
  3. Source: Chem G-9 by Polymer Chemicals, Incorporated or equal.
- H. Ribs, Beams, Channels, Plates and Retainers: ASTM A36.
- I. Timber for Blocking, Lagging, Foot Blocks and Cribbing: Sound, well-seasoned hardwood timber of rectangular cross section.
- J. Pea Gravel: Smooth, rounded pieces of gravel, clean and free from objectionable material, such as soft particles, coal and lignite particles or friable particles, graded from 1/4 to 3/8 inch in size.
- K. Sand: Section 03300, fine aggregate, except with 100-percent passing U.S. Standard Size 16 sieve.
- L. Sealant and Back-Up Rod:
  1. Siloxane-polymer sealant: FS TT-S-230.
  2. Back-up rod: 5/8-inch diameter polyethylene.
- M. White Lead (for Coating Grout-Plug Threads): FS TT-W-261.
- N. Bentonite Slurry: Stable suspension of powdered bentonite in water.
- O. Epoxy Mortar: Two-component, epoxy-resin and sand system without solvents; containing 100-percent solids, workable from 50F to 60F.
  1. Sand grading: Three parts No. 16 sand to one part No. 90 sieve sand, high-silica content, dry and bagged.
  2. Mortar mix: One part epoxy to maximum of one part sand.
- P. Premolded Circumferential Filler:
  1. Closed-cell neoprene, ASTM D1056, Grade SCE-45.
  2. Water absorption: No increase in weight in excess of two percent when tested in accordance with ASTM D1056 and completely immersed in water for 70 hours at 65F to 95F.
  3. Hardness: 50 plus-or-minus five on the Shore A durometer as measured by procedures given in ASTM D2240.
  4. Size: One-inch thick, width and length as shown.
- Q. Asphalt-Saturated Felt Filler: AASHTO M33.
- R. Electrical Insulative Coating:
  1. Properties: Moisture-insensitive coating, 100-percent solids, containing no solvents, for use on dry or damp concrete or steel surfaces, with the following additional requirements:
    - a. Minimum tensile strength: ASTM D638, 5,000 psi in 14 days.
    - b. Dielectric strength: ASTM D1304, 440-465 volts per mil.
    - c. Dielectric constant: ASTM D1304 as follows:
      - 1) 60 Hertz: 3.4-3.5.
      - 2) 1,000 Hertz: 3.3-3.4.

- d. Power factor: ASTM D1304 as follows:
  - 1) 60 Hertz: 0.006-0.007.
  - 2) 1,000 Hertz: 0.03-0.04.
- e. Viscosity: 6,000 centipoises plus-or-minus 1,000 centipoises, as determined by Brookfield Viscometer using No. 6 spindle at 50 rpm.
- 2. Primer: Zinc-rich, MS MIL-P-26915 (USAF) Type 1, Class B.

## **2.02 GROUT MIX DESIGN:**

- A. Stage I Mix: To develop compressive strength of 100 to 120 psi at 24 hours.
  - 1. Mix sand and cement dry.
  - 2. Add minimum water to achieve water-cement ratio compatible with pumping and placing requirements.
  - 3. Mix in high-speed mixer for minimum of three minutes.
  - 4. Prepare batches so that standing time does not exceed 45 minutes.
  - 5. Prepare trial mixes for laboratory testing.
  - 6. Perform tests of compressive strength in accordance with ASTM C109.
- B. Stage II Mix: Neat cement and water.

## **2.03 INSTRUMENT PLATFORM MOUNTING BRACKETS:**

- A. Construction: Steel, minimum 1/8-inch thick, having a smooth finish where instrument attaches. Make bracket rigid enough to resist deflection or movement when a theodolite is mounted and operated on top of it. If deflection or movement is apparent, add bracing supports as directed by the Engineer.
- B. Bracket Supports: Attach bracket supports to the underside of platform mounting bracket to provide a clear and unobstructed working area at and above platform.
- C. Size: Sufficient length and width to allow efficient set-up and operation of various theodolite and electronic distance measuring instruments (EDMI).
  - 1. Minimum width: Nine inches.
  - 2. Minimum length: Sufficient to allow a mounted instrument a at least one foot clearance from tunnel lining.
- D. Install platform mounting brackets to a level plane within the adjustment limits of a standard tribrach.
- E. Forced Centering Hole: Provide each platform mounting bracket with a forced centering hole to accept a brass instrument mounting screw (standard 5/8-inch by 11-inch thread) for securing a standard tribrach.
  - 1. Provide a brass mounting screw that is hollowed and of sufficient diameter to allow the instrument operator to site below platform mounting bracket with a nadir optical plummet.
  - 2. Mill force centering hole and brass mounting screw to match each other within 0.001 inch tolerance.
  - 3. Provide the Engineer with three mounting screws for duration of the Contract.
- F. Surveyor Platform: Provide a platform underneath each instrument mounting bracket for the purpose of supporting a surveyor during measurement observation process from wither side of instrument.

## **PART 3 - EXECUTION**

### **3.01 TEMPORARY VENTILATION:**

- A. Provide, operate and maintain for duration of project a temporary ventilation system which conforms to specified safety requirements and those of jurisdictional authorities, and is capable of providing twice the required volume and velocity of air flow as specified in OSHA Standard 1926.800(k)(2) AND (3). Assume that other conditions likely to produce harmful vapors or gases may be present at portions of the alignment. Remove system from site when work is completed.
- B. Use equipment which is adequate to maintain sufficient supply of fresh air in underground work areas.

### **3.02 SAFETY REQUIREMENTS:**

- A. Perform work so as to maximize safety and reduce exposure of men and equipment to hazardous and potentially hazardous conditions in accordance with specified safety requirements.
- B. Emergencies:
  - 1. In case of emergency or work stoppage likely to endanger excavation or adjacent structures, continuously maintain full work force 24 hours per day including weekends and holidays until emergency or hazardous conditions no longer jeopardize stability and safety of the work.
  - 2. For emergency purposes, have always on-site and ready for use a minimum of 12 steel rib rings and lagging sufficient to support 25 feet of tunnel.
- C. Perform tunnel construction so as to minimize ground movement in front of and surrounding tunnel and prevent subsidence of surface, structures and utilities above and in vicinity of tunnel.
- D. Support ground continuously so as to prevent loss of ground and keep perimeters and maintain stability of tunnel faces, passages and bottoms of shafts.
- E. If the Environmental Property Assessment Reports required in Section 101, indicate the potential for encountering contaminated groundwater or contaminated soil along the alignment, have electrical equipment in the tunnel and shafts comply with OSHA regulations CFR 1910720 and CFR 1926.800. Provide toxic and explosive gas sensors in the shafts, running tunnels and on the shield at the tunnel face to monitor the presence of potentially toxic or combustible materials.

### **3.03 BLASTING:**

- A. Whenever material requiring blasting is encountered, perform the work in accordance with Section 02410 and Section 101.

### **3.04 DISTANCE BETWEEN HEADINGS:**

- A. Maintain longitudinal distance of no less than 150 feet between adjacent tunnel headings being simultaneously excavated.
- B. Where tunnel heading is being advanced adjacent to previously excavated tunnel, ensure that initial support in first tunnel is completely installed and that voids behind lining are filled and tendency of lining to distort is minimized before commencing work on second tunnel.

- C. Where two adjacent tunnels are to be installed at different levels, complete and support lower level tunnel first as specified for previously excavated adjacent tunnel.

**3.05 SURVEILLANCE OF HEADINGS:**

- A. If tunnel invert is below groundwater level, maintain qualified personnel on duty to monitor conditions that might threaten stability of heading whenever tunnel excavation is suspended or shut down.
- B. Use of monitoring devices, such as closed-circuit television, which permit continuous monitoring of conditions at face by qualified observers from outside tunnel is permitted subject to approval.

**3.06 AIR QUALITY:**

- A. Conduct drilling and tunneling operations by methods and with equipment which ensure control of dust, fumes, vapors, gases, fibers, fogs, mists or other atmospheric impurities in accordance with specified safety requirements.
- B. Provide instrumentation for testing quality of tunnel atmosphere and obtain samples under working conditions at prescribed intervals. Submit results of quality tests.

**3.07 DISPOSAL OF EXCAVATED MATERIAL:**

- A. Dispose of excavated materials at locations outside the Authority's right-of-way.

**3.08 DETECTION OF MOVEMENT:**

- A. Rib and Segment Ring Movement:
  - 1. Monitor dimensions and elevations of ribs and segmental rings as follows:
    - a. Measure width of each rib and segmented ring at spring line to within plus-or-minus 0.01 foot.
    - b. Measure height of each rib and segmented ring from crown to invert or foot block to within plus-or-minus 0.01 foot.
    - c. Measure crown elevation of each rib and segmented ring and elevation of each footblock to within plus-or-minus 0.01 foot.
  - 2. Take measurements of width and height of each rib and crown elevation of each rib and each segmented ring within one hour after each rib or segmented ring is expanded or emerges from tail of machine.
  - 3. Take measurement of width and crown elevation of each segmented ring within 12 hours after each segmented ring is expanded or emerges from tail of machine.
  - 4. Following such initial readings, the Engineer will select one segmented ring in each 12-foot section of tunnel for additional measurements. Take measurements of width, height and crown elevation of each segmented ring on selected sets of ribs or rings three days after selected ring erected, and at monthly intervals thereafter until they are concreted in.
  - 5. If impracticable to obtain these measurements because of design of tunneling equipment or method of construction, use alternative methods of measurement as approved.
  - 6. If measurements indicate excessive deformations are occurring, take corrective measures, such as installation of ribs, and additional measurements on selected elements and on additional elements as directed.

- B. Ground Movement: Install, maintain and make observations of instrumentation shown..

### **3.09 CONCRETE FILLED VOID:**

- A. Should run-in of the soil produce a concrete filled void as defined above, stop tunneling operations immediately and notify the Engineer. Secure the tunnel and construct a temporary bulkhead to prevent further run-ins. Provide a bulkhead which is capable of resisting lateral earth and hydrostatic pressure, waterproof and capable of removal without damage to the tunnel liner.
- B. Fill the void from the surface with lean concrete.
- C. Resume tunneling operations after a minimum of 48 hours has passed after filling the voids with lean concrete and after approval of the Engineer.

### **3.10 FIELD QUALITY CONTROL:**

- A. Allowable Tolerances:
  - 1. Cast-in-place tunnel concrete: Place cast-in-place tunnel concrete to the following tolerances:
    - a. Tunnel lining:
      - 1) Departure of tunnel from line or grade shown as measured from working point of tunnel: One inch.
      - 2) Variation in thickness of lining at any point: Minus zero inch.
      - 3) Variation in internal diameter at any point: Plus-or-minus one inch.
      - 4) For two-pass system where final cast-in-place liner is less than 12 inches but equal to or greater than nine inches, provide additional reinforcing as shown on the Contingency Reinforcement Drawing, at no additional cost to the Authority.
      - 5) No final liner wall thickness less than nine inches will be accepted. Tunnel remaining necessary to maintain the allowable final liner thickness is at no additional cost to the Authority.
    - b. Invert: Section 03300.
    - c. Safety walk: Section 03300.
  - 2. Precast concrete segmented tunnel lining: Install precast concrete segmented tunnel lining to tolerances shown.

### **3.11 EQUIPMENT:**

- A. General: Use shields and machines which can be controlled to desired line and grade and minimize over excavation and loss of ground and provide for erection of specified tunnel linings.
- B. Tunnel Shields:
  - 1. Use tunnel shields suitable for work conforming to shape of tunnel and having uniform exterior surface from leading edge of head or poling plates to rear edge of tail and free of projections. Horseshoe-shaped shield may have closed or open bottom; circular shield to have closed bottom. Permanent poling plates incorporated in the hood of the shield are prohibited.
  - 2. On shield, provide substantially proportioned hood, which projects not less than two feet, nor more than two feet six inches, beyond shield bottom and rear overhang or tail long enough to provide at least 12 inches of overlap beyond last installed element of lining when shield has been pushed forward to fullest extent possible. Ensure that

annular space between tail and lining is in accordance with current practice but in no case greater than 1-1/2 inches.

3. Provide a shield with either a suitably designed hydraulically operated breasting system with tight breast boards, with breast-jacks or breast-tables or both, and such other means necessary to accomplish the same results. Hinged or "orange peel plates" as the sole means of face support will not be approved. In addition, provide such means as necessary to continuously support the face of the tunnel without loss of ground through a continuous grouting operation where necessary.
4. Make the pattern of breast-jacks and soldier beams to fully support the upper 50 percent of the tunnel face in order to provide direct face support. Provide the forward bulkhead with reaction points for trench jacks to support the upper half moon breast boards.
5. Mechanical excavators may be used provided that they can be retracted and do not interfere with the capability of breasting. Do not allow excavation to extend beyond the leading edge of the hood.
6. Design breasting system to do the following:
  - a. Permit drilling and soil sampling from the exploratory holes for grouting from the face of the shield.
  - b. Provide space and facilities for grouting for ground stabilization.
  - c. Provide capability to install probes ahead of the excavation face.
7. Include propulsion system on shield capable of moving shield in forward direction, while maintaining construction tolerances with respect to line, grade and direction. Design propulsion system so that in event of failure of propulsion-system elements there is no over stressing and distortion of lining, and there is no movement backward.
8. Jack loads: For precast-concrete tunnel lining, use shields and machines in which each jack load is applied uniformly at centerline of longitudinal rib of segment and over area equivalent to cross section of longitudinal rib. Use a minimum of 18 jacks each of 150-ton capacity, or 24 jacks each of 125-ton capacity, located at centerline of each longitudinal rib of lining.
9. Incorporate seal in tail of each shield to prevent leakage of grout into tunnel space between shield and lining.
10. Erection system: Equip shield with erector arm or erection system capable of handling largest sizes of lining and of erecting sections of lining to tolerances shown without damage to lining.
  - a. Use erection system that allows for prompt expansion of the segment against the soil when segment emerges from tail of the shield.
  - b. Use erection system that is fully integrated with the tunnel machine and capable of erecting the pre-cast liners in a smooth operation.
  - c. Have previously installed segments in a ring supported prior to installation of ring expansion jacks.
  - d. Have the erector arm equipped with a hydraulic system which prevents sudden movement of the liner during erection and which provides a fail-safe system should hydraulic pressure be lost in order to prevent accidental segment droppage.
11. Provide an adequate expansion system to include the following:
  - a. Capability to start expansion as soon as clearances permit.
  - b. Reaction for expansion jacks independent of shield and shield movement.
  - c. Expansion system expanding outward and upward.
  - d. A minimum capacity expansion of two 100-ton hydraulic jacks.
  - e. If required because of insufficient expansion, ability to modify the system by increasing the jack capacity, adding more jacks and points of expansion, or by other means in accordance with a plan subject to the Engineer's approval.

12. Tunnel guidance: Provide a tunnel shield guidance system for automatic computation of curved axis coordinates to maintain proper tunnel line and grade within specified tolerances.
    - a. Use guidance system capable of calculating and displaying the position and attitude of the tunnel shield or boring machine (TBM) relative to the designed tunnel axis at each point, including predicted points at the face of the shield or some specified distance ahead of the shield.
    - b. Include in the tunnel shield guidance the following features:
      - 1) The parts and equipment necessary to continually and automatically measure horizontal, vertical, and axial displacement as well as horizontal, vertical, and main axis rotation.
      - 2) A control unit capable of storing the design tunnel alignment using a three-dimensional coordinate system and displaying the present position and attitude of the shield or the TBM and its predicted deviation from the design axis of the tunnel.
      - 3) Motorized electronic theodolite with electronic distance measuring instrument (EDMI) and laser. Have the laser directed through the eyepiece of the theodolite, used to automatically update laser beam directional information. Use the EDM to automatically update the shield or TBM drive distance.
      - 4) An above-ground computer which enables entry, modification and verification of the designed tunnel axis coordinates.
        - a) Have the above-ground computer display, print and digitally store the information available at the control unit and to document the position and progress of the tunnel drive without leaving the office. Make this information available to the Engineer upon request or at the end of each shift.
        - b) Have the above-ground computer electronically connected to the equipment underground via cable or modem.
    - c. Source for guidance system: Subject to the requirements, use ZED-260 or equal.
  13. Equip shield with permissible electrical systems equipped with toxic gas and combustible gas sensors. Have toxic gas and combustible gas sensors linked to the machine operation to automatically shut the machine down should measured gaseous concentrations exceed established safety threshold values.
- C. Tunnel Machines: Use tunnel machines which minimize loss of ground ahead of and around machine and provide for erection of specified tunnel linings within machine. Use machines which have same features as shields except for face-support requirement. For tunneling with Earth Pressure Balance Machines (EPBM) see Section 02416.
- D. Grouting Equipment:
1. For pumping grout, use pump capable of developing specified uniform pressure at grout hole connection and hoses with minimum inside diameter of 1-1/2 inches. Provide automatic recording of volumes and pressures during grouting operations.
  2. Provide mixing equipment with capacity to fill voids outside last ring after each advancement of tunnel shield.
  3. Provide automatic shutoff control to prevent grouting pressure from exceeding that specified
  4. Keep equipment lines clean by constant circulation of grout and by periodic flushing with water.
  5. Use equipment that allows flushing with grout-intake valve closed, water-supply valve open and grout pump running at full speed.

6. Provide two pressure gauges, one at the pump and other on manifold hookup at collar of hole being grouted. Use pressure-gauge ranges as necessary for each part of grouting program.
7. Provide suitable stop valves at collar of hole to maintain necessary pressure until grout has set.
8. Provide grouting equipment with means of accurately determining amount of grout injected.
9. Furnish accurately calibrated, high-precision pressure gauge to periodically check accuracy of pressure gauges.

### **3.12 OPERATIONS BY TUNNEL SHIELDS AND MACHINES:**

- A. On initial setup, properly support tunnel shields or tunneling machines on concrete cradle at lines and grades which permit correct installation of tunnel lining. Based on design or existing soil conditions or both, pre-support grouting or dewatering or both may be required.
- B. During forward movement of shield, provide sufficient support at excavation face to prevent movement of materials, except such materials as are physically displaced by elements of shield itself.
- C. Control face efficiently using appropriate support procedures and methods, such as breasting, poling, face jacks, slide tables, singly or in combination.
  1. No tunnel advance will be permitted until the crown has been grouted, and it has been determined by the Engineer that additional pre-support grouting is not required, to provide a stable soil mass into which to tunnel.
  2. Perform pre-support grouting from existing ground surface locations shown. Extend the grouted arch at least two tunnel diameters in front of the shield when grouting from the surface and one tunnel diameter in front of the shield when grouting from within the tunnel prior to an advance of the tunnel face. The minimum required thickness of the grouted arch is five feet.
  3. Additional pre-support (chemical) grouting will be required if, in the judgement of the Engineer, the ground conditions in advance of the excavation require it.
  4. During probing, identify substantially cohesive deposits (such as T1, P1/P3 soils – See Appendix G, Geotechnical Design Report, of the General Requirements) which are continuous and occupy essentially the upper 50 percent of the face. Additionally, the observed performance of the excavation with respect to surface settlement and lateral deformation determined from the geotechnical instrumentation monitoring program will be evaluated in conjunction with the probe data.
  5. More extensive pre-support ground control other than grouting may be required depending on the effectiveness of the dewatering system, the pre-support grouting and the data obtained from the geotechnical instrumentation program.
- D. Dispose of excavated materials as required.
- E. During shutdown periods, support face of excavation by positive means such as breasting of face. Do not rely solely on support by hydraulic pressure. Provide surveillance as specified above.

### **3.13 INSTALLATION OF TUNNEL LININGS:**

- A. Lining of One-Pass System or Bolted Initial Liner of Two-Pass System:
  1. Install tunnel lining so as not to damage lining or coating. Use taper rings on curves. Develop and submit the details of taper rings not shown.

2. When installing segments, ensure that edges are clean and free from material that could interfere with proper bearing.
  3. Install bolted connections consisting of one bolt, one nut, two grommets and two washers arranged and conforming to sizes as shown. Tighten bolts in accordance with AISC requirements for structural joints. After each advance of shield or tunneling machine, check tension of bolts on last two rings and retighten or replace if necessary those bolts which do not meet requirements.
  4. Replace grommets at bolts which show signs of leakage.
  5. Staggering Longitudinal Joints:
    - a. For metallic lining, stagger longitudinal joints in adjacent rings by one half of segment length, but in no case by less than 25 percent of segment length.
    - b. For precast concrete segmented lining, stagger joints in adjacent rings by one third of segment length. One joint between adjacent rings may be continuous.
  6. After approval of bolted connections, clean out caulking recesses.
  7. Insert metallic lead caulking in metallic lining or sealant with backup rod in precast-concrete lining so that it completely fills recess and forms tight and continuous plug providing watertight joint.
  8. Recaulk joints which are leaking.
  9. After each advance of shield or tunneling machine, fill voids between lining and excavated surfaces with grout. Where approved, pea gravel followed by neat portland-cement grout or one-to-one sand-cement grout may be used to fill voids in lieu of two-stage grouting. For special purposes, finer sand may be used. Do not exceed 30 psi at grout hole.
  10. Perform grouting in two stages as follows:
    - a. First stage: Perform immediately after each forward thrust of equipment, at nozzle pressure which will not cause movement of soil or lining nor damage to lining, but not exceeding pressure specified. Keep topmost hole in liner open as air vent. Assist Engineer in checking adequacy of first stage grouting.
    - b. Prior to performing Stage II grouting, completely drill out previously filled grout holes and prepare for regrouting. When grouting of ring is completed and grout has set, clean threads of holes and plugs, coat plug threads with white lead, and screw plugs completely and tightly into holes.
    - c. Second stage: Fill soft spots or voids which may be detected, no later than 24 hours nor more than 50 feet behind first stage grouting. Use nozzle pressures specified.
  11. Avoid spillage or leakage of grout into tunnel. Clean up spillage promptly and remove it from tunnel.
  12. Complete electrical bonding of segments as shown.
  13. Install corrosion test rods through grout holes where shown, ensuring full contact with surrounding earth. Use insulating bushing in grout holes.
  14. Support trailing edge of last installed ring by means of horizontal tie rod or vertical strut inserted before shield or tunneling machine is advanced. Keep support in place until grouting around lining has been completed and the tendency of lining to distort or surrounding ground to move has been overcome.
  15. Repair or replace as directed damaged segments in previously placed ring.
  16. Completely seal area of tunnel roof described by arch of approximately 45 degrees each side of tunnel's vertical centerline to at least one-foot beyond outside face of contact rail and on opposite side of track to one-foot beyond outside face of running rail. Perform such work in accordance with manufacturer's recommendations.
- B. Expanded (Jacked) Initial Liner of the Two-Pass System:
1. Install tunnel lining so as not to cause damage to lining or coating. Use taper rings on curves as necessary. Develop and submit the details of taper ring not shown.

2. When installing segments, ensure that edges are clean and free from material that could interfere with proper bearing.
3. Ensure that each ring is positioned properly and that each segment is supported in a secure position during erection within the shield, allowing for the shield expansion of the ring. Expand the rings with the use of jacking rings (or other approved equivalent measures). However, to provide proper bearing at the joints of the segments, use two 100-ton capacity hydraulic jacks in the circumferential "gap" in the segmented precast concrete ring and maintain pressure in these jacks. Install a plywood board on the outside of the initial liner at the "gap" to prevent ground loss during further expansion and installation of the liner ring.
4. Immediately after leaving the shield, expand initial liner segments outwards and radially using hydraulic jacks with jacking rings (or other approved equivalent measures) and hydraulic jacks in the "gap" so that the segments are in good contact with the ground. After the initial liner segments are fully expanded, install the steel dutchmen in the "gap" of the segmented ring and ensure proper bearing with the use of shims if necessary, and secure these dutchmen to prevent movement or loss of support.
5. First Stage Contact Grout (cement-sand grout):
  - a. Perform the First Stage Contact Grout on the outside of the initial tunnel liner to fill the annular space between the initial liner and the excavated surface within 16 hours after initial tunnel support ring installation, but not more than the installation of four rings, or when directed by the Engineer. Use nozzle pressure that will not cause movement of soil or lining nor damage to the lining, and not exceeding 30 psi at the grout hole.
  - b. Subject to the Engineer's approval, perform the First Stage Contact Grout on the outside of the initial tunnel liner to fill the annular space between the initial liner and the excavated surface after each advance of the tunnel machine. Use nozzle pressure that will not cause movement of soil or lining nor damage to the lining, and not exceeding 30 psi at the grout hole.
6. After the installation of the dutchmen in the "gap" and the removal of the jacks from the "gap", dry pack the "gap" with non-shrink grout after the heading has advanced no further than 150 feet past the ring, or within 48 hours from the time of the initial ring expansion.
7. After expansion and initial deformation of initial liner ring has occurred, if measurements indicate excessive deformations or indicate additional "squat" of more than one inch at the crown, install internal bracing to arrest additional deformation. Place contact grout behind the initial precast liner.
8. Seal leaking joints.
9. Avoid spillage or leakage of grout into tunnel. Clean up spillage promptly and remove from tunnel.
10. Support last installed ring by means of an erection arm, expansion system, horizontal tie rod or vertical strut inserted before shield or tunneling machine is advanced. Keep support in place until the tendency of lining to distort, or surrounding ground to move, has been overcome.
11. Repair or replace as directed damaged segments in previously installed rings

### **3.14 INSTALLATION OF ELECTRICAL INSULATIVE COATING:**

- A. Apply coating prior to placement of invert and safety-walk concrete on precast segmented lining.
- B. Surface Preparation: Remove dirt, grease and heavy laitance by wet sandblasting, water blasting or wire brushing.

- C. Application: Apply in two coats of equal thickness totaling 20 mils minimum dry-film thickness in accordance with recommendations of coating manufacturer.

### **3.15 CONCRETE CONSTRUCTION:**

- A. Prior to construction of the permanent liner, install the tunnel waterproofing with water barriers as shown. See Section 07137.
- B. Complete electrical bonding of lining and invert shown. Electrically bond the invert of the final lining at each end of each unit.
- C. Install corrosion test rods where shown, ensuring full contact with surrounding earth. Use bushing in grout holes.
- D. Perform cast-in-place concrete work in accordance with Sections 03100, 03200 and 03300.
- E. Place concrete for lining upper portion of tunnel by mechanical or pneumatic methods through pipes which discharge as nearly as practicable to highest point of structure.
- F. Prior to placement of concrete, remove timber blocks or wedges extending within concrete design line so as to avoid compromising stability of initial support and surrounding ground.
- G. Fill enlargements of tunnel excavation beyond dimensions shown with concrete or grouted prepacking as approved.
- H. Schedule erection of concrete tunnel lining so that no concrete is placed closer than 500 feet from tunnel excavation heading, unless otherwise approved.
- I. Perform contact grouting through grout nipples, in such quantity and at sufficient pressure to fill voids. Use grouting pressure shown.

### **3.16 TUNNEL CONNECTIONS AND TERMINATIONS AND TEMPORARY BULKHEADS:**

- A. Connect new tunnels to existing structures by removing existing bulkheads if necessary and sealing junction as shown.
- B. Provide temporary bulkheads to seal terminations of tunnels which are not connected to permanent structures.
- C. Design temporary bulkheads where and when necessary. Obtain approval of design prior to construction. Provide bulkhead which is capable of resisting lateral earth and hydrostatic pressures, waterproof and capable of removal without damage to permanent liner.
- D. Provide portal transitions as shown.

### **3.17 TEMPORARY WORKSHAFTS AND OTHER OPENINGS:**

- A. Excavate and support temporary workshafts and other openings in accordance with Sections 02320, 02240 and 02260.
- B. Seal such openings when no longer necessary.
- C. Form and place Class 2500 concrete, two feet thick, in shafts over tunnels to prevent damage to tunnel shape. When concrete has achieved design strength, backfill remaining void in accordance with Section 02320.

### **3.18 DEFECTIVE LINING:**

- A. Precast concrete segmented bolted tunnel lining will be considered defective unless it is watertight, properly finished, within specified tolerances and has undamaged edges and joints.
- B. Watertightness Criteria: Section 03300.
- C. Precast concrete expanded or jacked tunnel initial liner is considered defective unless it is properly finished, within specified tolerances and has undamaged edges and joints.
- D. Defective concrete criteria for cast-in-place final liner for the two-pass system: Section 03300.

### **3.19 CORRECTIVE WORK:**

- A. Repair of Precast Concrete Segments: Repair segments which have minor chipping of edges and corners, using epoxy mortar having surface color and texture closely matching adjacent concrete surfaces. As directed, repair or replace with new segments those cracked segments which impair structural integrity of tunnel lining as determined by the Engineer.
  - 1. Ensure that surfaces to be repaired are clean, dry, free from dirt, dust, oil, water and other contaminants.
  - 2. Mix and place epoxy mortar as recommended by manufacturer. Grind rough or raised projections smooth and flush with adjacent surfaces.
- B. Contingency Reinforcement: When tunneling misalignment results in a final liner thickness of less than 12 inches but greater than or equal to nine inches, install contingency reinforcement as shown. Furnish and install contingency reinforcement when required at no additional cost to the Authority.
- C. Correction of Misalignment: In the case of misalignment which will result in a final thickness of less than nine inches, enlarge the tunnel excavation by re-mining or as otherwise approved. Provide additional materials and redesign required due to misalignment at no additional cost to the Authority.

### **3.20 LEAK REMEDIATION:**

- A. If water leakage into tunnel exceeds specified allowable limit, undertake remedial measures such as injection of bentonite slurry, cement, chemical grout or combination thereof in accordance with Section 07125 and 07170.
- B. Prior to beginning work, submit leak-remediation plan.
- C. If possible, use existing grout holes for injecting material.
- D. Establish injection pressure by means of on-site demonstration. Do not exceed structural capacity of lining.

**END OF SECTION**

## SECTION 02416

### EARTH (EPBM) TUNNELING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies the following:
  - 1. Earth tunneling for running sections, side drifts, adits and auxiliary tunnels.
  - 2. Installing tunnel linings.
  
- B. Related Work Specified Elsewhere:
  - 1. Excavation and backfilling: Section 02320.
  - 2. Dewatering: Section 02240.
  - 3. Support of excavation: Section 02260.
  - 4. Maintenance, support and restoration of utility facilities: Section 02270.
  - 5. Underpinning, support and restoration structures: Section 02255.
  - 6. Subway drainage system: Section 02625.
  - 7. Pre-cast concrete tunnel lining: Section 02425.
  - 8. Concrete formwork: Section 03100.
  - 9. Concrete reinforcement: Section 03200.
  - 10. Cast-in-place structural concrete: Section 03300.
  - 11. Structural steel: Section 05120.
  - 12. Tunnel waterproofing: Section 07137.
  - 13. Geotechnical instrumentation: Section 02291.
  
- C. Definitions:
  - 1. Earth tunneling: Mined excavation in earth, including but not limited to filled ground, rock fill, boulders, concrete or stone masonry, buried trees, timbers or plankings, conduits, pipes or drains, wood, concrete or steel pipes and sheeting, soft decomposed or disintegrated rock, concretionary rock-like material in lenses or layers, cemented sands, unconsolidated lignitized wood deposits, and naturally occurring gravel, cobbles and boulders.
  - 2. Mixed-face tunneling: Mind excavation of soil strata with a face exposing more than one type of soil or material including rock and hard rock in the same heading at the same time.
  - 3. Initial lining: Precast concrete elements furnished and installed by the Contractor for stability and safety during construction preparatory to the construction of final lining.
  - 4. Final lining: Cast-in-place concrete lining and waterproofing membrane placed after installation of initial lining.
  - 5. Precast concrete lining: For single pass system precast elements, per Contract Drawings to carry both short term and long term loads and adequate provision to exclude water into tunnel by use of gaskets.
  - 6. EPBM: Earth pressure balance machine.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. Geotechnical Design Summary Report (GDSR), included as Appendix G to the General Requirements.
  - 3. ASTM: C109, C144, C150.
  - 4. FGCC: Standards and Specifications for Geodetic Control Networks.

- B. Watertightness Criteria: Section 03300.
- C. Personnel qualifications: Have the Earth Pressure Balance Machine (EPBM) operated only by personnel who have had successful experience in similar work.
- D. Survey control: Provide qualified survey personnel in accordance with General Requirements Article titled Layout of Work.

**1.03 SUBMITTALS:**

- A. Submit the following for approval in accordance with the General Requirements and with the following additional requirements as specified for each:
  - 1. Working Drawings:
    - a. General: Detailed descriptions, design, specifications, data and calculations of proposed facilities, equipment to be used and, method of construction, including, but not limited to, the following:
      - 1) Method of operation and other data pertaining to the EPBM.
      - 2) Hoisting plant tunnel ventilation, lighting and drainage, groundwater control methods, temporary shafts, cuts, ramps and tunnels, breakouts, cross passages, bulkheads; initial support, methods of construction including details of installation of initial support; final lining and waterproofing membrane, method of controlling line and grade of shield and lining and, details for segment ring movement measurement.
      - 3) Have drawings and computations certified by a professional engineer experienced in earth tunneling and registered in the jurisdiction in which the work is to be performed.
    - b. Details of temporary ventilation: Details of equipment not covered by the Safety Requirements article of the General Requirements. Approval of the use of alternative equipment depends on submitted research information concerning performance in accordance with applicable standards in common use.
    - c. Water inflow control, initial lining:
      - 1) Submit proposed method, equipment details and schedule, as well as complete manufacturer's literature, data, instructions and recommendations.
      - 2) Submit prior to beginning tunnel excavation.
    - d. Leak remediation plan, final lining: Include proposed application method, equipment details and schedule, as well as complete manufacturer's literature, data, instructions and recommendations.
    - e. Contact grouting:
      - 1) Grouting procedure: Detailed description of proposed grouting equipment and layout, and the proposed order of grouting.
      - 2) Grout mix: Details for materials, grout mix proportions, and the results of trial mixes and test specimens for sand-cement grout.
      - 3) Records:
        - a) Maintain and submit weekly a record of drill holes, the time of each change of grouting operations, pressures, rates of pumping, amount of cement for each change in water-cement ratio, admixtures, and other such data required by the Engineer.

- b) Maintain and submit daily records of grout take for each liner ring and the time performed. Have records available the following day for on-site review by the Engineer.
- f. Earth pressure balance machine (EPBM):
  - 1) Provide a complete technical description of the EPBM and backup equipment, including the cutters and cutterhead, thrust and steering systems, drive system, muck system, machine and tail seals, segment erector, machine-liner interface, guidance system, grout hole drilling system, ventilation system, and muck transport system. Make the level of detail in the submittal sufficient to clearly demonstrate that aspects of the specification requirements are met, including design for the maximum hydrostatic pressure specified. Have the technical description include drawings from the EPBM manufacturer showing details of the EPBM and backup equipment, the cutterhead assembly, muck system, thrust and steering system, drive system, machine and tail seals, grout hole drilling system, segment erector and the interface of the EPBM with the precast segmental lining system elements. Have the drawings show the relation between the excavated tunnel size, the ground support system and the tolerances specified. Submit equipment, software and operation details for the EPBM guidance system and include specific information on the method of controlling and correcting line and grade of the EPBM.
  - 2) Have the proposed EPBM manufacturer certify in writing that the EPBM and backup equipment meet the requirements of this section.
  - 3) Written certification from the EPBM manufacturer of design coordination between the EPBM manufacturer and the liner manufacturer. Include in the certification a statement of compatibility between the EPBM and liner system.
  - 4) Description of EPBM spare parts required in paragraph 2.3.B.4.d giving storage location and condition.
  - 5) A method statement covering the intended machine parameters to achieve earth pressure balance mode at the tunnel face for each of the expected ground conditions described in the Geotechnical Design Summary Report (GDSR) as Appendix G to the General Requirements. Have this include, but not be limited to, cutterhead rotation speed and torque, EPBM thrust, screw conveyor rotation speed and torque, discharger rate, rate of EPBM advance, muck conditioning materials and methods, and mix quantities and volumetric control of the screw conveyor discharge.
  - 6) A method statement covering the start-up of the EPBM and the launch of the EPBM into the ground through the portal and shaft structure.
  - 7) A method statement covering the disassembly and removal of the EPBM and back-up equipment.
- 2. Documentation:
  - a. Permits for disposal of excavated material: Each permit and release form from each property owner where excavated materials will be deposited, absolving the Authority from responsibility in connection with the disposal of such materials.
  - b. Air quality reports: Reports of tests for dust, toxic and hazardous gases and other atmospheric impurities in working environment.
  - c. Qualifications of personnel operating the EPBM.
  - d. Description of Contractor's experience with an EPBM similar to that specified for this work, operated in similar tunneling conditions. The

experience record si to demonstrate a successful completion of at least one project using a similar EPBMi in similar conditions. Include descriptions of the following in the information:

- 1) Features of EPBM used.
  - 2) Lengths and diameters of tunnels, geologic conditions, and ground support systems installed.
  - 3) EPBM performance, including average daily advance, average EPBM penetration or excavation rate, utilization, and description of any major machine-related delays.
3. Schedule Information:
    - a. Contractor's estimated average daily advance for tunnel excavation in feet per day, average EPBM penetration or excavation rate in feet per hour, linear erection rate in minutes per ring and utilization, and average muck system and cutter wear in either parts, cost per cubic yards excavated per change.
    - b. Schedule for the design, manufacturing or rebuilding of EPBM, shop testing, dismantling and shipment to site.
  4. EPBM Quality Assurance Submittals: Submit continuous monitoring data of EPBM performance on a weekly basis for the duration of the EPBM excavation. Accomplish data collection by either automatic recording systems or manually. Include the following in the data to be collected:
    - a. For every shove or stroke of the EPBM, the date, time and tunnel station at start of shove; duration and length of shove; average drive motor current and thrust and propel cylinder pressure; number of operating motors; mode of operation and cutterhead chamber pressure.
    - b. Description of delays longer than 15 minutes, water inflow, incidence of ground loss or other unusual events.
    - c. Cutter and muck system components changes, including time and date of replacement, cutter position and number.
  5. Survey Quality Assurance Submittals:
    - a. Survey personnel qualifications.
    - b. Type and location of horizontal and vertical control monuments to be set.
    - c. Survey procedures and equipment.
    - d. Design and location of theodolite instrument platform mounting bracket, bracing support hardware, method of attachment to initial liner, brass mounting screw and standing platform underneath instrument mounting bracket.
    - e. Survey data collection equipment and software; and traverse reduction and adjustment software.
    - f. Survey equipment certification of adjustment; and calibration results of electronic distance measuring instruments (EDMI's) and prisms.
    - g. Tribrach adjustment method and equipment.

#### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Maintain adequate supply of straight and tapered precast initial lining segments on site.
- B. Avoid damage to surfaces and undue strain on segments during handling. The Engineer retains the right to reject damaged segments resulting from improper fabrication, handling, storing, transporting or erection.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS:**

- A. Track drainage: Section 02625.
- B. Precast concrete tunnel lining: Section 02425.
- C. Reinforcing steel: Section 03200.
- D. Final lining, working slab, invert slab and safety walk concrete: Section 03300, Class 4000.
- E. Grout: Ingredients that are compatible, noncorrosive to steel, and free from calcium chloride.
  - 1. Cement: ASTM C150, Type II.
  - 2. Sand: ASTM C144.
  - 3. Water: Potable.
  - 4. Admixture and additives: Fly ash or other pozzolanic materials; fluidifiers; accelerating, retarding, and water-reducing agents; and bentonite may be used if approved.
- F. Sand: Section 03300, fine aggregate, except that 100 percent passes US Standard Size 16 sieve.
- G. Epoxy mortar: Two-component, solventless, epoxy-resin system, containing 100 percent solids, workable from 50 degrees F to 60 degrees F when one part epoxy is mixed with maximum of one part sand graded as follows:
  - 1. Three parts No. 16 sieve sand to one part No. 90 sieve sand, high-silica content, dry and bagged.
- H. Shrinkage-compensating grout: Section 03300.
- I. Gasket lubricant: As recommended by gasket manufacturer.
- J. Gasket: Section 02425.

**2.02 GROUT MIX DESIGN:**

- A. Contact Grouting Stage One Mix: To develop compressive strength of 100 to 120 psi at 24 hours.
  - 1. Mix sand and cement dry.
  - 2. Add minimum water to achieve water-cement ratio compatible with pumping and pacing requirements.
  - 3. Mix in high speed mixer for minimum of three minutes.
  - 4. Prepare batches so that standing time does not exceed 45 minutes.
  - 5. Prepare trial mixes for laboratory testing.
  - 6. Perform tests of compressive strength in accordance with ASTM C109.
- B. Contact grouting stage Two mix: Neat cement and water.

**2.03 EQUIPMENT:**

- A. General Requirements:
  - 1. Use an excavation machine that can be controlled to desired line and grade, minimize over excavation and loss of ground and provide for erection of specified tunnel linings.
- B. Earth pressure balance machine (EPBM):
  - 1. General:

- a. The EPBM is to be a full face earth pressure balance machine designed for the excavation of saturated soils under maximum hydrostatic pressure described in the GDSR.
  - b. Soil type, density, gradation, strength and abrasivity, and the maximum hydrostatic pressure for the various tunnel reaches, as well as the ground conditions expected, are presented in the GDSR. Design the EPBM to operate in all the ground conditions, including running or flowing sands and clay, and combination thereof indicated in the GDSR.
  - c. The EPBM shall be designed to operate in either open (unpressurized) or closed (pressurized) mode using a muck disposal system fitted with a pressure lock out system. Accomplish switching from open to close mode within one minute or less.
  - d. The average width of the annular space between outside surface of the tunnel liner segments and excavated soil surface is not to exceed 2.5 inches.
  - e. Equip the EPBM with overcutters not more than 3/4-inch thick.
  - f. Equip the EPBM with a grouting system to allow soil grouting ahead of face of excavation.
  - g. Design the EPBM to maintain heading (face) stability at all times under all conditions described in the GSDR during excavation and periods of EPBM shutdown.
  - h. The EPBM is to have provisions for removal of boulders 12 inches in diameter and larger, and other obstructions as described in the GDSR.
2. Cutters and Cutterhead:
    - a. The EPBM shall be Design the EPBM to pass up to 12-inch size cobbles through the head without special procedures.
    - b. Design the EPBM with the capacity to use other techniques such as grouting, slurry, or foam injection to control the tunnel face, maintain tunnel integrity and mucking operations.
    - c. Make cutters serviceable and replaceable from behind the cutterhead of the EPBM.
  3. Thrust System and Steering:
    - a. Designed the EPBM to provide forward thrust by thrust cylinders reacting against the installed segmental liner for the full range and combination of ground conditions described in the GSDR.
    - b. Thrust system capacity is to exceed the combined reaction from maximum hydrostatic pressure, shield friction and face stabilization load.
    - c. Provide symmetrically arranged thrust cylinders which have individual actuation, synchronized actuation for cylinders or for groups of cylinders as necessary for EPBM steering, and individual maximum thrust control. Thrust cylinders are not to exert forces when idle, but are to resist displacements.
    - d. The shield is to be articulated if the total length exceeds 90 percent of the tunnel outside diameter. Shield length is measured from the last gauge cutter to the back of the tail.
  4. Drive System:
    - a. The EPBM is to have sufficient drive motor power, such that the machine is not torque limited when operating in earth pressure balance mode for the full range and combination of ground conditions described in the GDSR.
    - b. The EPBM is to have the ability to start the cutterhead with at least rated full load torque. Provide clutches or hydraulic assist with an electric drive, or a variable speed hydraulic drive system may be used.
    - c. The EPBM design shall permit the replacement of the main bearings and cutterhead seals from within the tunnel.
    - d. One spare main bearing assembly and seals, and one spare main drive gear are be available for replacement of the corresponding parts, and

- provided with the EPBM in the event that those parts fail. Make the spare parts available for the duration of the EPBM excavation and make them deliverable to the site within 36 hours notice. The spare parts may be used, provided they are in like-new condition, as certified in writing by the EPBM manufacturer.
- e. Make the EPBM drive system operate the cutterhead such that it is fully operational in either direction or rotation.
  - f. Make the EPBM configured to provide access to the head of the machine for maintenance, repair or obstacle removal.
5. Muck System:
- a. Fit the EPBM with a screw conveyor for controlled muck removal from the cutterhead chamber. Design the screw conveyor for operation in the soils described in the GDSR and for efficient replacement from within the tunnel.
  - b. Design the screw conveyor to be closed and sealed against maximum hydrostatic pressure at both the front and rear.
  - c. Fit the EPBM with a pressure lock out system, such as a piston discharger, rotary discharger or equivalent, to separate the high pressure groundwater and muck within the screw conveyor from the atmospheric pressure at the muck discharge point of the tunnel.
  - d. Design the discharge for the controlled release of muck under maximum hydrostatic pressure and readily maintained or replaced. Make the discharger operate in ground conditions described in the GDSR.
  - e. Design the muck systems for operation in either an open mode (unpressurized cutterhead chamber) or a closed mode (pressurized chamber).
  - f. For operations in the open mode, design the muck system capacity for continuous operation. Design the muck system such that changing from closed to open mode, or open mode to closed mode, takes less than four 12-hour shifts.
  - g. Muck transport in the tunnel may be by conveyor, rail or slurry system. Design the system selected for abrasive fines and high water content muck.
  - h. Design the EPBM for water, polymer, or slurry foam injections to facilitate mucking operations through the control of muck consistency.
6. Seals:
- a. Provide high pressure seals designed for maximum hydrostatic pressure, as indicated in the GDSR, at the cutterhead drive and main bearings, the articulation joint, the tail shield, and probe and injection grout drill hole points.
  - b. Design and equip the EPBM with a suitable tail seal capable of handling the anticipated ground conditions and hydrostatic pressures. Also consider the influence of liner grouting in seal design.
  - c. Make tail seals replaceable from within the tunnel.
  - d. Employ a grout deal located at the rear of the tail shield to limit grout migration along the shield toward the cutterhead.
7. Segment Erector and Erection Ring:
- a. Make the segment erector and erection ring compatible with the machine and the liner system and gasket selected to ensure safe and efficient segment installation and closing the ring.
  - b. Actuate the erector in the axial, radial, and circumferential directions and in the three articulation angles corresponding to the six degrees of freedom of the liner segments to grip and erect the segments properly such that they are positioned accurately, gaskets are aligned within the required tolerances, and no damage or distortion of the segments or gaskets occur and that the gasket is fully compressed when the ring is closed.
  - c. Once gripped by the erector, make it not possible for the segment to relocate with the erector under external loads or under the dead load of the

- segment, in the axial direction as well as in the direction of the articulation angles, when corresponding actuators are idle.
- d. Have the erector include a suitable gripping device for gripping the segments. Make segment design consistent with the chosen method of gripping.
  - e. For smooth and continuous operation, proportional valves are required on hydraulic actuators, or variable speed motors are required on electric actuators.
  - f. Equip the EPBM with measurement devices to indicate correct radial and circumferential positioning of the segments.
8. Machine-liner interface:
- a. Do not exceed 1800 psi maximum bearing pressure at any point and at any time on the liner segment unless otherwise submitted and reviewed by the Engineer.
  - b. Equip the thrust cylinder with a jacking ring or shoes and pads to equally distribute the jacking forces to the liner. Make the design of thrust cylinder jacking ring or shoes and pads consistent with segment and segment joint design.
  - c. Do not bear jacking ring, shoes and pads on gaskets at any time.
  - d. Start contact grouting as soon as the grout holes are clear of the last tail seal. Do not install the next ring of segments in the tail shield until grouting is complete.
  - e. Coordinate the tail seal and the liner system to ensure a competent seal.
  - f. For tail seals requiring grease or other liquid sealants, make the sealant compatible with the liner system gaskets. Use inert materials which will not contaminate the surrounding ground or cause the long term deterioration of the liner concrete, the joint connector, the gaskets or joint packers.
9. Guidance System and Alignment Control:
- a. Provide the DYWIDAG-Leica, ZED-260 or approved equivalent tunneling machine guidance system for automatic computation of curved axis coordinates to maintain proper tunnel line and grade within specified tolerances.
  - b. Make the guidance system capable of calculating and displaying the position and attitude of the EPBM relative to the designed tunnel axis at all points, including predicted points at the face of the shield or some specified distance ahead of the shield.
  - c. Have the EPBM guidance system include the following salient features:
    - 1) The parts and equipment necessary to continually and automatically measure horizontal, vertical, and axial displacement as well as horizontal, vertical and main axis rotation
    - 2) A control unit that is capable of storing the design tunnel alignment using a three-dimensional coordinate system and displaying the present position and the attitude of the EPBM and its predicted deviation from the design of the tunnel.
    - 3) Motorized electronic theodolite with electronic distance measuring instrument (EDMI) and laser. Direct the laser through the eyepiece of the theodolite that is used to automatically update laser beam directional information. Use the EDM to automatically update the EPBM drive distance.
    - 4) An above-ground computer which enables entry, modification and verification of the designed tunnel axis coordinates.
      - a) Have the above-ground computer display, print and digitally store the information available at the control unit to document the position and progress of the tunnel drive without leaving the office. Make the information available to the Engineer upon request, or at the end of each shift.

- b) Electronically connect the above-ground computer to the equipment underground via cable or modem.
    - 5) Design the EPBM and backup equipment to negotiate curves in the alignment with minimum radius as shown, and meet the specified alignment tolerances.
  - 10. Other Features:
    - a. Equip the EPBM with a fire suppression system and hand operated fire extinguishers.
    - b. Design the EPBM to control the ground at the heading and flow of ground water through the tail seal by grouting during abnormal conditions, construction removal or EPBM maintenance. Store at the site equipment and materials necessary to control the excavation during conditions described above, tested and ready to use when needed.
    - c. Provide and maintain a stock of spare parts and consumables on site.
    - d. Use fire resistant hydraulic fluids throughout the EPBM.
  - C. Contact Grouting Equipment:
    - 1. For pumping grout, use approved pump capable of developing specified uniform pressure at grout hole connection and hoses with minimum inside diameter of 1-1/2 inches.
    - 2. Provide mixing equipment with capacity to fill voids and annular space, outside last ring after each advancement of the EPBM.
    - 3. Provide automatic shutoff control to prevent grouting pressure from exceeding that specified.
    - 4. Use equipment that allows flushing with grout intake valve closed, water-supply valve open and grout pump running at full speed.
    - 5. Provide two pressure gauges, one at the pump and a second on the manifold hookup at the collar of hole being grouted. Use pressure-gauge ranges as necessary for each part of grouting program.
    - 6. Provide suitable stop valves at collar of hole to maintain necessary pressure until grout has set.
    - 7. Provide grouting equipment with means of accurately determining amount of grout injected.
    - 8. Furnish accurately calibrated, high-precision pressure gauge to periodically check accuracy of pressure gauges.

## **PART 3 - EXECUTION**

### **3.01 TEMPORARY VENTILATION AND AIR QUALITY:**

- A. For the duration of the project, provide, operate and maintain a temporary ventilation system which conforms to specified safety requirements and those of jurisdictional authorities. Remove system from site when work is completed.
- B. Use equipment which is adequate to maintain sufficient supply of fresh air in underground work areas.
- C. Conduct drilling and tunneling operations by methods, and with equipment, which ensure control of dust, fumes, vapors, gases, fibers, fogs, mists or other atmospheric impurities, in accordance with specified safety requirements.
- D. Provide approved instrumentation for testing quality of tunnel atmosphere and obtain samples under working conditions at prescribed intervals. Submit results of quality tests.

### **3.02 TEMPORARY WORKSHAFTS AND OTHER OPENINGS:**

- A. Excavate and support temporary workshafts and other openings in accordance with Sections 02320 and 02260.
- B. Seal such openings when no longer necessary.
- C. Form and place Class 2500 concrete, two-feet-thick, in shafts over tunnels to prevent damage to tunnel shape. When concrete has achieved design strength, backfill remaining void in accordance with Section 02320.

### **3.03 SAFETY REQUIREMENTS:**

- A. Perform work to maximize safety and reduce exposure of personnel and equipment to hazardous and potentially hazardous conditions in accordance with specified safety requirements.
- B. In case of emergency or work stoppage likely to endanger excavation or adjacent structures, continuously maintain full work force 24 hours per day, including weekends and holidays, until emergency or hazardous conditions no longer jeopardize the stability and safety of the work. In addition to rib rings and lagging needed for planned work and shown on Contract Drawings, have on site and ready for use in emergencies a minimum of 12 steel rib rings (W8 x 40 or larger) and lagging sufficient to support 25 feet of tunnel.
- C. Perform tunnel construction to minimize ground movement in front of, and surrounding, tunnel and minimize subsidence if surface, structures and utilities above and in vicinity of tunnel for the ground conditions encountered.
- D. Support ground continuously at the excavation face and surrounding tunnel perimeter to prevent loss of ground and to maintain stability of tunnel faces, passages and bottoms of shafts.

### **3.04 DISTANCE BETWEEN HEADINGS:**

- A. Maintain longitudinal distance of no less than 150 feet between adjacent tunnel headings being simultaneously excavated.
- B. Where a tunnel heading is being advanced adjacent to a previously excavated tunnel, ensure initial support in first tunnel is completely installed, that voids behind linings are completely filled, and that the tendency of the lining to distort is minimized before commencing work on the second tunnel.

### **3.05 SURVEILLANCE OF HEADINGS:**

- A. If tunnel invert is below groundwater level, maintain qualified personnel on duty to monitor conditions that might threaten stability of heading whenever tunnel excavation is suspended or shut down.
- B. Use of approved monitoring devices, such as closed-circuit television, which permit continuous monitoring of conditions at the face by qualified observers from outside the tunnel is permitted.
- C. At the first indication of misalignment exceeding the bull's eye limit in the tunnel heading, stop the work and notify the Engineer immediately.

### 3.06 DETECTION OF MOVEMENT:

- A. Segment Ring Movement:
  - 1. Monitor dimensions and elevations of segmental rings as follows:
    - a. Measure width of each segmented ring to within plus-or-minus 0.01 foot.
    - b. Measure height of each segmented ring from crown to invert to within plus-or-minus 0.01 foot.
    - c. Measure crown elevation of each segmented ring to within plus-or-minus 0.01 foot.
  - 2. Take measurements of width and height of each segmented ring within one hour after each segmented ring emerges from the tail of the machine.
  - 3. Take measurement of width and crown elevation of each segmented ring within 12 hours after each segmented ring emerges from the tail of the machine.
  - 4. Following such initial readings, Engineer will select one segmented ring in each 25-foot section of tunnel for additional measurements. Take measurements of width, height and crown elevation of each segmented ring on selected sets of rings daily after each selected ring erected and within 250 feet of the trailing gear; monitor tunneling weekly between 250 feet and 1,000 feet, and at monthly intervals thereafter until the cast-in-place liner is installed.
  - 5. If measurements indicate excessive deformations are occurring, take corrective measures and additional measurements on selected elements and on additional elements as directed by the Engineer.
- B. Ground Movement:
  - 1. Install, maintain and make observations as specified of instrumentation shown on the Contract Drawings and/or as specified in Section 02291.

### 3.07 FIELD QUALITY CONTROL:

- A. Place cast-in-place tunnel concrete to the following tolerances:
  - 1. Tunnel lining:
    - a. Departure of tunnel from line or grade shown as measured from working point of tunnel: one inch.
    - b. Variation in internal diameter at any point: plus-or-minus one inch.
    - c. Where thickness of cast-in-place tunnel lining is less than 12 inches but greater or equal to nine inches, provide additional reinforcing as shown, at no additional cost to the Authority.
    - d. No final lining thickness below nine inches will be accepted. Tunnel remaining necessary to maintain the allowable final lining thickness is at no additional cost to the Authority.
  - 2. Invert: Section 03300.
  - 3. Safety walk: Section 03300.
- B. Install initial precast concrete segmental tunnel lining to tolerances shown on the Contract Drawings.
- C. Contact Grouting:
  - 1. Keep workers aware that tunnel grouting is one of a series of linked tunneling processes, each one depending for its proper performance on the proper performance of the others; adverse consequences are likely to result for inadequate performance of tunnel grouting.
  - 2. Provide facilities and assistance necessary for the Engineer to inspect the grouted initial lining to ensure complete filling of voids, including assistance in drilling, probing, or sounding through the grout hole.

3. An inspection will be made by the Engineer not later than 24 hours after, nor more than 60 feet behind, the initial injection. Have voids, as determined by the Engineer, completely grouted by an additional injection performed immediately after this inspection.
4. From time to time, the Engineer may require the drilling through grout holes in precast segments, and up to one foot into surrounding ground, not to exceed one every 100 feet of tunnel on the average. If regrouting is required, drill additional check holes. Fill check holes flush with surface using epoxy mortar.

### **3.08 FIELD SURVEY CONTROL:**

- A. Secondary Survey Control System:
  1. Establish a secondary survey control system consisting of horizontal and vertical reference points for driving the EPBM and placing final liner concrete. Install horizontal control points either as a brass disc or lead and tack. Install vertical control points either as a brass disc or 1/2-inch diameter by a minimum three-inch-long anchor bolt with nut and washer.
  2. Employ survey procedures and equipment in accordance with FGCC Standards and Specifications for Geodetic Control Networks using Second Order, Class 1 specifications for horizontal control work and Second Order, Class 1 specifications for vertical control work.
  3. Construct tunnel horizontal traverses as closed loops adjusted by the least squares method. Tunnel vertical traverses are to be closed loops and adjusted by distributing the error of closure equally through the turning points. Furnish the Engineer with traverse adjustment results within 24 hours.
  4. Advance and verify underground tunnel control after every 300 feet maximum of tunnel lining placement.
  5. Install vertical control points maximum 300 feet on center throughout tunnel.
  6. Platform mounting brackets:
    - a. Install inter-visible theodolite instrument platform mounting brackets in the tunnel initial liner, at or below springline, at maximum intervals of 500 feet on center throughout the tunnel, for the purpose of maintaining the secondary horizontal control system. Install additional platform mounting brackets where tunnel alignment curvature does not allow for intervisibility between instrument locations. Fabricate platform mounting bracket from steel, having a smooth finish where the instrument attaches. Make brackets rigid enough to resist deflection or movement when a theodolite is mounted and operated on top of it. If deflection or movement is apparent then add bracing supports to sufficiently stabilize the platform mounting bracket and install additional bracing supports as directed by the Engineer. Use minimum 1/8-inch-thick steel for brackets. Attach bracket supports to the underside of platform, mounting bracket to provide a clear and unobstructed working area at and above platform. The platform mounting bracket shall be of sufficient length and width to allow efficient set-up and operation of theodolite and electronic distance measuring instrument (EDMI). Minimum width of platform mounting bracket is nine inches; minimum length of platform mounting bracket is equal to a distance sufficient to allow a mounted instrument a minimum one foot of clearance from tunnel lining. Install platform mounting brackets to a level plane within the adjustment limits of a standard tribrach.
    - b. Provide each platform mounting bracket with a forced centering hole that can accept a brass instrument mounting screw (standard 5/8-inch by 11-inch thread) for securing a standard tribrach. Mill force centering hole and brass mounting screw to match each other within 0.001 inch. Make the brass mounting screw hollow and of sufficient diameter to allow the instrument operator to site below platform mounting bracket with a nadir

optical plummet. Provide the Engineer with three mounting screws for the duration of the Contract. Construct and install a platform underneath the instrument mounting bracket for the purpose of supporting a surveyor during measurement observation process from either side of instrument.

- B. Survey Data Collection:
1. Provide and maintain equipment and software necessary to record secondary survey control measurement observations. Assemble measurement observations in digital data collection files and provide data to the Engineer in a format that is compatible and in accordance with the AASHTO Survey Data Management System (SDMS) technical specification for survey data.
  2. Have the survey data collection files transmitted to the Engineer contain: a time and date stamp for each observation, original field measurements, and the correctly computed coordinates and elevations in addition to the survey data tags necessary to recompute the file if required.
  3. Preserve original unedited data collection files and provide one copy of each file to the Engineer.
- C. Survey Equipment Adjustment and Calibration:
1. Adjust instrument for collimation error every six months, or whenever difference between reverse and direct readings of theodolite depart from 180 degrees by more than 15 seconds. Readjust cross hairs and level bubble whenever their misalignments affect instrument readings by amount of least count.
  2. The National Geodetic Survey (NGS) has established specific calibration baselines for the purpose of comparing survey equipment to known monumentation to verify correct instrument operation and verification of compliance with manufacturer's specifications. Service every six months and check frequently the electronic distance measuring instruments (EDMI's) and retroreflectors over lines of known distances at an approved NGS baseline. Recalibrate EDM if physical damage is incurred.
  3. Compute calibration results using procedures in NOS NGS-10, Use of Calibration Base Lines. Record actual measurements, apply atmospheric corrections and then adjust by least squares to compute a constant, as well as a relative correction factor (scale correction). Calibrate prisms at the same facility.
  4. Forward results of this calibration to the Engineer. Post correction factors in Contractor's office for computing area and apply them as required to maintain specific accuracy.
  5. Immediately remove and repair, or replace instruments found to be in disrepair or misalignment.
  6. Provide a certification of adjustment to the Engineer for instruments to be utilized before commencement of survey work.
  7. Provide and maintain the ability in-house to check and adjust tribrachs for eccentricity. Perform adjustment checks at least once a week. Keep a record of adjustments to tribrachs current and made available to the Engineer monthly, or upon request. Number and tag each tribrach with date of last adjustment.

### **3.09 OPERATION BY THE EPBM:**

- A. On initial setup, support the EPBM on concrete cradle properly at lines and grades which will permit correct installation of tunnel lining.
- B. During forward movement of the EPBM, provide sufficient support at excavation face to prevent movement of materials, except such materials as are physically displaced by elements of shield itself.
- C. Control face efficiently using appropriate support procedures and methods.

- D. Dispose of excavated materials as specified.
- E. During shutdown periods, due to abnormal conditions, obstruction removal, EPBM maintenance or other reasons, ensure stability of the tunnel with appropriate support measures. In areas where the tunnel face stability cannot be maintained directly by the EPBM, support face of excavation by other means, such as grouting.
- F. In the event of EPBM stoppage for more than 12 hours, inject bentonite slurry into gap between tail of shield and foil to facilitate resuming of EPBM advancement.

### **3.10 INSTALLATION OF INITIAL LINING:**

- A. Support segments as necessary to prevent damage or undue strain. During handling of segments, wire ropes, keep chains or hooks from direct contact with concrete or gaskets. Ship tapered segments in units of complete rings, properly identified.
- B. Inspect segments with gaskets before taking them underground and just prior to erection. Damaged segments shall not be installed in the tunnel. Damaged segments shall be repaired or replaced as directed, at no additional cost to the Authority.
- C. Install the segmented tunnel lining system to the specified dimensions and tolerances for line and grade, within the design tolerances for joint and structural performance. Projection or lipping (abrupt surface irregularity) of a segment with respect to the adjoining segment will is not allowed in excess of that shown on the Contact Drawings under Tolerances.
- D. Assemble and mechanically connect each ring of segments inside the tunneling shield. Keep the invert of the EPBM free of excavated material prior to erection of each ring. Hose clean the joint surfaces of each segment with clean water immediately prior to erection. At time of erection, make joint and gasket surfaces free of material that could interfere with proper bearing and watertightness. Lubricate gasket along cross joints of key segments prior to key segment installation.
- E. Prior to jacking the EPBM have mechanical connectors across joints in place ahead of the segment ring and tightened sufficiently to provide joint closure pressure as specified in Section 02425. Maintain the design tolerances on joint closure during erection of subsequent rings. If necessary, retighten the mechanical connectors of the last circumferential joint prior to retracting jacking rings or shoes.
- F. Do not apply loads or eccentricities to the segments that are detrimental to the lining system as a result of the erection sequence. Do not permit jacking rings or shoes and pads to bear on the circumferential joint gaskets.
- G. Use tapered rings on curves and elsewhere as necessary to maintain line and grade tolerances. In no case is compression packing to be added to or removed from the circumferential joints to adjust line and grade.
- H. Stagger longitudinal joints in adjacent rings.
- I. Perform contact grouting behind each ring and shall begin as soon as segment grout holes are clear of the tail seal.

- J. Hangars for utility lines necessary for construction of the tunnel may be connected to concrete segments, but may not interfere with proper erection of each ring. Cast or drilled holes or embedded anchorages may be used for this purpose, if approved by the Engineer.
- K. Support trailing edge of last installed ring by means of horizontal tie rod or vertical strut inserted before EPBM is advanced. Keep support in place until grouting around lining has been completed and tendency of lining to distort, or surrounding ground to move, has been overcome.
- L. Repair or replace, as directed, damaged segments in previously placed ring.

### **3.11 WATERTIGHTNESS:**

- A. Watertightness of Initial Lining (of Two-Pass System):
  1. Provide clean, dewatered conditions during waterproofing membrane placement and installation of final lining.
  2. Prior to beginning work, submit plan for control of water entering tunnel through the initial lining. Include capacity of proposed water pumps.
  3. If water leakage into tunnel exceeds capacity of the proposed water pumps, undertake remedial measures, such as injection of bentonite slurry, cement, chemical grout or combination thereof.
  4. Repair visible leaks.
  5. If possible, use existing grout holes for injecting materials.
  6. Establish injection pressure by means of on-site demonstration. Do not exceed structural capacity of the lining, or combined hydrostatic and soil overburden pressure as determined for construction conditions.
- B. Watertightness of Precast Concrete Lining (of Single-Pass System):
  1. Comply with Leak Remediation, specified above.

### **3.12 CONCRETE CONSTRUCTION:**

- A. For Two-Pass System:
  1. Perform concrete work in accordance with Sections 03100, 03200 and 03300.
  2. Clean and roughen working slab surface to expose aggregates prior to placing invert slab concrete.
  3. Place concrete for lining upper portion of tunnel by mechanical or pneumatic methods through pipes which discharge as nearly as practicable to highest point of structure.
  4. Do not perform concreting of final lining of the first tunnel excavated until excavation of the second tunnel has progressed at least 100 feet beyond the limits of active concreting, unless otherwise approved.
  5. Schedule erection of concrete lining of the second tunnel so that no concrete is placed closer than 500 feet from tunnel excavation heading, unless otherwise approved.
  6. Perform contact grouting through grout nipples, in such quantity and at sufficient pressure to completely fill voids. Use grouting pressure as specified.
  7. Drill and grout safety walk reinforcement into final lining using shrinkage-compensating grout. Exercise care during drilling operation not to impair waterproofing membrane.
  8. Install remaining reinforcing steel in the safety wells and pour concrete.
- B. For Single-Pass System:
  1. Perform concrete work in accordance with Sections 03100, 03200 and 03300.
  2. Place invert slab concrete on the cleared liner or over the insulative coating, if used.

3. Do not place the invert in the first tunnel excavated until excavation of the second tunnel has progressed at least 100 feet beyond the limits of active concreting, unless otherwise approved.
4. Schedule placement of the invert of the second tunnel so that no concrete is placed closer than 400 feet from tunnel excavation heading unless otherwise approved.
5. Install safety walk dowels per Contract Drawings, provide remaining reinforcing steel and place concrete in the safety walks.

### **3.13 CONTACT GROUTING:**

- A. First Stage-Precast Concrete Initial Lining (for Two-Pass System) and Precast Concrete Lining (for One-Pass System):
  1. Perform cement-sand grouting behind initial tunnel support to fill the annular space between the initial support system and the excavated surface. Use nozzle pressure that will not cause movement of soil or lining nor damage to lining, and not exceed 30 psi at the grout hole. Keep topmost hole in liner open as air vent. Assist Engineer in checking adequacy of first stage grouting.
  2. Consider grouting of a hole complete when the hole refuses grout for 60 seconds at 90 percent of highest pressure stipulated for conditions at that hole location. After the grouting of a hole is completed, maintain pressure by means of a stop cock or other suitable device until the grout has set sufficiently to be retained in the hole.
  3. After grout has set, remove valves and fittings. Fill grout holes with epoxy mortar at completion of the grouting operations to have a smooth finished surface acceptable to the Engineer.
- B. Second Stage-Cast-in-Place Concrete Final Lining (for Two-Pass System Only):
  1. Place grout pipes or connections in the concrete lining or concrete pipe shown on the Drawings and as specified herein. Place grout pipes in the lining at a nominal 25 foot spacing. Place pipes behind the concrete forms and held securely in position. Suitably plug grout pipe perforations to prevent the entrance of concrete. Drilled holes may not be used in lieu of cast-in-place grout pipes
  2. Ensure that concrete lining has reached 28-day strength prior to commencement of grouting operations.
  3. Use nozzle pressure which will not puncture or otherwise injure waterproofing membrane.
  4. Make connections by threaded fittings of ample strength and tightness to prevent leakage or with approved packers, and provide each with a straightway cock or valve. Remove plugs on ends of adjacent ungrouted pipes to ensure escape of air and water and filling of spaces with grout. Replace plugs as required to prevent loss of grout. The general direction of advance is to be from lower elevations to higher elevations.
  5. Prior to injection of grout, inspect each grout pipe to ensure that the pipe is clear and open. Hook-up and pump grout at each grout pipe.
  6. Operate and control grout pumps so that the grout is delivered uniformly and steadily. Inject grout in a sequential side-to-side progression along the tunnel to fill voids with grout.
  7. Grouting at each grout pipe connection will be considered complete when no more grout of the required mix and consistency can be injected at the specified pressure or when clean grout appears at the next hole.
  8. Exercise care to prevent the setting of escaped grout on exposed surfaces. Remove such grout and restore surfaces to their original conditions.
  9. Upon completion of the grouting at each connection, close the valve and leave it in place until the grout has set, after which remove the valves and fitting. Remove grout supply connections from the embedded grout pipe to a minimum depth of two inches, and fill the hole with epoxy mortar to give a smooth finished surface.

- C. Keep equipment lines clean by constant circulation of grout and by periodic flushing with water.

**3.14 DEFECTIVE LINING:**

- A. Precast concrete segmented tunnel lining will be considered defective unless it is properly finished, and within specified tolerances and has undamaged edges and joints.

**3.15 CORRECTIVE WORK:**

- A. Repair of Concrete Segments: Repair segments which have chips, spaces, or formed depressions meeting the conditions set forth in Section 07137, Tunnel Waterproofing. As directed, repair or replace with new segments those cracked segments which impair structural integrity of tunnel lining as determined by the Engineer.
  1. Ensure that surfaces to be repaired are clean, dry, free from dirt, dust, oils, water and other contaminants.
  2. Mix and place epoxy mortar as recommended by manufacturer. Grind rough or raised projections smooth and flush with adjacent surfaces.

**3.16 LEAK REMEDIATION:**

- A. For Two-Pass System:
  1. If water leakage into tunnel after placement of final cast-in-place concrete lining exceeds specified allowable limit, undertake remedial measures such as injection of bentonite slurry, cement, chemical grout or combination thereof.
  2. Prior to beginning work, submit leak-remediation plan.
  3. If possible, use existing grout holes for injecting material.
  4. Establish injection pressure by means of on-site demonstrations. Do not exceed structural capacity of lining.
- B. For Single-Pass System:
  1. If water leakage into tunnel exceeds specified allowable limits, undertake remedial measures such as injection of bentonite slurry, cement, chemical grout, or combination thereof.
  2. Prior to beginning work, submit leak-remediation plan.
  3. If possible, use existing grout holes for injecting material.
  4. Establish injection pressure by means of on-site demonstration. Do not exceed structural capacity of lining.

**3.17 DISPOSAL OF EXCAVATED MATERIAL:**

- A. Dispose of excavated materials at locations outside of the Authority's right-of-way.

**END OF SECTION**

## SECTION 02417

### NATM EXCAVATION ( SOFT GROUND )

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies the excavation and support of the NATM tunnels (center drift, middle drifts, side drifts, shafts and station, as applicable) in accordance with the construction sequences and limits of excavation shown for the NATM.<sup>1</sup>
1. Stations indicating limits of typical excavation and support types, pre-support types, and of concrete lining are approximate only and may vary due to geological and hydrological conditions actually encountered in the field.
  2. Stations are outbound stations; apply inbound stations accordingly.
- B. Related Work Specified Elsewhere:
1. Grading, excavating and backfilling: Section 02320.
  2. Dewatering: Section 02240.
  3. Support of excavation: Section 02260.
  4. Subway drainage system: Section 02625.
  5. NATM shotcrete lining: Section 02426.
  6. Concrete work: Sections 03100, 03200, and 03300.
  7. NATM concrete lining: Section 02427.
  8. Shotcrete: Section 03370.
  9. Tunnel waterproofing (NATM system): Section 07138.
  10. Geotechnical instrumentation: Section 02291.
- C. Definitions:
1. Excavation Line: Theoretical line of excavation inside of which no earth or surrounding ground may protrude.
  2. NATM Excavation in Soft Ground: Mined excavation in earth by the New Austrian Tunneling Method (NATM). The following, among others, are classified as excavation in earth: Filled ground including rock fill, boulders, concrete or stone masonry, buried trees, timbers or plankings, conduits, pipes or drains, wood, concrete or steel piles and sheeting, and shotcrete applied for protecting heading or as support for previously excavated drift, and soil pretreated by grouting.
  3. Mixed-face Excavation: Mined excavation of soil strata with a face exposing more than one type of soil or material, including rock and hard rock, in the same heading at the same time.
  4. NATM Portal Wall: A temporary, rigid structure that supports a mass of soil and from which NATM excavation can begin.
  5. Support: Support for NATM construction includes those measures necessary to maintain the inherent strength of the ground surrounding the tunnel openings while preventing unnecessary loosening and enhancing the stress redistribution process. This function of support is enhanced by installation of pre-support and local support where required by ground conditions.
  6. Pre-support: Systematic measures including chemical grout arch installed by directional drilling, grouted pipe spiling and rebar spiling installed as shown prior to or during NATM tunnel excavation.

7. Local Support: Grouted pipe spiling and rebar spiling installed in a non-systematic manner, dowels, face shotcrete, and face stabilization wedge installed individually or otherwise in addition to specified pre-support, for local stabilization and safety during tunneling.
8. Rebar Spiling: Rebars without end hardware installed at the tunnel heading ahead of excavation as a means to pre-support the ground.
9. Grouted Pipe Spiling: Perforated steel pipes installed at the tunnel heading ahead of excavation and grouted as a means to pre-support the ground.
10. Shotcrete of Initial Lining: Shotcrete layer of a minimum seven inches thickness reinforced with welded wire fabric, lattice girders, splice bars and splice clip.
11. Concrete or Final Lining: Cast-in-place concrete placed after installation of shotcrete lining and waterproofing.
12. Excavation and Support Type: Prescribed excavation sequence, support and local support based on the type of host material in both top heading and bench/invert encountered as well as by the anticipated response and behavior of the host material during excavation.<sup>\*2</sup>
13. Break-Out: Support installed at support of excavation walls prior to and during the start-up of NATM tunneling including reinforced shotcrete collar, dowels, and thickened shotcrete lining.
14. Chemical Grout Arch: Zone of soil improved by chemical grouting above the tunnel roof and reinforced longitudinally by minimum two-inch ID tube-a-manchette steel pipes through which grout has been injected. Steel pipes installed in drill holes drilled by means of directional drilling.
15. Directional Drilling: Soil stabilization, for sandy and other running soil, chemical grouting by installing continuous horizontal grouting pipes. Directional drilling is also used for horizontal dewatering pipes. If it is necessary to use horizontal directional drilling for additional geologic investigation, have adequate records and logs maintained during the entire drilling operation.<sup>\*3</sup>
16. Dowels: Injection bore anchors with end hardware installed at break-outs as shown to tie the shotcrete collar to the ground and pre-support the loosened ground where required.
17. Length of Round: Length of the unsupported span of exposed ground opened up during one round of excavation. Excavation to be immediately followed by the installation of support as shown.
18. Flash-crete: Minimum one-inch thick layer of unreinforced shotcrete placed immediately after excavation on exposed surface to seal and protect the material from deterioration and initial loosening. It is not part of the structural shotcrete lining as shown and specified.
19. Face Stabilization Wedge: Unexcavated portion of the heading temporarily left in place to enhance face stability.
20. Vacuum Lances: Slotted PVC or other approved temporary pipes with filter fabric inserted into the ground from within the tunnel for the purpose of performing local dewatering and removing perched water using vacuum pressure during excavation.
21. Drain Pipes: Slotted PVC pipes, or other pipes approved by the Engineer, with filter fabric inserted into the ground from within the tunnel to drain water and perched water by gravity during excavation.
22. Water Sheet and Drain Hose: PVC-sheet and PVC-hose or similar materials as approved by the Engineer. Use watersheet and drain hose to collect and drain off ground water from areas at either the excavated ground surface before applying shotcrete lining to prevent hydrostatic pressure build-up behind the shotcrete lining and/or for dewatering of seepage through the shotcrete lining. Use drain hose individually applied to drain off water ingress at localized spots behind the shotcrete lining.

23. Geologic Overbreak: The amount of ground dislocated beyond the theoretical excavation line primarily due to running or flowing in materials, like P2 material, and falling out of blocks along fissures in materials, like P1 material..

## 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  1. Comply with codes and regulations of the jurisdictional authorities.
  2. Geotechnical Design Summary Report (GDSR) in the Appendix G of the General Requirements.
  3. AASHTO: Survey Data Management System
  4. ASTM: A36, A53, A325, A615, C109, C144, C150, D638, D1304, D2240.
  5. MS: MIL-P-26915
  6. FGCC: Standards and Specifications for Geodetic Control Networks.
- B. NATM Engineer: Have field staff include a civil engineer (NATM engineer) meeting the following requirements:
  1. Education: Graduate civil engineer from an accredited college or university, foreign or domestic.
  2. Experience: Field and design experience in soft ground NATM tunnel engineering.
  3. Proficient in spoken and written English.
  4. Do not commence field work until NATM engineer has been approved in writing by the Authority.
  5. Have approved engineer report for work at the site at least six weeks prior to commencement of NATM excavation-related work, including installation of chemical grout arch, and remain at the site for four weeks after completion of the excavation work.
  6. Duties include the following:
    - a. Supervising excavation to ensure safety of construction.
    - b. Coordinating preventative and remedial measures when ground loss at tunnel heading or instability of tunnel occurs, or when they appear likely.
    - c. Preparing daily written interpretation of instrumentation measurement readings during excavation.
    - d. Holding daily discussion with the Engineer at the tunnel face regarding ground conditions and corresponding Excavation and Support Type and other supports and keeping written records thereof.
    - e. Submitting a weekly report on geologic conditions as encountered during excavation for the Engineer's use including record of daily discussion. Have the geologic report include geologic mapping of the face for a frequency recommended for various Excavation and Support types.<sup>\*4</sup>
    - f. Participating in pertinent coordination meetings with the Engineer, and providing minutes of each meeting to the Authority within one week. Preparing final reports on geologic conditions encountered, ground control measures taken, problems encountered and geometrical measurements.
  7. Be always available to report to the site.
- C. Survey Control:
  1. Provide qualified survey personnel in accordance with the General Requirements pertaining to Layout of Work.
  2. Establish a secondary survey control system consisting of horizontal and vertical reference points for driving the tunnels and placing concrete lining. Install horizontal control points either as a brass disc or lead and tack. Install vertical control points

either as a brass disk or a 1/2-inch diameter by minimum three-inch long anchor bolt with nut and washer.

- a. Employ survey procedures and equipment in accordance with FGCC Standards and Specifications for Geodetic Control Networks, using Second Order, Class 1 specifications for horizontal control work and Second Order, Class 1 specifications for vertical control work.
- b. Make tunnel horizontal transverses closed loops and adjusted by the least squares method. Make tunnel vertical traverses closed loops and adjusted by distributing the error of closure equally through the turning points. Provide the Engineer with traverse adjustment results within 24 hours.
- c. Advance and verify underground tunnel control after each 500 feet of tunnel lining placement.
- d. Install vertical control points maximum 300 feet on center throughout tunnel.
- e. Install inter-visible theodolite instrument platform mounting brackets in the shotcrete lining, at or below the springline, at maximum intervals of 500 feet on center throughout the tunnel, for the purpose of maintaining the secondary horizontal control system. Install additional platform mounting brackets where tunnel alignment curvature does not allow for intervisibility between instrument locations.
- f. See Part 2 - Products for bracket and surveyor platform specifications.
- g. Survey Data Collection:
  - 1) Provide and maintain equipment and software necessary to record secondary survey control measurement observations. Assemble measurement observations in digital data collection files and provide data to the Engineer in a format that is compatible and in accordance with the AASHTO Survey Data Management System (SDMS) technical specification for survey data.
  - 2) Survey data collection files transmitted to the Engineer are to contain a time and date stamp for each observation, original field measurements, and the correctly computed coordinates/elevations in addition to the survey data tags necessary to recompute the file if required.
  - 3) Preserve original unedited data collection files and provide one copy of each file to the Engineer.
- h. Survey Equipment Adjustment and Calibration:
  - 1) Adjust instrument for collimation error every six months or whenever difference between direct and reverse readings of theodolite depart from 180 degrees by more than 15 seconds. Readjust cross hairs and level bubble whenever their misalignments affect instrument reading by amount of least count.
  - 2) The National Geodetic Survey (NGS) has established specific calibration baselines for the purpose of comparing survey equipment to known monumentation to verify correct instrument operation and verification of compliance with manufacturer's specifications. Service every six months and check frequently the electronic distance measuring instruments (EDMI's) and retroreflectors over lines of known distance at an approved NGS baseline. Recalibrate an EDM I if physical damage is incurred.
  - 3) Compute calibration results using procedures in NOS NGS-10 Use of Calibration Base Lines. Record actual measurements, apply atmospheric corrections and then adjust by least squares to compute a constant, as well as a relative correction factor (scale correction). Calibrate prisms at the same facility.

- 4) Forward results of this calibration to the Engineer. Post correction factors in Contractor's office for computing area and apply them as required to maintain specified accuracy.
  - 5) Immediately remove and repair, or replace instruments found to be in disrepair or misalignment.
  - 6) Provide a certification of adjustment to the Engineer for instruments to be utilized before commencement of survey work.
  - 7) Provide and maintain the ability in-house to check and adjust tribrachs for eccentricity. Perform adjustment checks at least once a week. Keep a record of adjustments to tribrachs current and made available to the Engineer monthly or upon request. Number and tag each tribrach with date of last adjustment.
- D. NATM Tunnel Heading Inspector: Contractor's field staff to include inspector for each shift of work.
1. Qualifications of such persons to include inspection experience in soft ground NATM tunnel construction, proficiency in the English language, and capability to assume duties of NATM engineer.
  2. By the Engineer approved inspector to report for work at the site prior to commencement of NATM excavation.
  3. In the event that ground loss at the tunnel heading or instability of tunnel heading occurs or appears likely, and NATM engineer is not physically present at the tunnel heading, duties of inspectors to include the following:
    - a. Directing modifications in tunneling techniques.
    - b. Notifying the Engineer of ground losses at tunnel heading.
    - c. Notifying personnel responsible for performing preventative and/or remedial measures to report immediately at tunnel heading.
    - d. Coordinating preventative and remedial measures.
    - e. Notifying personnel responsible for monitoring instruments to increase frequency of monitoring as specified.
- E. Have qualified firm or specialist, and necessary equipment in working order and always present at the site, for performing directional drilling, chemical grouting, probe drilling, installation of pre-support and local support, and other approved measures.
- F. Have qualified firm or specialist responsible for groundwater control measures and knowledgeable in dewatering methods for use in this type of soils, preferably with adequate experience within the project areas.
- G. \*<sup>5</sup>
- H. NATM Portal Wall:\*<sup>6</sup>

### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings: Design, specifications, method of operation and other data pertaining to the following:
    - a. Grouted pipe spiling pipes and rebars.
    - b. Casings, packers, rubber sleeve pipes and drill rods to be used for chemical grouting, grout pipe spiling, probe drilling and installation of drain pipes and vacuum lances.

2. Working Drawings:
  - a. Detailed descriptions, data or calculations of proposed facilities, equipment to be utilized and method of construction including, but not limited to, the following:
    - 1) Groundwater control system including the installation of vacuum lances and drain pipes, temporary sumps, construction drains, pumps, procedures to be followed and standby power supply.
    - 2) Number, location, direction and timing of headings including temporary drifts.
    - 3) Temporary tunnels, widenings, shafts, cuts and ramps.
    - 4) Batching plants, hoisting plant, tunnel ventilation, lighting and drainage.
    - 5) Methods of construction including details of installation of shotcrete lining, support elements (including lattice girder, welded wire fabric, forepoling bars and sheets, as necessary) and concrete lining.
    - 6) Method of controlling line and grade of lining; directional drilling and chemical grout arch.
  - b. Reinforcement design for cast-in-place lining wherever thickness of cast-in-place concrete is less than 12 inches but greater than nine.
  - c. Have drawings and computations certified by a professional engineer experienced in NATM tunneling and registered in the jurisdiction in which the work is to be performed.
  - d. For excavation of tunnels, submit drawings, calculations, descriptions and specifications for the following:
    - 1) Sequence and timing of excavation of top heading and bench/invert including excavation sequencing for individual excavation and support types, key excavation plan including sequence of installation of chemical grout arch, grouted pipe spiling and anticipated rate of advance.
    - 2) Concrete lining elements, support elements and their relationship to the plan and sequence of excavation and support, and waterproofing installation.
    - 3) Excavation equipment details including make and model numbers, specifications, and complete manufacturer's literature including copies of owner's manual and maintenance records.
3. Documentation:
  - a. Permits for disposal of excavated material:
    - 1) Arrange for disposal of excavated materials at locations outside the Authority's right-of-way, and obtain written permits from owners of property where excavated materials will be disposed.
    - 2) Submit permits and releases from each property owner absolving the Authority from responsibility in connection with disposal of such material.
  - b. Details of temporary ventilation:
    - 1) In the event it is planned to use equipment not covered by the SAFETY REQUIREMENTS Article of the General Requirements, submit details of such equipment for approval by the Engineer.
    - 2) Approval of the use of alternative equipment will depend on submitted research information concerning performance in accordance with applicable standards in common use.
  - c. Air quality reports: Daily reports of test for dust, toxic and hazardous gases and other atmospheric impurities in the working environment during construction.
  - d. Leak remediation plan:

- e. Include proposed application method equipment details and schedule, as well as complete manufacturer's literature, data, instructions and recommendations.
  - 1) Submit plans prior to beginning leak remediation work.
  - 2) Establish injection pressure by means of on-site demonstration; do not exceed structural capacity of lining.
- 4. Survey Control:
  - a. Survey personnel qualifications.
  - b. Type and location of horizontal and vertical control monuments to be set.
  - c. Survey procedures and equipment.
  - d. Design and location of theodolite instrument platform mounting bracket, bracing support hardware, method of attachment to shotcrete lining, brass mounting screw and standing platform underneath instrument mounting bracket.
  - e. Survey data collection equipment and software; and traverse reduction and adjustment software.
  - f. Survey equipment certification of adjustment; and calibration results of electronic distance measuring instruments (EDMI's) and prisms.
  - g. Tribrach adjustment method and equipment.
- 5. Samples:
  - a. One-foot long sections of vacuum lances, and drain pipes that show full cross section and type to be used. Submit three samples for each.
  - b. Two-foot long section of pipe to be used for grouted pipe spiling and rebar spiling that show full cross section and configuration of tip to be used. Minimum three-foot long tube-a-machette pipe.
- 6. Contingency Measures: At least 30 days prior to starting NATM excavation, submit the following for the Engineer's approval:
  - a. Name and qualification of personnel responsible for implementing contingency measures.
  - b. Plans outlining measures to be undertaken in the event of ground loss or instability at tunnel heading.
  - c. Plans outlining surveillance during longer stoppages such as weekends and holidays.
- 7. Submit to the Engineer for approval the qualifications and experience of the NATM engineer within 10 days of Notice to Proceed. Do not commence field work until approval in writing of the Engineer has been received by the Authority.
- 8. Submit to the Engineer for approval the qualifications and experience of NATM tunnel heading inspectors within 30 days of Notice to Proceed.
- 9. Submit to the Engineer for approval the qualifications of the firm or specialist responsible for groundwater control, and directional drilling within 10 days of Notice to Proceed.

**1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Have adequate supply of required materials for performing chemical grouting, grouted pipe spiling, rebar spiling, vacuum lances, drain pipes, water sheets and drain hoses, and other approved materials for measures always present at the site.

**PART 2 - PRODUCTS**

**2.01 NATM SHOTCRETE LINING:**

- A. See Section 02426.

**2.02 SHOTCRETE:**

- A. See Section 03370.

**2.03 CHEMICAL GROUTING AND DIRECTIONAL DRILLING:**

- A. As shown.\*7

**2.04 VACUUM LANCES AND DRAIN PIPES:**

- A. Two-inch diameter, rigid PVC pipe with filter fabric, slotted, length as required.

**2.05 WATERSHEETS AND DRAIN HOSES:**

- A. PVC sheet for application at exposed ground surfaces: System AKWA DRAIN, or equal.
- B. Flexible PVC hose with end couplings as required.

**2.06 WATERPROOFING:**

- A. See Section 07137.

**2.07 GROUTED PIPE SPILING:**

- A. General:
  - 1. 1- 1/2-inch diameter pipe, length 15 feet.
  - 2. Steel, black: ASTM A53.
  - 3. Perforated as shown and approved by the Engineer.
- B. Grout Mix Design: Ingredients that are compatible, noncorrosive to steel and free from calcium chloride.
  - 1. Cement: ASTM C150, Type 1.
  - 2. Sand: ASTM C144, except maximum particle size limited to Size 8 sieve. Water: Potable.
  - 3. Admixtures and additives: Fly ash or other pozzolanic materials; fluidifiers; accelerating, retarding and water reducing agents; and bentonite may be used if approved.

**2.08 REBAR SPILING:**

- A. No. 8 standard deformed reinforcing steel bars, length eight feet as shown on the Contract Drawings, conforming to ASTM A615, Grade 60.\*8

**2.09 DOWELS:**

- A. Injection Bore Anchors:
  - 1. Assembly: Length 10 feet, O.D. 30 mm, bearing plate washer and nut.
  - 2. Bearing plate 3/8-inch thick, with bearing area not less than 36 inches, conforming to ASTM A36.
  - 3. Washer and nut: ASTM A325.
  - 4. Source: Subject to meeting requirements of dowels, as manufactured by G. D. Chance Company, or equal.
- B. Grout Mix Design: According to manufacturer's recommendations.

## **2.10 GROUT MIX FOR CONTACT GROUTING:**

- A. Grout for Contact Grouting: One part portland cement, one part fine aggregate and approved admixture, or as approved otherwise by the Engineer.
- B. Minimum Compressive Strength: 100 psi within 24 hours. Perform and submit tests of comprehensive strength in accordance with C109.
- C. Water: Minimum water as needed to achieve water-cement ratio compatible with pumping and placing requirements.

## **2.11 ELECTRICAL INSULATIVE COATING:**

- A. Electrical Insulative Coating: Approved moisture-insensitive coating, 100 percent solids, containing no solvents for use on dry or damp concrete of steel surfaces, with the following additional requirements:
  - 1. Properties:
    - a. Minimum tensile strength: ASTM D638, 5,000 psi in 14 days
    - b. Dielectric strength: ASTM D1304, 440-465 volts per mil.
    - c. Dielectric constant: ASTM D1304 as follows:
      - 1) 60 Hertz: 3.4 - 3.5.
      - 2) 1,000 Hertz 3.3 - 3.4.
    - d. Power factor: ASTM D1304 as follows:
      - 1) 60 Hertz: 0.006 - 0.007.
      - 2) 1,000 Hertz 0.03 - 0.04.
    - e. Viscosity: 6,000 centipoises plus-or-us 1,000 centipoises, as determined by Brookfield Viscometer using No. 6 spindle at 50 rpm.
  - 2. Primer: Zinc-rich, MS MIL-P-26915 (USAF) Type 1, Class B.

## **2.12 INSTRUMENT PLATFORM MOUNTING BRACKETS:**

- A. Construction: Steel, minimum 1/8-inch thick, having a smooth finish where instrument attaches. Make bracket rigid enough to resist deflection or movement when a theodolite is mounted and operated on top of it. If deflection or movement is apparent, add bracing supports as directed by the Engineer.
- B. Bracket Supports: Attach bracket supports to the underside of platform mounting bracket to provide a clear and unobstructed working area at and above platform.
- C. Size: Sufficient length and width to allow efficient set-up and operation of various theodolite and electronic distance measuring instruments (EDMI).
  - 1. Minimum width: Nine inches.
  - 2. Minimum length: Sufficient to allow a mounted instrument a at least one foot clearance from tunnel lining.
- D. Install platform mounting brackets to a level plane within the adjustment limits of a standard tribrach.
- E. Forced Centering Hole: Provide each platform mounting bracket with a forced centering hole to accept a brass instrument mounting screw (standard 5/8-inch by 11-inch thread) for securing a standard tribrach.

1. Provide a brass mounting screw that is hollowed and of sufficient diameter to allow the instrument operator to site below platform mounting bracket with a nadir optical plummet
  2. Mill force centering hole and brass mounting screw to match each other within 0.001 inch tolerance.
  3. Provide the Engineer with three mounting screws for duration of the Contract.
- F. Surveyor Platform: Provide a platform underneath each instrument mounting bracket for the purpose of supporting a surveyor during measurement observation process from wither side of instrument.

### **PART 3 - EXECUTION**

#### **3.01 TEMPORARY VENTILATION:**

- A. Provide, operate and maintain for the duration of the project a temporary ventilation system which will conform to specified safety requirements and those of jurisdictional authorities. Remove the system from the site when work is completed.
- B. Use equipment which is adequate to maintain a sufficient supply of fresh air in underground work areas.

#### **3.02 SAFETY REQUIREMENTS:**

- A. Perform work so as to minimize safety hazards and exposure of men and equipment to hazardous and potentially hazardous conditions in accordance with specified safety requirements.
- B. In case of an emergency or work stoppage likely to endanger excavation or adjacent structures, continuously maintain full work force 24 hours per day including weekends and holidays until emergency or hazardous conditions no longer jeopardize stability and safety of the work.
- C. Perform tunnel construction so as to minimize ground movement in front of and surrounding the tunnel and prevent subsidence of surface, structures and utilities above and in the vicinity of the tunnel. Perform specified pre-support measures.
- D. Support ground continuously so as to prevent loss of ground and keep perimeters and maintain stability of tunnel faces, passages and bottom of shafts.

#### **3.03 DISTANCE BETWEEN HEADINGS:**

- A. Maintain longitudinal distance of a minimum of 150 feet between adjacent active tunnel faces being simultaneously excavated.
- B. Where tunnel heading is being advanced adjacent to previously excavated tunnel, ensure that shotcrete lining in the first tunnel is completely installed and stable.
- C. Where two tunnel headings of the same tunnel tube are being excavated toward each other, stop excavation at one face and install at this face elements of shotcrete lining and pre-support as specified and a minimum seven-inch thick one layer welded wire fabric reinforced shotcrete face support. Place these support measures at a minimum distance of 100 feet between the headings.

- D. Where tunnel heading is being advanced toward previously excavated tunnel, ensure that shotcrete lining and face support as specified in the stopped tunnel are completely installed and stable.

**3.04 SURVEILLANCE OF HEADINGS:**

- A. Maintain qualified personnel on duty to monitor conditions that might threaten stability of heading whenever tunnel excavation is suspended or shut down.
- B. Have one qualified inspector always on duty to monitor stability of face and roof during tunneling operations. Use of approved monitoring devices, such as closed circuit television, which permit continuous monitoring of conditions at the face by qualified observers from outside of the tunnel is permitted.

**3.05 DETECTION OF MOVEMENT:**

- A. Install instruments shown and monitor the horizontal and vertical movements of the tunnels and the station as applicable as specified in Section 02291. If movements are observed, take appropriate action to arrest these movements.
- B. Displacement Limits of Initial Lining:
  - 1. NATM tunnels:
    - a. Horizontal: 0.30 inch.
    - b. Vertical: 0.30 inch.
  - 2. NATM station:
    - a. Center drift:
      - 1) Horizontal: 0.50 inch.
      - 2) Vertical: 0.40 inch.
    - b. Side drifts:
      - 1) Horizontal: 0.20 inch.
      - 2) Vertical: 0.25 inch.
    - c. Center drift during excavation of side drifts in addition to 2.a. above:
      - 1) Horizontal: 0.50 inch.
      - 2) Vertical: 0.05 inch.
    - d. Middle drift:
      - 1) Horizontal: 0.30 inch.
      - 2) Vertical roof: 0.50 inch.
      - 3) Vertical invert: 0.60 inch.
  - 3. NATM shafts:
    - a. Shallow shafts:
      - 1) Horizontal: 1.0 inch.
      - 2) Vertical: 0.5 inch.
    - b. Deep shafts:
      - 1) Horizontal: 0.5 inch.
      - 2) Vertical: 0.5 inch.

**3.06 FIELD QUALITY CONTROL:**

- A. Do not encroach on NATM lining clearance line with shotcrete lining. Consider inaccuracy of construction, material tolerances, and shotcrete lining deflection to determine dimensions of actual excavation and support and pre-support elements.
  - 1. Install lattice girders as close as possible to the line of excavation but not closer than one inch (unless otherwise shown on the Contract Drawings), from the defined inside face of the initial lining.

2. Submit survey protocols and plotted profiles with a maximum spacing of 20 feet not later than 90 days after excavation.
- B. Document stability of the tunnel support system by monitoring as specified. Demonstrate the absence of continuing and significant deflection or increase of stress before installing the waterproofing system and the concrete tunnel lining.
1. Submit monitoring protocols and plotted information.
- C. Allowable Tolerances: Place cast-in-place concrete to the following tolerances:
1. Departure of tunnel, shaft and station from line or grade shown as measured from working point of tunnel, shaft and station: One inch.
  2. Variation in thickness of lining: Minus zero inch.
  3. Variation in internal diametrical distance between two points: Plus-or-minus one inch.

### **3.07 EQUIPMENT:**

- A. General:
1. Use equipment that can be controlled to desired line grade, minimize over excavation and loss of ground, capable of excavating the ground materials and grouted soils. Provide specified tunnels, shaft and station lining.
  2. Use equipment and methods that satisfy the requirements of this section while preserving and protecting the inherent strength of the material surrounding the tunnel, shafts and station.
- B. Grouting Equipment for Contact Grouting:
1. For pumping grout, use approved pump capable of developing specified uniform pressure at grout hole connection.
  2. Provide automatic shutoff control to prevent grouting pressure from exceeding that specified.
  3. Keep equipment lines clean by constant circulation of grout and by periodic flushing with water.
  4. Use equipment that allows flushing with grout-intake valve closed, water-supply valve open and grout pump running at full speed.
  5. Provide two pressure gauges, one at the pump and other on manifold hookup at collar of hole being grouted. Use pressure-gauge ranges as necessary for each part of the grouting program.
  6. Provide suitable stop valves at collar of hole to maintain necessary pressure until grout has set.
  7. Provide grouting equipment with means of accurately determining amount of grout injected.
  8. Furnish accurately calibrated, high-precision gauge to periodically check accuracy of pressure gauges.

### **3.08 INSTALLATION OF NATM SHOTCRETE LINING:**

- A. NATM Shotcrete Lining: Section 02426.

### **3.09 TUNNEL WATERPROOFING:**

- A. Install in accordance with Section 07138.

### 3.10 EXCAVATION:

- A. General:
1. Excavate to lines, grades, dimensions and tolerances, as shown and specified to accommodate shotcrete lining and concrete linings including waterproofing.
  2. Install support, pre-support systems and shotcrete lining as shown. Allow neither the shotcrete lining nor other support or pre-support systems to intrude into clearances required for the placement of the final concrete lining.
  3. Unless otherwise noted or approved by the Engineer, open up a new round of excavation only following the complete installation of the support elements of the previous round and for a length not exceeding the maximum length of unsupported excavation shown for the respective support and excavation type and specified herein. However, reduce the spacing of the lattice girders and the length of round if ground conditions and the actual stand-up time encountered or achieved by pre-support means so dictate.
  4. For station, remove shotcrete installed to support previously excavated tunnel or drift within the station interior as shown.<sup>9</sup>
  5. Apply additional subdivision of excavation areas, and face stabilization by means of a face stabilization wedge and/or shotcrete wherever ground conditions require to do so. The selected method is subject to approval by the Engineer.
  6. Apply a flash-crete layer immediately after excavation to seal and protect material from deterioration and initial loosening. Install shotcrete lining in a timely manner so as to maintain the inherent strength of the ground.
  7. Full face support with a minimum of two inches of shotcrete is mandatory for stoppages longer than 24 hours but not exceeding 72 hours. For stoppages beyond 72 hours full face support by a minimum seven inches thick shotcrete layer reinforced with one layer welded wire fabric is mandatory.
- B. General Excavation Sequences:
1. Top Heading: Apply pre-support in advance of excavation wherever required by ground conditions or specified hereafter.
  2. Bench/Invert: Excavate bench/invert alternating with advance of the top heading, with a remaining separation as shown.<sup>10</sup>
- C. Excavation and Support Types:
1. Generally, make the determination of excavation and support type in the top heading, and under consideration of the anticipated subsurface conditions immediately ahead of the face and in the following bench and invert area.
  2. Make evaluation of the ground conditions and of the appropriate excavation and support type in the top heading, and under consideration of the anticipated subsurface conditions immediately ahead of the face and in the following bench and invert areas.
  3. The approval of the proposed excavation and support type by the Engineer or his failure to call attention upon improper or inadequate application of the related excavation sequence and/or tunnel support and/or pre-support, or to require respective chance will not relieve the Contractor of his responsibility for the integrity of the tunnel support or the proper excavation of the work.
  4. Excavation and Support Type 1:
    - a. Top heading and bench/invert excavation, top heading two rounds ahead of bench/invert excavation as shown.
    - b. Tunnel support requirements include:
      - 1) Shotcrete lining: minimum seven-inch thick shotcrete, reinforced with one layer of welded wire fabric type 6 x 6 - w4.0 x w4.0, lattice

- girders, splice bards, and splice clip as shown on the Contract Drawings.
  - 2) Grouted pipe spiling: 1.5-inch I.D. perforated steel pipe. Where no systematic grouted pipe spiling pre-support measures have been installed as specified herein, install grouted pipe spiling at length and at locations as required. Where installed for more than one section overlap, make spiling minimum three feet.
  - c. Face stabilization:
    - 1) Shotcrete minimum two inch thickness as required.
    - 2) Face stabilization wedge in top heading or bench/invert as required.
  - d. Maximum length of unsupported excavation (excluding length for wwf reinforcement overlap as shown): Install support elements within a distance to the face of 3'-4" in the top heading, and 6'-8" in the bench/invert.
  - e. Maximum distance between top heading face and shotcrete closure in the invert: 16'-8" (excluding lengths for welded wire fabric overlap as shown).
  - f. In case of stoppages and in addition to other requirements, provide invert closure at a maximum distance of 11'-10" for stoppages exceeding 72 hours.
5. Excavation and Support Type 2:
- a. Top heading and bench/invert excavation, top heading one round ahead of bench/invert excavation as shown.
  - b. Tunnel support requirements include:
    - 1) Shotcrete lining: minimum seven-inch thick shotcrete, reinforced with one layer of welded wire fabric type 6 x 6 - w4.0 x w4.0, lattice girders, splice bards, and splice clip as shown.
  - c. Rebar Spiling: No. 8 rebar, eight feet long, installed as required individually or up to around tunnel roof perimeter as shown.
  - d. Face stabilization:
    - 1) Shotcrete minimum two-inch thickness.
    - 2) Face stabilization wedge in top heading or bench-invert as required.
  - e. Maximum length of unsupported excavation (excluding length for wwf reinforcement overlap as shown on the Contract Drawings): Install support elements within a distance to the face of three feet four inches in the top heading, and six feet eight inches in the bench-invert.
  - f. Maximum distance between top heading face and shotcrete closure in the invert: 13'-4" (excluding lengths for welded wire fabric overlap as shown).
  - g. In case of stoppages and in addition to other requirements, provide invert closure at a maximum distance of 8'-6" for stoppages exceeding 24 hours.<sup>\*\*11</sup>

D. Pre-Support:<sup>\*\*12</sup>

- 1. Three types of tunnel roof pre-support are specified:
  - a. Chemical grouting.
  - b. Grouted pipe spiling.
  - c. Rebar spiling.
- 2. Do not perform NATM tunnel excavation without the aid of specified pre-support measures
- 3. Install chemical grout arch above both inbound and outbound tunnels as shown. Install grouting pipes for the chemical grouting canopy by means of directional drilling and perform chemical grouting as specified.
- 4. Perform grouted pipe spiling in a systematic manner as shown and as specified for both the inbound and outbound tunnels
  - a. Exact extent of grouted pipe spiling to be determined in the field in accordance with the following requirements:

- 1) Grouted pipe spiling to overlap with chemical grout arch for a length of a minimum of five feet.
  - 2) Grouted pipe spiling to be installed as long as cover of P1 material above tunnel crown is five feet or less.
  - b. Install pipes for grouted pipe spiling in four-inch diameter pre-drilled holes. Use distancers to center pipes in boreholes.
  - c. Inject cement grout through perforated pipes with low pressure until entire predrilled hole is grouted.
  5. Rebar spiling: Install rebars without end hardware by jacking.
  6. As required by geologic conditions encountered, substitute specified roof pre-support with another specified measure after obtaining written approval from the Engineer.
  7. Provide additional pre-support measures as required by geological conditions encountered or as directed by the Engineer.
- E. Sequence and Direction of Tunneling:
1. Install chemical grout arch as shown.
  2. For limitations and direction of tunneling conform to **Section \_\_\_\_\_**.
- F. Probe Drilling:
1. During excavation in accordance with Excavation and Support Type 1 drill two-inch minimum diameter probe holes to determine soil and groundwater conditions ahead of tunneling.
  2. Drill a minimum of three probe holes in the top heading; one located at approximately the tunnel center line and two feet below the tunnel roof, one each to both sides of the tunnel approximately two feet above the top heading invert and three feet distant from the tunnel wall. Alter location of probe holes as approved or as directed by the Engineer.
  3. Add more probe holes as required and as directed by the Engineer.
  4. Drill probe holes to minimum distance of 50 feet ahead of the excavation face.
  5. Drill 50 feet probe holes after every 40 feet of tunneling so that soil and groundwater conditions are always known for a minimum 10 feet ahead of tunneling.
  6. Drill probe holes only in the presence of the Engineer.<sup>\*13</sup>
- G. Groundwater Control:
1. Control groundwater in soil surrounding each tunnel to prevent the following:
    - a. Heaving of invert, blow-ups, hazardous seepage, and sudden flow of soil in the tunnel face.
    - b. Loss of ground and surface subsidence.
  2. Perform free-air tunneling when groundwater levels, as observed in piezometers are:
    - a. Lowered to the top of P1 material or lower four weeks prior to tunneling. Use at a minimum piezometers CP-1, CP-2 and CP-3 as shown on the Contract Drawings to verify groundwater levels.
    - b. Dewatering requirements are provided in accordance with Section 02240.
  3. Maintain groundwater levels as specified herein and in Section 02240 during tunneling and until minimum four weeks after cast-in-place concrete lining is installed and approved.
  4. Collect infiltrating groundwater and pump or drain it out of the tunnel.
  5. Where a probe hole indicates water inflow apply further investigation by drilling an additional probe hole approximately two feet below the water bearing probe hole. Repeat this procedure until invert level is reached.
    - a. Use vacuum lances and/or drain pipes installed along the tunnel perimeter or otherwise as required to provide relief from water.

- b. Commence tunneling after sufficient results of dewatering could be verified, or as directed by the Engineer.
  6. Upon approaching saturated strata during tunneling, seal entire excavation face with a minimum four inches of shotcrete, reinforced with one layer welded wire fabric, and apply drain pipes and/or vacuum lances as dewatering measures. Excavation may continue after sufficient results of the additional dewatering measures could be verified, or as directed by the Engineer.
  7. Prior to application of shotcrete lining, collect seeping groundwater or local groundwater inflow by means of drain hoses or water sheets or both to prevent build up of hydrostatic pressure behind the shotcrete lining and to prevent deterioration or reduction of the strength properties of the fresh shotcrete. Use water sheet to collect water seepage through shotcrete and drain away by means of drain hoses.
  8. Install and always maintain temporary drainage sumps at minimum one foot below tunnel invert and locations as required, and construction drains at tunnel sidewalls of sufficient capacity to pump out water collected from within the tunnel.
  9. Maintain drainage and pumping systems free of hardness build-up caused by calcification and/or corrosive characteristics of the groundwater, treat systems to prevent or kill bacterial clogging of screens, piping and sumps.
  10. Use approaching previously drilled exploratory or other borings which intersect the tunneling cross section, ensure that procedures and materials are in place to immediately seal off and stabilize the borehole as required to prevent water inrush and/or associated groundloss.
- H. Break-Out:
1. Install shotcrete reinforced collars around the proposed break-outs from the support of excavation as shown on Contract Drawings. Submit for approval by the Engineer collar arrangement and break-out construction procedures as adjusted to actual support of excavation.
  2. Excavate and support tunnels in the start-up section as shown.
  3. Prior to break-out construction, install horizontal drain pipes and/or vacuum lances as required two feet below the tunnel invert for the local dewatering.
    - a. Utilize knowledge of geologic conditions based on shaft excavation.
    - b. As required to promote invert stability, limit length of round in bench/invert to three feet and four inches.
  4. Construct break-out prior to "hole through" at support of excavation.
  5. Construct break-out following installation of chemical grout arch.
- I. Air Quality:
1. Conduct drilling and tunneling operations by methods and with equipment that will positively control dust, fumes, vapors, gases, fibers, fogs, mists or other atmospheric impurities in accordance with specified safety requirements.
  2. Provide approved instruments for testing quality of tunnel atmosphere, take samples under working conditions at prescribed intervals. Submit results of the quality tests on a daily basis.
- J. Dispose of excavated material at locations outside the Authority's right-of-way. If contaminated soil is unexpectedly encountered, inform the Engineer immediately for a resolution.
- K. Dispose of groundwater and wastewater from the operation as quickly as possible without causing damage. Maintain ditches and sump pumps. Dispose of groundwater in an environmentally approved manner to meet or exceed the code requirements.

- L. Temporary Backfill: Protect the invert area of tunnel tubes from construction equipment traffic until placing of the final invert concrete by means of a work slab, gravel bed, or other suitable material approved by the Engineer. Have the temporary backfill protect the shotcrete lining from being damaged. This invert protection road to have a height in the centerline of the tunnel of at least three feet unless otherwise approved.
- M. NATM Portal Wall:
  - 1. The Contractor may choose slurry wall or other equivalent methods to construct the NATM portal wall.
  - 2. The Contractor is not allowed methods such as soldier piles and lagging method to construct the NATM portal wall.
  - 3. Have methods of excavation and portal wall construction approved by the Engineer before starting excavation and construction of the portal wall.

### **3.11 TEMPORARY TUNNEL WIDENINGS, WORKSHAFTS AND OTHER OPENINGS:**

- A. Design, excavate, support and backfill temporary tunnel widenings, workshafts and other openings conforming to this section, and in accordance with Sections 02320 and 02260.
- B. Seal such openings when no longer necessary.
- C. Form and place Class 2500 concrete, two feet thick, in shafts over tunnels to prevent damage to tunnel shape. When concrete has achieved design strength, backfill remaining void in accordance with Section 02320.

### **3.12 TUNNEL CONNECTION AND TERMINATIONS AND TEMPORARY BULKHEADS:**

- A. Connect new tunnels to existing structures by removing existing bulkheads if necessary and sealing junctions.
- B. Provide temporary bulkheads to seal terminations of tunnels which are not connected to permanent structures.
- C. Design temporary bulkheads where and when necessary. Obtain approval of the design prior to construction. Provide bulkhead which is capable of resisting lateral earth and hydrostatic pressures, waterproof and capable of removal without damage to concrete lining.

### **3.13 CONCRETE CONSTRUCTION:**

- A. Fill enlargements of tunnel excavation beyond dimensions shown with concrete, to provide a proper surface for installing waterproofing.
- B. Install waterproofing and perform concrete work in accordance with Sections 03100, 03200, and 03300.
- C. Place concrete for lining upper portion of tunnel by mechanical or pneumatic methods through pipes which discharge as nearly as practicable to highest point of structure.
- D. Protect waterproofing during installation of reinforcement and forms for placing cast-in-place concrete lining.
- E. Schedule erection of concrete tunnel lining so that the concrete is placed after decline of shotcrete lining deflection.

- F. Perform contact grouting through grout pipes in the roof.

**3.14 DEFECTIVE LINING:**

- A. Watertightness Criteria: Section 03300.
- B. Cast-in-place concrete lining will be considered defective if thickness of cast-in-place concrete at any point is less than 12 inches.

**3.15 CORRECTIVE WORK:**

- A. Provide reinforcement in cast-in-place lining wherever thickness of cast-in-place concrete at is less than 12 inches but greater than nine, at no additional cost to the Authority.
- B. Cast-in-place lining less than nine inches thick:
  - 1. Wherever cast-in-place concrete lining is less than nine inches thick, enlarge the excavation cross section by remining, so that the specified minimum thickness is achieved.
  - 2. Support the tunnel shotcrete lining during remining.
  - 3. Submit method of support during remining, including design calculation signed by a professional engineer registered in the jurisdiction where the work is being performed, description of material, and sequence of operation for the Engineer's approval.
  - 4. Maintain qualified personnel, equipment and adequate supply of materials on-site to perform emergency support measures during remining. Submit emergency action plan for the Engineer's approval prior to starting remining operations.

**3.16 INSTALLATION OF ELECTRICAL INSULATIVE COATING:**

- A. Electric insulative coating installation may be omitted if the geomembrane meets the dielectric strength of 440-465 volts per mil as specified for electric insulative coating. If electric insulative coating will be installed, install as follows:
- B. Apply coating prior to placement of invert and safety walk concrete on shotcrete lining.
- C. Surface Preparation: Remove dirt, grease and heavy laitance by wet sandblasting, water blasting or wire brushing.
- D. Application: Apply in two coats of equal thicknesses totaling 20 mils minimum dry film thickness in accordance with recommendations of coating manufacturer

**PART 4 - MEASUREMENT AND PAYMENT**

**4.01 MEASUREMENT:**

- A. Placement of perforated steel pipes in predrilled holes: Lineal feet.
- B. Placement of steel bars: Lineal feet.
- C. Placement of lances and drain pipes (slotted PVC pipes): Lineal feet.
- D. Measurement for payment will not be made for the following items:
  - 1. Drilled holes, grouted pipe spiling, rebar spiling, vacuum lances or drain pipes lost or damaged due to Contractor's negligence.

2. Grout loss due to improper anchorage of grout pipes, injections, and failure of Contractor to seal leaks.
  3. Loss of grout when work is not being performed in accordance with specifications and is interrupted by the Engineer, or when work is stopped to implement specified contingency measures.
- E. Except as defined below, no separate measurement or payment will be made for work specified in this section, such work being considered incidental to and part of other pay items.

#### **4.02 PAYMENT:**

- A. Compensation for the following will be made on unit price basis.
1. Furnishing and installing Grouted Pipe Spiling for NATM Tunnels: Payment will be made for total length of pipes incorporated in work. Cost of pipes, drilling holes, grouting, fittings, manifolds, pumps, hoses, connections, and other incidentals required to perform work will be included in cost for placing pipes.
  2. Furnishing and installing rebar spiling for NATM Tunnels: Payment will be made for total length of steel bars incorporated in work. Cost of steel bars and other incidentals required to perform work will be included in cost of placing rebar spiling.
  3. Furnishing and Installing Vacuum Lances and Drain Pipes for NATM Tunnels: Payment will be made for total length of slotted PVC pipes incorporated in work. Cost of lances and pipes, hoses, connections, fittings, filter fabric, collection pipes, pumps, operating costs and other incidentals required to perform work will be included in cost for placing lances and drain pipes.
  4. Cost of work includes cost of materials, labor and equipment required to perform work.
  5. Compensation for work specified in this section will be made in the following manner:
    - a. Grouted Pipe Spiling in NATM Tunnels: Lineal feet.
    - b. Rebar Spiling in NATM Tunnels: Lineal feet.
    - c. Vacuum Lances and Drain Pipes: Lineal feet
    - d. Work not included in above is included in Lump Sum Pay Item No. 1.

**SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.**

#### **ENDNOTES:**

- \*1. Include the limits of NATM excavation and construction sequence on structural Contract Drawing.
- \*2. Include "Excavation and Support Types" based on the material anticipated being encountered during the proposed excavation. These types should also be shown and clarified on the structural Contract Drawings.
- \*3. On a case-by-case basis, if directional drilling is to be used, write a new specification section on directional drilling.
- \*4. Establish the frequency of mapping.
- \*5. List additional Quality Assurance (QA) requirements, including requiring other specialists as necessary on the Contractor's field staff, depending on the soil encountered and the procedures proposed. As an example, a proposal for jet grouting should be included in the definitions and QA sections and a jet grouting specialist should be required on the Contractor's staff.

- \*6. If an NATM Portal Wall is proposed at the beginning of excavation, include requirements such as the maximum lateral movement of soil behind the wall, the vertical movement of the wall, provisions for grouting for pre-support and chemical grout arch etc.. Otherwise delete this paragraph.
- \*7. If directional drilling is to be used, write a new specification section on directional drilling.
- \*8. If rebar spiling is used, show it on the Structural Contract Drawings. The size and the length of spiling rebar may be changed by the Section Designer if warranted by subsoil conditions.
- \*9. Show these on the Contract Drawings.
- \*10. Show the scheme of excavation sequence indicating heading, bench/invert, center drift, side drifts, middle drift, etc.
- \*11. Revise these support Types 1 and 2, if necessary, to suite the subsurface conditions anticipated, based on the subsoil exploration.
- \*12. Show types and extent of such support on Contract Drawings.
- \*13. Show the arrangement of probe holes on Contract Drawings

**END OF SECTION**

## SECTION 02420

### ROCK REINFORCEMENT

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing and testing rock bolts, accessories, welded-wire fabric and miscellaneous steel for reinforcement of rock.
- B. Related Work Specified Elsewhere:
  - 1. Rock tunneling: Section 02410.
  - 2. Drilling and pressure grouting: Section 02431.
- C. Definitions:
  - 1. Initial support: Section 02410.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ASTM: A185, A615, C144, C150, C579, F432.
- B. Demonstration:
  - 1. Prior to installation of rock bolts, arrange demonstration to show that specified test requirements have been met.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Prior to beginning work, submit the following:
      - 1) Locations, installation procedures and layouts of rock bolt installations.
      - 2) Pattern covering crown, sidewalls and face.
      - 3) Spacing, type, size and length of rock bolts, together with type of bolt accessories and surface covering.
      - 4) Relationship to rock discontinuities and execution sequence as well as time and distance from face for installation.
  - 2. Samples:
    - a. Bolts:
      - 1) At least 30 days prior to purchase of rock bolts, obtain samples of various sizes and types to be used from normal stock of manufacturer. Submit three such sample bolts of each type for testing by an independent testing agency designated by the Engineer.
      - 2) In the event of failure, provide additional samples until it can be demonstrated that bolts scheduled for delivery meet specified requirements.
    - b. Grout additive:
      - 1) One two-ounce sample of pure, unpolished metallic aluminum powder or similar additive proposed for use in grout mixture.

- c. Resin cartridges:
  - 1) Three samples of each type of resin cartridge.
- 3. Certification:
  - a. Prior to installation of rock bolts, arrange demonstration to show that specified test requirements have been met.
  - b. Certificates verifying that samples for testing are from normal stock.
  - c. Certified mill reports of the bolts.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS:**

- A. Rock Bolts and Accessories:
  - 1. General requirements:
    - a. In accordance with ASTM F432.
    - b. Rock-bolt assembly: Bolt, bearing plate, washer and nut as specified.
    - c. At least 5-1/2 inches of rolled thread on outer end.
    - d. Fabricated from deformed bars.
  - 2. Type 1, with resin end anchors and fully resin-encapsulated:
    - a. ASTM A615, Grade 60.
    - b. Approved method of resin anchorage to take specified tension.
  - 3. Type 2, with mechanical end anchors and fully grouted:
    - a. ASTM F432, Grade 55, hollow core.
    - b. Approved expansion-shell anchorage on inner end.
  - 4. Protective grease: Type used for bilge protection, containing rust-inhibiting compounds, factory-applied to threads of rock bolts and entire surface of nuts and washers.
  - 5. Steel bearing plates: Square, not less than 3/8-inch thick, having bearing area of at least 36 square inches unless otherwise shown, with holes for injection of grout, for effective air release and for bolt. Hole in steel bearing plate of sufficient size to eliminate binding of bolt.
  - 6. Nuts: Hexagonal head
  - 7. Steel washers: Quenched and tempered. Hard-steel washers to be two inches in diameter and 1/8-inch thick unless otherwise shown. Center hole to be 1/8-inch larger in diameter than bolt with which it is to be used.
- B. Miscellaneous Steel: Products of recognized manufacturer, comprising rock-bolt mats, mine roof ties, mine roof channels or similar members which are attached to roof surface by means of rock bolts.
- C. Wire Fabric: ASTM A185, hot-dip galvanized.
- D. Expansion Shells: As approved, capable of developing guaranteed minimum yield strength of rock bolt.
- E. Grout and Mortar:
  - 1. Cement: ASTM C150, Type I.
  - 2. Water: Section 03300.
  - 3. Additive: Pure, unpolished metallic aluminum powder or other approved additive.
  - 4. Sand: ASTM C144, except maximum particle size limited to Size 8 sieve.
- F. Lubricant for Threads and Washers: Molybdenum-disulfide base, Molykote G, Alpha Molykote Corporation or equal.
- G. Resin Cartridges:

1. Two components as follows:
  - a. Resin: High-strength unsaturated polyester with predominance of nonreactive inorganic filler.
  - b. Catalyst: Containing peroxide with nonreactive inorganic filler.
2. Strength of mixed and cured resin when tested in accordance with ASTM C579:
  - a. Compressive strength: 17,000 psi.
  - b. Tensile strength: 7,500 psi.
  - c. Shear strength: 4,800 psi.
3. Gel time:
  - a. Gel and cure time of fast-set resin: Sufficient to permit bolt tensioning within 10 minutes or as recommended by manufacturer for the particular application.
  - b. Gel time of slow-set resin: 15 to 30 minutes.
4. Materials to have thixotropic and viscous properties to permit adequate mixing of materials by manipulating bolt and to prevent mixture from running out of hole after mixing.
5. Shelf life: Six months, minimum.
6. Casing constructed of saturated polyester providing optimum resistance to moisture but easily fractured to enable complete mixing during installation.

## **2.02 MIXES:**

- A. Grout:
  1. Mix cement and sand dry.
  2. Add water to obtain water-cement ratio of approximately 0.4 by weight.
  3. Mix in high-speed mixer for three minutes minimum.
  4. Prepare batches so that time before use does not exceed 45 minutes.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION - GENERAL:**

- A. For underground excavation in rock on which bolts are used, install rock bolts within three feet of heading and within eight hours after blasting and prior to next shot.
- B. When excavating with tunneling machine which provides direct ground support over machine such as a shield, install rock bolts within three feet of trailing edge of such support.
- C. After each exposure of final rock surface, examine surface and confirm that rock bolt pattern to be installed will be adequate. Provide rock reinforcement that is adequate at all times to ensure safety of personnel and construction operations.
- D. Drill holes in rock of depth and diameter necessary to accommodate bolt and to give anchorage consistent with type and length shown on Contract Drawings and approved shop drawings. Clean holes of drill cuttings, sludge and debris.
- E. Avoid damaging threads on projecting end of bolt during installation.
- F. Remove protective grease from threads and nuts.
- G. Apply lubricant to threads. Use lubricant between washers and nuts.
- H. Between bearing plate and steel washer, set bearing surface of nut perpendicular to bolt by use of bevel washers as necessary.

### **3.02 INSTALLATION OF RESIN-ANCHORED (TYPE 1) ROCK BOLTS:**

- A. For installation of resin-anchored rock bolts, have qualified representative of manufacturer supervise installation of initial 50 rock bolts. Have representative periodically reinspect installation procedures.
- B. After drilling of rock bolt holes has been completed, insert resin cartridges in accordance with manufacturer's recommendations for anchorage conditions. Avoid rupture of cartridge skin.
- C. To rupture cartridge and mix resin, insert bolt in hole rotating it at penetration rate of two inches per second through cartridge. Rotate bolt by mechanical means for five to ten seconds after bolt reaches bottom of hole or for 20 seconds minimum, whichever is least.
- D. Apply tension as specified after recommended cure time for fast-set resin has elapsed, but before gel time for slow-set resin has elapsed.

### **3.03 INSTALLATION OF MECHANICALLY ANCHORED (TYPE 2) ROCK BOLTS:**

- A. Insert bolt in hole and set anchorage at necessary depth.
- B. Tension bolt as specified.
- C. Grout bolt as specified.

### **3.04 GROUTING OF ROCK BOLTS:**

- A. Pack or seal holes in bearing plate and between bearing plate and rock or shotcrete surface so that grout will be retained in hole.
- B. Inject grout into hole at pressure not greater than that necessary to fill hole adequately.
- C. Continue injecting grout until there is full return of grout through air vent.
- D. If, during grouting of bolt, grout is found to flow from points in adjacent rock surface, plug or caulk leaks until leakage is stopped.
- E. Grout only rock bolts located further than 50 feet behind working face as heading advances.

### **3.05 TENSIONING OF ROCK BOLTS:**

- A. Type 1 - Resin Anchored: Nominal tension to ensure proper nut tightening, not to exceed 20 percent of bolt guaranteed minimum yield strength.
- B. Type 2 - Mechanically Anchored: Tension rock bolts by direct pull using approved hydraulic jacks and accurate calibrating techniques to between 60 and 80 percent of bolt guaranteed minimum yield strength; tighten nut.
- C. If specified tension is not achieved for tensioned rock bolts, submit modified procedure for approval.

### **3.06 PULL TESTS ON INSTALLED BOLTS:**

- A. Equipment:
  - 1. Provide equipment consisting of suitably sized hollow ram jack, adjustable bearing truss for aligning direction of pull with centerline of bolt, extension bar for attaching

jack to bolt, hydraulic pump with gauge calibrated to read directly in pounds for ram being used, dial gauge which reads in increments of 0.001-inch over a range of two inches, magnetic or independent dial gauge mounting and other necessary accessories.

2. Calibrate pump gauge while connected to jack by testing machine before performing pull tests and at subsequent times as directed during construction period.
3. Maintain ready access to spare parts for testing equipment, especially gauges and pump seals, so that work will not be delayed.
4. Maintain pull test equipment in good working condition.
5. Ensure that equipment is used exclusively for pull tests. Store as directed.

B. Testing:

1. Conduct pull tests on installed rock bolts as directed.
2. Perform testing to:
  - a. Measure head movement.
  - b. Verify that specified tension can be sustained by bolt and anchorage without yield of steel or rock or slip of anchor.
  - c. Check grouting procedure and prove grout strength.
3. Test rock bolts as follows:
  - a. As selected at random by the Engineer according to the following schedule:

For Each Rock Bolt Type Installed	Required Testing
First 100 bolts	10
Remaining bolts	1 per 100

- b. No earlier than 24 hours and no later than three days after installation.
  - c. To at least 80 percent of minimum specified yield strength.
4. Correction of defective work:
  - a. For test purposes, bolt will be considered to have failed if outward movement of bolt anchorage in excess of 0.001-inch occurs and continues to occur at sustained loading below tension specified.
  - b. Replace bolts that fail or pull out with bolts that meet specified testing requirements.
  - c. Perform further testing, up to a minimum of five rock bolts in vicinity of failed bolt as directed. Replace as directed bolts that fail or pull out.

**3.07 ROCK SURFACE REINFORCEMENT:**

- A. Install where shown, where directed and where approved when conditions at the site dictate, rock surface reinforcement consisting of wire fabric, miscellaneous steel or a combination of both. Rock conditions which may require surface reinforcement include, but are not limited to, places where the rock is weathered, excessively jointed or fractured or where it has a tendency to spall.
- B. For installation of surface reinforcement and rock bolts simultaneously, place reinforcing materials over rock bolts between rock surface and steel bearing plate; tension bolt to draw reinforcing materials up tightly to the rock surface. Where wire fabric is used, overlap 1-1/2 times mesh dimension.
- C. Where surface covering or reinforcement is placed after installation of rock bolts, attach materials to previously installed bolts by use of additional steel plate and nut by welding or

by supporting with additional rock bolts. Check existing rock bolts to which extra steel plate and nut are added.

- D. Replace installed bolts which become loose after attachment of surface reinforcement.
- E. Firmly attach surface covering or reinforcement so that it closely follows approximate contour of rock.

**END OF SECTION**

## SECTION 02425

### PRECAST-CONCRETE TUNNEL LINING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing precast-concrete segments for use as lining rings in one-pass tunnels with waterproofing gaskets and bolts, and as the initial lining of the two-pass system tunnels. Precast concrete lining segments for the two-pass system may be either gasketed and bolted when the initial liner needs to exclude water from tunnels being driven; or the segments may be jacked in place and retained by steel dutchmen and then grouted
- B. Related Work Specified Elsewhere:
  - 1. Installation of the linings: Section 02415.
  - 2. Concrete formwork: Section 03100.
  - 3. Concrete reinforcement: Section 03200.
  - 4. Cast-in-place structural concrete: Section 03300.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. MS: MIL-23241 (Ships), MIL-P-26915 (USAF).
  - 3. FS: QQ-L-201, TT-S-230.
  - 4. ACI: 318.
  - 5. ASTM: A36, A123, A126, A153, A185, A325, A615, A706, C143, C309, C509, D395, D412, D471, D2240, D2628, F436.
  - 6. AWS: D1.4.
- B. Dimensional Tolerances:
  - 1. Fabricate segments to dimensions and tolerances shown. Contractor may use closer tolerances if necessary for erection, watertightness or both.
  - 2. Maintain tolerances at mean temperature of 68F. Measure tolerances prior to installation of gasket and elastomeric compression packing. Replace or correct segments which do not comply with tolerances shown.
  - 3. Determine the necessary taper of rings to cope with horizontal and vertical curves or to correct misalignment, and submit details for approval.
  - 4. Provide labor, tools, templates and facilities necessary for inspection of manufactured segments.
  - 5.
- C. Demonstration Lining:
  - 1. Before starting production of precast-concrete segments, furnish five-ring long section of complete precast-concrete segment lining, including gasket, compression packing, exterior coating, nuts, bolts and accessories to demonstrate construction of completed precast-concrete segment lining within tolerances shown. Include in demonstration lining two rings using tapered segments. For segments to be installed in earth tunnels include water-repellant treatment.
  - 2. Assemble entire demonstration lining at job site, above ground, with longitudinal axis of rings horizontal. Provide temporary support structures such as base cradle and lateral bracing for such demonstration. Place rings in longitudinal compression using identical type of holding devices proposed for use in tunnel erection.
  - 3. Notify the Engineer 15 days prior to installation of demonstration lining.

4. Maintain demonstration lining until tolerances of completed lining are verified and removal is approved. Dismantled segments may be used for permanent tunnel lining, if approved.
  5. If approval is withheld, dismantle demonstration lining as directed, adjust forms, cast new segments, if necessary, and erect new demonstration lining for approval.
- D. Production Units:
1. Commence production of segments only after written approval of demonstration lining has been obtained.
- E. Recorders: If casting is done at off-site plants, recorders described in Section 03300 are not required.
- F. Tunnel Demonstration Lining:
1. Construct one additional demonstration lining in initial 20 feet of tunnel. Erect the lining within the tail of the shield utilizing the erection methods for this project. The purpose of this additional demonstration lining is to ensure that the tunneling and erection procedures are capable of erecting the complete tunnel lining to the specified tolerances.
  2. Stop tunneling after installation of the 20 feet (five rings) of demonstration lining until tolerances are verified and approved.
  3. If approval is withheld, submit proposed measures to rectify the 20-foot demonstration lining as well as proposed modification of procedures to ensure satisfactory installation of the tunnel lining.
  4. Do not resume tunneling until corrective measures are approved and implemented.
  5. After approval of corrective measures, construct an additional lining if required by the Engineer.
- G. Quality-Assurance Program for Gaskets: Before starting production of gaskets, provide quality-assurance program to ensure that manufactured gaskets meet the same specifications and quality as originally approved.
- H. Rebar-Coating Applicator: Company approved by the Engineer specializing in hot-dip galvanizing after fabrication.
- I. Qualifications of Fabricator: Have precast-concrete segments fabricated by a firm with recent continuous successful experience in the fabrication of precast-concrete structural units with tolerances equivalent to those specified in this section.
- J. Adjust, if necessary, the gasket and gasket-groove dimensions to satisfy gasket testing requirements specified in Article 3.3.B, with the approval of the Engineer.

### **1.03 SUBMITTALS:**

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings:
    - a. Include complete details of formwork, reinforcement, inserts and accessories necessary for manufacturing, transportation and erection.
      - 1) Have drawings and design certified by a professional engineer licensed to practice in the jurisdiction where the work is to be performed.
      - 2) Detailed design for segment lifting devices, providing for complete removal of lifting device if device intrudes into tunnel space
    - b. Plant layout: Detailed flow diagram showing stages in manufacture of segments.

- c. Procedures:
  - 1) Detailed description of procedures for fabricating, handling, transporting, storing and erecting segments, including calculations of stresses during handling.
  - 2) If the reinforcement shown on the Contract Drawings is inadequate for the handling, storage, stacking and erection forces, including jacking, provide additional reinforcement to compensate for the anticipated stresses at no additional cost to the Authority.
- 2. Samples
  - a. Exterior coal-tar epoxy coating: One quart.
  - b. Gasket: One complete ring for each type.
  - c. Compression packing: Two square feet.
  - d. Adhesive: One pint of each kind used.
  - e. Bolt, with washer, nut and grommet in sets: Two of each set.
  - f. Sealant: Two tubes.
  - g. Back-up rod: Three feet.
  - h. Grout plugs: Two.
  - i. Water-repellant treatment: One-quart container and one concrete panel, 12 inches square, treated on one side.
  - j. Bolt sleeves, if required: Two.
- 3. Certification:
  - a. Certified reports of successful testing by an independent testing agency verifying that elastomeric joint-seal materials conform to the requirements of ASTM D2628 for earth-tunnel segments and with ASTM C509 for rock-tunnel segments.
  - b. Certification that fabricator of segments has demonstrable experience in the fabrication of precast-concrete structural units similar to specified units as a predominant portion of its production.
  - c. Certification for concrete as specified in Section 03300.

#### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Precast Concrete Segments:
  - 1. Store and handle materials in accordance with Section 03300, with the following additional requirements:
    - a. Transport, store and handle segment units so as to prevent damage to surfaces, edges and corners and to prevent development of stresses within units.
  - 2. Keep units under cover and protected prior to installation.
  - 3. Protect mating surfaces of segments and gaskets from detrimental conditions during transportation.
  - 4. The Authority retains the right to reject any segments structurally damaged as a result of improper fabrication, handling, storing, stacking or transporting of the segments.
  - 5. Ship tapered units of complete rings, properly identified, when the segments are to be bolted for erection.
  - 6. Provide a positive means of identifying each segment, acceptable to the Authority. Identification markings must be cast in or stenciled on the interior face of the segments.
- B. Water-Repellant Treatment:
  - 1. Deliver products to the job site in their original unopened containers clearly labeled with the manufacturer's name and brand designation, the referenced specification number, and the quantity or net weight of contents.
  - 2. Store products in an approved dry area and protect from contact with soil and from exposure to the elements. Keep products from freezing.

3. Handle products in a manner that will prevent breakage of container and damage to contents.
- C. Markings, including logos, trademarks and proprietary information, but excluding panel-identification markings, are prohibited on surfaces of tunnel-lining segments.

#### 1.05 JOB CONDITIONS:

- A. Environmental Requirements:
1. Do not apply water-repellant treatment to unprotected surfaces in wet weather or to surfaces on which ice, frost, or water is present.
  2. Do not apply water-repellant treatment unless the ambient temperature is at least 50F and rising unless approved in writing.
  3. Provide ventilation in accordance with specified safety requirements.

#### PART 2 - MATERIALS:

##### 2.01 MATERIALS:

- A. Concrete:
1. Section 03300, with not less than seven bags of cement per cubic yard of concrete, with the following additional requirements as determined by ASTM C143:
    - a. Rock-tunnel segments: Class 5000.
    - b. Earth-tunnel segments: Class 8000.
    - c. Initial liner segment for two-pass tunnel: Class 6000.
    - d. Use mix of portland cement and ground-iron blast-furnace slag. Blast-furnace slag amount not to exceed 50 percent of the cement weight.
  2. Admixtures, if used, to contain no chlorides, fluorides or nitrates.
  3. Maximum size of aggregate: 3/4 inch.
- B. Reinforcement: Section 03200, with the following additional requirements:
1. Rock-tunnel segments: Welded-wire fabric, ASTM A185.
  2. Earth tunnel segments: ASTM A706, Grade 60 and ASTM A615, Grade 60. When welding of the reinforcing bars is required, use ASTM A706, Grade 60 bars. Conform to the Structural Welding Code—Reinforcing Steel, AWS D1.4 for the welding of reinforcing bars.
    - a. Liner rebar cage: Hot-dip galvanized, Section 05120. Coat reinforcing cages after assembly and welding.
- C. Inserts, Anchors, Dowels and Accessories: Steel, ASTM A36 or equal; zinc-coated in accordance with ASTM A123. \*1
- D. Gasket:
1. Elastomeric seal: ASTM D2628.
  2. Manufactured as continuous ring sized to fit panels snugly, formed to shape and size shown, with gasket corners molded, mitered and vulcanized to provide uniform thickness along entire length of mating surfaces.
  3. Hardness: ASTM D2240, Shore A Durometer, as follows:
    - a. Rock-tunnel segments: 40, plus-or-minus five
    - b. Earth-tunnel segments: 55, plus-or-minus five.
  4. Tensile strength: ASTM D412, 2,250-psi minimum, minus 10 percent.
  5. Elongation: ASTM D412, 300-percent minimum, minus 25 percent.
  6. Water absorption: ASTM D471, 24 hours at 212F, 10-percent maximum by weight.
  7. Compression set: ASTM D395, Method B, 70 hours at 212F, 25-percent maximum.
  8. Fire rating: Self extinguishing.

9. Dimensional tolerances: Plus-or-minus three percent.
  10. Stress relaxations: 25 percent.
  11. Contact pressure: Between 200 psi and 400 psi, as determined by specified compression test. \*2
- E. Compression Packing:
1. Neoprene sheet: 30 mils thick.
  2. Hardness: ASTM D2240, Type A Durometer, 65, plus-or-minus five.
- F. Adhesive:
1. As recommended by manufacturer of compression packing and gasket and compatible for conditions of application, including areas of applied waterproofing.
  2. Use solution recommended by manufacturer for cleaning elastomers at time of segment installation.
- G. Exterior Coating:
1. Coal-tar epoxy, MS MIL-P-23241 (Ships), Type 1, Class 2.
  2. Thinner: As recommended by coating manufacturer.
- H. Bond Breaker: Section 03100, non-staining.
- I. Grout Plugs:
1. ASTM A126, Class B, 1-1/2 inch NSPM external threads, galvanized in accordance with ASTM A153, threads coated with thread sealing compound SEAL UNYTE or T-UTYPE 555 manufactured by J.C. Whitman Manufacturing Company, Wadsworth, Ohio, or approved equal.
  2. Lead washer: FS QQ-L-201.
- J. Fasteners:
1. Bolts and nuts: ASTM A325, Type I, galvanized. Bolts to have rolled threads.
  2. Washers: ASTM F436, galvanized.
  3. Grommets: Low-density polyethylene, hardness Shore D Durometer 45 to 55, ASTM D2240, configuration to seal bolt holes under conditions of maximum misalignment.
- K. Water-Repellant Treatment: Acrylic, water-emulsion, ASTM C309.
- L. Grout: Section 02415.
- M. Sealant: Siloxane polymer and fillers, FS TT-S-230.
1. Backup rod: Polyethylene rod, closed cell, 5/8-inch diameter.
- N. Primer: Zinc-rich primer, MS MIL-P-26915 (USAF), Type 1, Class
- O. Bolt Sleeves: Low-density polyethylene, ribbed, hardness Shore D Durometer 45 to 55, ASTM D2240, minimum 1/8-inch wall thickness plus ribs, configuration as shown.

## **PART 3 - EXECUTION**

### **3.01 FABRICATION:**

- A. Formwork:
1. Fabricated of steel.
  2. Special sizes and cross sections as shown, with metal thickness, reinforcement, stiffness and surface finish as necessary to form concrete surfaces that are smooth, free of irregularities, welding blemishes and concrete stain.

3. Machine form surfaces for contact faces of segments to tolerance of plus-or-minus 0.016 inch.
4. Clean and coat forms with bond breaker prior to each reuse.
5. Ensure smooth surfaces for application of adhesive.
6. Accurately place reinforcing steel with tolerances in accordance with ACI 318.
7. Securely anchor form inserts and embedded items to formwork.
8. Mix and place concrete in accordance with Section 03300.

### **3.02 CURING:**

- A. Cure by steam in accordance with the following requirements:
  1. Immediately after segments have been cast, enclose forms in an enclosure capable of vapor tight sealing to prevent escape of moisture and heat, and which is large enough to allow complete circulation of steam.
  2. Introduce saturated steam into enclosure and maintain atmosphere in a saturated condition until compressive strength of 4,000 psi is attained, as determined by test cylinders. Do not attempt removal of segments from forms until 4,000 psi compressive strength is attained. The Engineer reserves the right to require compressive strength up to 0.75f<sub>c</sub>, if there is evidence of distortion, cracking, spalling or similar damage which could occur during handling and storage of segments.
  3. Enclosure ambient temperature: Not to exceed 100F for first two hours of curing. Thereafter, maintain temperature within 95F to 150F until specified curing strength is achieved.
  4. Do not allow rate of change of temperature to exceed 30F per hour.
  5. When specified strength is attained, allow segments to cool slowly but not exceeding rate of change specified in subparagraph 4. above.

### **3.03 TESTING:**

- A. Test in accordance with Section 03300, with the following additional requirements:
  1. Mix design and curing strength test:
    - a. Prior to manufacture establish concrete mix that will produce concrete of specified compressive strengths and submit data for approval.
    - b. After approval of initial mix design has been obtained, make six cylinders from each single batch of concrete.
    - c. Obtain prior approval of changes in mix design during segment manufacture.
    - d. Prepare, cure and test cylinders in accordance with procedures specified for segment manufacture.
    - e. For cylinders prepared prior to manufacture:
      - 1) Remove in pairs at appropriate time intervals during curing and test immediately upon removal to establish correct curing duration and compressive strength.
    - f. For cylinders prepared as result of change in mix design and as directed:
      - 1) Follow procedures specified for cylinders prepared prior to manufacture.
      - 2) Obtain approval of test results prior to manufacture of segments using new mix design. Inclusion or exclusion of any additives or admixtures to be treated as a change in mix design.
- B. Production test cylinders:
  1. Prepare three cylinders and cure as specified for each work shift or each 100 cubic yards of concrete used, whichever is more frequent.
    - a. Test cylinders in accordance with Section 03300.

- b. 28-day compressive strength: 85 percent of cylinders to meet specified compressive strength.

C. Gasket Testing:

1. Compression test:

a. Testing device:

- 1) Hydraulic equipment capable of applying 20,000-pound force with load-scale capable of reading up to 20,000 pounds in 20-pound increments.
- 2) Two steel plates 16 inches by five inches by 1-1/2 inches thick, each plate with machined groove having dimensions and geometry of gasket groove in precast-concrete segments on one side.
- 3) Minimum 3/4-inch diameter rod by which upper steel plate is attached to hydraulic equipment.

b. Test preparation:

- 1) Attach compression packing to high side of groove on each plate.
- 2) Cut two pieces of gasket 16 inches long and attach one to each plate with contact cement. Center gasket in groove.
- 3) Attach steel end plates on both sides of bottom plate to prevent longitudinal deformation of both top and bottom gaskets.
- 4) Prepare bed of grout underneath bottom plate. Bring upper plate in contact with lower plate. Apply pressure until grout squeezes out from below bottom plate. Ensure that gaskets are properly aligned by placing 1/8-inch spacer between low sides of grooves while grout is setting. Leave in position until grout sets.

c. Test:

- 1) Apply pressure at rate of 400 lb/min. until closure is completed.
- 2) Calculate closure pressure based on two-inch width of gasket.
- 3) Record, calculate and submit closure load (lb.), gasket thickness (inches), length of gasket (inches), load rate (lb/min) and closure pressure (psi).

d. Test supervision: Have all phases of mechanical test supervised by test engineer with experience in similar test procedures.

2. Leakage test:

a. Testing device:

- 1) Two steel plates 16 inches by 16 inches by two inches thick with machined groove running along perimeter of plates and having geometry and dimensions of gaskets grooves in precast-concrete segments. Centerline of groove 2-1/2 inches from plate edge. Low side of groove to center of plate. Plates shall have 5/8-inch diameter holes evenly spaced around perimeter of plate between groove and edge. Both plates identical and symmetrical about centerline.
- 2) Eight 1/2-inch bolts capable of resisting 5,000-pound force.
- 3) Steel water tank, filled with water.
- 4) Nitrogen tank under 2,200-psi pressure with regulator.
- 5) Gasket material having passed mechanical test.

b. Test preparation:

- 1) Place gasket in groove by cutting 45-degree angles in ends of four equal pieces and gluing them together in a square with Super Glue or equal. Lengths of four pieces of gasket selected so as to fit squarely in groove of each steel plate. Attach gasket to each plate by means of contact cement.
- 2) Attach compression packing to high side of groove on each plate with contact cement.

- 3) Provide vent hole for escaping air pressure, and inlet hole for water, in center of top plate.
  - 4) Bolt both plates together, tightening bolts until plates just close.
  - c. Test:
    - 1) Attach water tank to plates. Add water to vent out air. Plug vent hole.
    - 2) Apply 200-psi pressure to water tank with nitrogen tank. Record pressure through gauge in nitrogen to water-tank line.
    - 3) Record pressure and inspect for leakage daily during period of one month. Submit result to the Engineer.
    - 4) Gasket will be accepted if no leakage is observed during entire duration of test.
  - d. Have all phases of mechanical test supervised by test engineer with experience in similar test procedures.
3. Frequency of tests: Perform both compression and leakage tests on gasket before production begins and at 25-percent, 50-percent and 75-percent production levels.

#### **3.04 INSTALLATION OF GASKET:**

- A. Prior to installation of gasket, apply water-repellant treatment to surface as shown.
- B. Use gasket adhesive as recommended by manufacturer of gasket at intervals of approximately 15 inches.
- C. Fit gasket snugly into groove provided around segments.

#### **3.05 INSTALLATION OF COMPRESSION PACKING:**

- A. Clean surface as necessary. Apply adhesive in accordance with manufacturer's recommendations.
- B. Cut elastomeric compression packing to proper dimensions and affix as shown.

#### **3.06 EXTERIOR-COATING APPLICATION:**

- A. Apply coating to exterior surfaces of segments. Do not coat mating surfaces or sealant grooves.
- B. Apply coating in two coats of equal thickness totaling 20-mil minimum dry-film thickness and in strict accordance with recommendations of manufacturer of protective coating, including pretreatment of first coat prior to application of second coat.
- C. Apply second coat before first coat has dried tack-free and not later than 24 hours after application of first coat, unless otherwise specified by coating manufacturer.

#### **3.07 APPLICATION OF WATER-REPELLANT TREATMENT:**

- A. Preparation:
  1. Apply water-repellant treatment only after concrete has cured as specified in Section 03300.
  2. Remove from surface to be treated dust, dirt, debris, oil, grease and other foreign matter. Prepare surfaces to be treated in accordance with treatment manufacturer's recommendations.
- B. Installation

1. Apply one base coat of water-repellant treatment to segment surfaces as shown and in accordance with manufacturer's recommendations.
2. Allow a minimum of 24 hours elapsed time between treatment-coating applications.

### **3.08 TUNNEL BREAKOUT**

- A. Provide special liner segments and special lining rings, complete with steel frame and temporary bracing, where shown.
- B. Upon completion of the tunnel breakout, remove and dispose of the special liner segments and special lining rings.

**SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.**

#### **ENDNOTES:**

- \*1. Other joint connection systems, eg. coil inserts, tylags, plastic washers, etc., to be included in specifications by the Section Designer.
- \*2. To be specified by the Section Designer.

**END OF SECTION**

## SECTION 02426

### NATM SHOTCRETE LINING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies the shotcrete lining applied following NATM excavation.
- B. Related Work Specified Elsewhere:
  - 1. NATM excavation: Section 02417.
  - 2. Shotcrete: Section 03370.
  - 3. NATM concrete lining: Section 02427.
  - 4. Tunnel waterproofing (NATM system): Section 07138.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ASTM: A36, A185, A325, A615, A706, C144, C150, C579.
- B. Installer with a minimum of two years experience.
- C. Lattice girder tolerances as certified by engineer's calculations.

##### 1.03 DEFINITIONS:

- A. Shotcrete: Section 03370.
- B. Lattice Girder: A lightweight, three-dimensional steel frame made to act as a unit by connecting components with lacing bars used in conjunction with shotcrete for shotcrete lining reinforcement.
- C. Splice Bar: Rebar installed to provide inherent connection of shotcrete in circumferential direction between top heading and bench shotcrete and at break-outs from cut-and-cover structures.
- D. Splice Clip: Rebar installed at arch lines as means of longitudinal reinforcement of the shotcrete lining.
- E. Local Support: See Section 02417.
- F. Pre-support: See Section 02417.
- G. Girder Brace: Rebar installed between two adjacent lattice girders for lateral support of lattice girders.
- H. Soil Anchor: Steel bar installed in borehole on the tunnel shotcrete lining and fully encapsulated in cement mortar grout with accelerator cartridge when and where shown on drawings.
- I. Forepoling or Spiling Bar: Steel bar without end hardware installed at the tunnel heading by jacking or other mechanical equipment.

- J. Forepoling Sheets: Steel plate installed at the tunnel heading by jacking using mechanical equipment to provide earth support during excavation.
- K. Grouting: Methods used for pre-support of tunnel excavation and ground stabilization by pressure injecting chemical grout or cement grout.

#### **1.04 SUBMITTALS:**

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Shotcrete lining indicating structural construction details.
    - b. Show relationship of waterproofing and concrete lining elements to shotcrete lining elements and to the plan and sequence of excavation and lining installation.
    - c. Show relationship of shotcrete lining to intermediate excavation and support stages at break-out of tunnel and at interfaces.
    - d. Design, specifications, method of operation and other data pertaining to the following:
      - 1) Fabrication details for lattice girders.
      - 2) Welded wire fabric, splice bars, and splice clips.
      - 3) Rebar spiles and perforated steel pipes.
  - 2. Documentation:
    - a. Calculations for lattice girder connection details. Have these calculations certified by a professional engineer registered in the jurisdiction where the work is being performed.
    - b. Tolerances: Include engineer's statement of acceptable tolerances in the certified calculations.
  - 3. Samples:
    - a. Lattice Girders: Submit a two foot long sample of lattice girder with its accessories which shows full cross section and type to be used. Submit three such samples of lattice girder.
    - b. Soil Anchors: Anchor bolts and accessories: Three samples of each.
    - c. Accelerator Cartridge: Three samples.
    - d. Forepoling Sheets and Bars: Three sample sections one foot long showing full cross section and type to be used.
  - 4. Testing:
    - a. Prior to installation of soil anchor, arrange demonstration to show that specified pull out strength requirements can be met.

#### **1.05 JOB CONDITIONS:**

- A. Maintain a minimum of a five-day supply of lattice girders and shotcrete on site to prevent delays to the work. Maintain constant and adequate supply of shotcrete at tunnel heading during excavation, such that shotcrete may be applied at any time.

#### **1.06 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. General:
  - 1. Load, transport, unload and store structural materials to keep them clean and free from damage.

2. Store material on platforms, skids or other supports above ground and ensure proper drainage and protection from corrosion.
- B. Lattice Girders:
1. When handling and shipping lattice girders prevent bending, scraping or overstressing members.
  2. Block projecting parts likely to be bent or damaged during handling with wood or other approved material.
  3. Replace pieces bent or damaged unless repair is approved.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS:**

- A. Shotcrete: Section 03370.
- B. Welded Wire Fabric: ASTM A185, Size 6 x 6 - W4.0 x W4.0.
- C. Splice Bar: Fabricated from No. 4 standard reinforcing steel conforming to ASTM A615 Grade 60 as shown.
- D. Splice Clips: Fabricated from No. 5 standard reinforcing steel conforming to ASTM A615 Grade 60 as shown.
- E. Lattice Girder:
1. General:
    - a. Fabricate lattice girders to consist of three primary retaining bars, dimensioned and arranged as shown and connected by stiffening elements of the manufacturer's design or as shown and from rebars conforming to ASTM A706 Grade 60.
      - 1) Facilitate shotcrete penetration into and behind the girder, thereby minimizing the creation of injection shadows.
      - 2) Provide optimum bonding between the steel and shotcrete in order to form a composite, continuous, reinforced shotcrete lining structure.
    - b. Provide lattice girders with moment properties about the neutral axes in a section perpendicular to the longitudinal axis of the border, as shown. Have the stiffening elements provide a minimum five percent of the total moments of inertia. This percentage is calculated as an average value along repeatable lengths of the lattice girder.
    - c. Ensure stability against buckling. Maintain the maximum spacing between stiffening elements at less than three times the cross sectional height of the girder.
  2. Dimensions:
    - a. As shown.
    - b. Fabricate the lattice girders to meet minimum clearances shown under consideration of inaccuracy of placement during construction, material tolerances, and of lining deflection following installation.
  3. Testing:
    - a. Test lattice girder segments of typical length randomly selected by the Engineer from the standard stock. The Engineer will observe the testing.
    - b. Test segments in single point flexure with loading and constrains representative of the in-situ conditions of the girder. Record measurements of the gradually applied load and deflection of the girder at the point of

application until failure occurs to verify that the girder satisfies the minimum structural requirements.

- c. Replace faulty lattice girders at no additional cost to the Authority.
- F. Soil Anchors: Anchor Bolts and Accessories:
  - 1. General Requirements:
    - a. Soil anchor assembly: Anchor bolt, anchor plate, washer and nut.
    - b. Fabricated from No. 6 standard deformed reinforcing steel bar suitably threaded conforming to ASTM A615 Grade 60.
    - c. Approved method of anchorage to take specified tension.
    - d. Anchor plate: Plate 3/8-inch thick conforming to ASTM A36 having bearing area of at least 64 square inches.
    - e. Nuts: Hexagonal head, ASTM A325.
    - f. Steel washers: Center hole to be 1/8-inch larger in diameter than bolt with which it is to be used. Flat or conical shape conforming to ASTM A325.
    - g. Grout and mortar:
      - 1) Cement: ASTM C150 Type 1.
      - 2) Water: Section 03300.
      - 3) Sand: ASTM C144.
      - 4) Accelerator cartridge: Accelerator cartridge to be such that pull out strength of 5,000 pounds is achieved within 20 minutes.
- G. Forepoling or Spiling Bars: Fabricated from No. 8 standard reinforcing steel conforming to ASTM A615 Grade 60 as shown.
- H. Forepoling Sheets: Steel ASTM A36.
- I. Girder Brace: Fabricated from No. 6 standard reinforcing steel conforming to ASTM A615 Grade 60 as shown.

## **2.02 FABRICATION:**

- A. Provide each of the primary retaining bars of lattice girder segment in one piece, that is without splice, of high strength steel having a yield strength of 60 ksi.
- B. Construct the connection elements at the end of the lattice girder segments of structural steel angles having a yield strength of 36 ksi or stronger, or of welded flat steel ensuring similar strength characteristics.
- C. Fabricate steel supports in accordance with Section 05120, except as follows
  - 1. Inspection of groove and fillet welds by visual inspection only.
  - 2. Grinding to remove nicks resulting from flame cutting is not required.
  - 3. Planing and facing of sheared edges or bearing surfaces is not required.
  - 4. Subpunching or subdrilling of bolt holes is not required.
  - 5. Portions of bearing members such as butt and foot plates need not be straightened, planed and connected after fabrication.

## **PART 3 - EXECUTION**

### **3.01 GENERAL:**

- A. Install shotcrete lining as shown and specified herein, and in accordance with applicable requirements of Section 02417.

- B. Verify that the ground types encountered in the tunnels or station excavation are the same as were considered in the design. If not, make the necessary changes to the excavation sequence with the prior approval of the Engineer.
- C. Excavation sequences of headings as shown for Excavation and Support Type 1 and Type 2.

**3.02 FLASH-CRETE:**

- A. Install as shown and as specified in Section 02417.

**3.03 LATTICE GIRDERS:**

- A. Install to conform to excavated shape as shown. Consider inaccuracy of construction, tolerances of materials, and initial lining deflection to determine actual dimensions. Provide minimum embedment as shown.
- B. Secure lattice girder segments by use of girder braces, temporary wood blocking and other appropriate means to maintain position during shocreting.
- C. Provide butt plates of lattice girder segments and expansion unit in invert as shown or otherwise approved by Engineer. Ensure tight connection of elements.

**3.04 WELDED WIRE FABRIC:**

- A. Install as shown. Provide minimum overlap of 12 inches in each direction or use splice bars as shown.

**3.05 SPLICE BARS AND SPLICE CLIPS:**

- A. Install splice bars and splice clips for additional reinforcement as shown.

**3.06 SHOTCRETE:**

- A. Install shotcrete lining to provide required shotcrete lining thickness as shown.

**3.07 SMOOTHNESS CRITERIA:**

- A. General Smoothness Criteria: Provide shotcrete with a surface meeting the following tolerance:
  - 1. Shotcrete lining: Depth-to-wavelength ratio as measured with a 10-foot straightedge in random direction to be 1/5 or less.

**3.08 DETECTION OF MOVEMENT:**

- A. As specified in Section 02417.

**3.09 FIELD QUALITY CONTROL:**

- A. As specified in Sections 02417 and 03370.

**END OF SECTION**

## SECTION 02427

### NATM CONCRETE LINING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies cast-in-place concrete lining installation in NATM tunnels.
- B. Related Work Specified Elsewhere:
  - 1. NATM shotcrete lining: Section 02426.
  - 2. Concrete formwork: Section 03100.
  - 3. Concrete reinforcement: Section 03200.
  - 4. Cast-in-place structural concrete: Section 03300.
  - 5. Shotcrete: Section 03370.
  - 6. Tunnel waterproofing (NATM system): Section 07138.
  - 7. Drilling and pressure grouting for rock tunnels: Section 02431.
  - 8. NATM excavation (soft ground): Section 02417.
- C. Definitions:
  - 1. NATM: New Austrian Tunneling Method.

##### 1.02 QUALITY ASSURANCE:

- A. Comply with the requirements of Sections 03100, 03200 and 03300.

##### 1.03 SUBMITTALS

- A. Comply with the requirements of Sections 03100, 03200 and 03300.

#### PART 2 - PRODUCTS

##### 2.01 MATERIALS:

- A. Comply with the requirements of Sections 03100, 03200 and 03300.

#### PART 3 - EXECUTION

##### 3.01 INSTALLATION OF CONCRETE LINING:

- A. Perform concrete work in accordance with Sections 03100, 03200 and 03300.
- B. Place concrete for lining upper portion of tunnel by mechanical or pneumatic methods through pipes which discharge as nearly as practicable to highest point of structure.
- C. Prior to placement of concrete, remove materials within concrete design lines so as to avoid compromising stability of shotcrete lining and surrounding ground.
- D. Fill enlargement of tunnel excavation beyond theoretical outer limit of concrete lining shown with concrete.

- E. Force concrete into contact with waterproofing.
- F. Schedule erection of concrete tunnel lining so that no concrete is placed closer than 500 feet from tunnel excavation heading, unless otherwise approved.
- G. Contact Grouting: Perform contact grout as specified in Section 02431 and 02417 and as follows:
  - 1. Perform contact grouting through grout pipes in roof, in such quantity and at sufficient pressure to fill all voids. Maximum allowable grouting pressure for contract grouting is not to exceed 20 psi.
  - 2. Pump grout until grout comes through adjacent grout pipes in the roof.
  - 3. Perform contact grouting behind concrete lining when concrete is more than 28 days old.

### **3.02 DEFECTIVE LINING:**

- A. Concrete tunnel lining is considered defective unless it is watertight, properly finished, is within specified tolerances and has undamaged surfaces and joints.
- B. Watertightness criteria: Section 03300.
- C. Cast-in-place concrete lining is considered defective if misalignments cause tunnel wall to be less than 12 inches thick.

### **3.03 CORRECTIVE WORK:**

- A. Repair of concrete: Repair concrete having minor chipping of surfaces using epoxy mortar having surface color and texture closely matching adjacent concrete surfaces. As directed, repair or replace with new concrete those cracked portions which impair structural integrity of tunnel lining as determined by the Engineer.
  - 1. Ensure that surfaces to be repaired are clean, dry, free from dirt, dust, oil, water and other contaminants.
  - 2. Mix and place epoxy mortar as recommended by the manufacturer. Grind rough or raised projections smooth and flush with adjacent surfaces.
- B. If cast-in-place concrete lining thickness falls below nine inches, to maintain line and grade, remine tunnel so that concrete lining thickness is at specified minimum thickness.
  - 1. Remine as specified in Section 02417.

### **3.04 LEAK REMEDIATION:**

- A. Leak remediation: Section 07138.

**END OF SECTION**

## SECTION 02431

### DRILLING AND PRESSURE GROUTING FOR ROCK TUNNELS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies drilling feeler, exploratory, drainage and other holes, furnishing and injecting grout and patching finished grout holes in rock tunnels
- B. Definitions:
  - 1. Contact grouting: Injection of grouting material at crown areas of tunnels to fill voids between tunnel lining and surrounding rock.
  - 2. Consolidation grouting: Injection of grouting material through holes drilled up to 25 feet long at appropriate intervals around periphery of rock tunnel prior to installation of lining.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ASTM: A53, C109, D1785, D2466.
- B. Qualifications:
  - 1. When taking rock cores, employ only experienced rock core-drilling personnel.
- C. Tests:
  - 1. Determine strength of cementitious grout from test specimens made and tested in accordance with ASTM C109.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Working Drawings:
    - a. Details of grout mix composition. Submit prior to grouting.
  - 2. Documentation:
    - a. Rock core logs prepared as approved. Submit daily.
      - 1) Include descriptions as follows:
        - a) Materials of whatever character encountered in drilling and their locations in the holes.
        - b) Length of each run with percentage of core recovery.
        - c) Location of special features such as mud seams, open cracks and soft or broken ground.
        - d) Points where abnormal loss or gain of drill water has occurred.
        - e) Groundwater levels or other items of interest in connection with grouting in exploratory drilling.
        - f) Significant actions of bit and reasons for loss of core.
  - 3. Rock Cores:
    - a. Place entire rock cores in boxes in same order they are recovered from each hole. Use wooden blocks to show lengths of core not recovered.

- b. Mark core boxes with number of boring and depths from which cores are recovered.
- c. Include the following information:
  - 1) Percentage of core recovered compared with actual depth of drilling necessary to obtain sample.
  - 2) Rock quality designation (RQD) for each core run.
- d. Deliver cores to Engineer as directed.

**1.04 JOB CONDITIONS:**

- A. Grouting Records:
  - 1. Cooperate with and assist the Engineer in keeping records of grouting operations including time of each change in grouting pressure, rate of pumping, amount of cement for each change in water-cement ratio and other necessary data.
- B. Start Date:
  - 1. Notify the Engineer at least one week prior to beginning grouting operations

**PART 2 - PRODUCTS**

**2.01 MATERIALS:**

- A. Cement: Section 03300, Type II.
- B. Water: Potable.
- C. Admixture: For plasticizing or retarding as approved.
- D. Fine Aggregate:
  - 1. As specified in Section 03300, with the following additional requirements:
    - a. 100-percent passing U.S. Standard sieve Number 16.
    - b. Graded as follows for contact grouting:

U.S. Standard Sieve Size	Percent Passing
16	100
30	65 - 90
50	20 - 60
100	5 - 15
200	0 - 15

- E. Grout Pipe and Fittings: ASTM A53, standard weight, Schedule 40, black.
- F. Plastic Drain Pipe: PVC, ASTM D1785 and ASTM D2466, Schedule 40.
- G. Core Boxes:
  - 1. Wood fabrication, sufficiently strong to withstand handling and transportation.
  - 2. Size: Forty-eight inches by nine inches by three inches.
  - 3. With solid-wood dividing strips, not plywood, to separate cores.

**2.02 GROUT MIXES:**

- A. Grout for Contact Grouting:
  - 1. Consisting of one part portland cement, one part fine aggregate and approved admixture or as otherwise approved.
  - 2. Minimum compressive strength: 100 psi within 24 hours.
  - 3. Fluid enough to be injected to fill voids.
  - 4. Comprising ingredients not corrosive to steel.

### **PART 3 - EXECUTION**

#### **3.01 EQUIPMENT:**

- A. For exploratory core drilling, use approved drilling equipment with double-tube core barrel to obtain continuous NX, minimum size cores, 2-1/8 inches diameter.
- B. For feeler, grout and drain holes, use rotary or percussion-drilling equipment.
- C. For pumping grout, use approved pump capable of developing appropriate, approved, uniform pressure at grout hole connection and hoses with inside diameter of 1-1/2 inches minimum.
- D. Use horizontal shaft paddle or colloidal pump mixer with minimum capacity of 20 cubic feet and with accurate meter which reads to nearest 1/10-cubic foot for measuring amount of mixing water added to grout.
- E. Provide approved pressure gauges at grout pump and on manifold hookup at collar of hole being grouted.

#### **3.02 FEELER HOLES:**

- A. Drill feeler holes as directed ahead of excavation to determine in advance nature and condition of materials to be excavated.
- B. Drill each hole to diameter of 1-1/2 inches minimum and length of 15 feet minimum and 30 feet maximum.
- C. While drilling feeler holes, suspend or modify other operations as necessary to permit such drilling. Drill holes only in the presence of the Engineer.
- D. Obtain approval for location, direction, length and number of holes.

#### **3.03 EXPLORATORY HOLES:**

- A. Drill exploratory holes in order to determine type and quality of rock.
- B. Depending on nature of rock, select length of drill run to ensure maximum core recovery, but in no case to exceed five feet.
- C. Package cores as specified and deliver to the Engineer as directed.
- D. Unless otherwise directed, pressure grout exploratory holes after removal of core.

#### **3.04 DRAIN HOLES:**

- A. Locate and drill holes where shown or as directed. Keep holes clear of obstructions.

- B. Use plastic pipe for weep holes where shown. Fasten fittings with adhesive or threads.

### 3.05 GROUTING:

- A. General Requirements:
1. Grout holes:
    - a. Drill grout holes in rock or lining to diameter of two inches minimum and as shown or as directed or use existing grout holes.
    - b. Avoid cutting embedded steel. If steel is encountered, cease cutting and patch hole.
    - c. Clean obstructed holes for entire depth prior to grouting.
    - d. Thoroughly wash grout holes immediately before starting pressure grouting.
  2. Pipes and fittings:
    - a. Place pipes to be embedded in tunnel lining for contact-grout connections and air vents as shown.
    - b. Set inner end of pipes not less than two inches back from finished inside surface and provide recesses from there to surfaces of lining. Fill recesses with concrete or mortar after grouting operations have been completed.
    - c. Set grout pipes so that grout flows freely to voids behind lining.
    - d. Hold pipes to be embedded firmly in position and protect from damage while concrete is being placed. Provide and attach caps or other devices to ends of pipe to prevent entry of concrete or other foreign materials prior to grouting and to facilitate location of grout pipe after forms are removed.
    - e. Avoid clogging or obstructing pipes before grout hookups are made. Clean clogged or obstructed pipes.
  3. Connections:
    - a. Make connections so as to prevent leakage.
    - b. Remove plugs on ends of grout holes or pipes to permit escape of air and water and filling of spaces with grout.
    - c. Provide straightway cock or valve at each connection.
  4. Grouting operations:
    - a. Perform grouting operations in the presence of the Engineer.
    - b. Use grout of consistency to suit the characteristics of the hole being grouted or the type of grouting being performed.
    - c. Use approved pressure at hole.
    - d. Consider grouting hole to be complete when hole refuses grout at 90 percent of highest pressure approved.
    - e. Upon completion of grouting at each connection, close valve and leave it in place until grout has set.
    - f. After grout has set remove valves and fittings and metal connections to depth of 1-1/2 inches minimum from face of concrete.
    - g. Fill grout holes with thick grout or dry pack at completion of grouting operations to leave smooth finished surface.
    - h. Do not block drains or drain lines during grouting operations.
    - i. Clean drains after each grouting operation.
- B. Consolidation Grouting:
1. Perform consolidation grouting as necessary.
  2. If consolidation grouting has to be performed after contact grouting, allow at least seven days to elapse between completion of contact grouting and beginning of consolidation grouting.
  3. Perform consolidation grouting within radius of 50 feet of cast-in-place concrete tunnel lining only when lining is more than 14 days old.
- C. Contact Grouting:

1. Perform contact grouting through holes drilled or placed in tunnel lining where shown.
2. Obtain approval of grouting pattern and order of grouting prior to start of contact grouting.
3. Provide vent pipes to suit conditions encountered.
4. Perform contact grouting behind concrete liner when concrete is more than 14 days old.
5. Use maximum pressure for contact grouting as approved.
6. Continue grouting until clear grout stream emerges from vent pipe.
7. Allow at least seven days after completion of contact grouting, before beginning further grouting.

**END OF SECTION**

## SECTION 02460

### PILES

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies furnishing and installing bearing piles, performance of Static Pile Load Tests and Dynamic Pile Testing.
1. Sequence of Work:
    - a. Conduct initial wave equation analysis, prepare Indicator Pile Order List and submit information to Engineer for review.
    - b. Piles shall not be driven until embankments or excavations shown have been completed to the specified grade.
    - c. Obtain and drive the indicator piles where shown on the drawings. During initial driving perform Dynamic Pile Testing and the refined wave equation analysis on each indicator pile to confirm the length, and control blow count. Determine pile driving criteria on the basis of the pile driving analysis (PDA) during the initial driving and the static load test. Incorporate results into driving of subsequent indicator piles.
    - d. Perform Static Pile Load Tests per Article 3.2.B.2 on indicator piles designated by the Engineer after all indicator piles have been installed. After Static Load Test is complete immediately restrike all indicator piles with Dynamic Testing Apparatus installed and functioning.
    - e. Analyze Static Pile Load Tests and evaluate data collected from Dynamic Pile Testing and refined wave equation analyses to determine pile driving criteria as indicated in item c.. Develop and submit the proposed "Order List" for production piles to the Engineer for approval.
    - f. Order and procure production piles based on the approved "Order List".
    - g. Drive each production pile to twice the pile design load and "production maximum tip elevation", and report all data as specified to evaluate the adequacy of the foundation system.
- B. Definitions:
1. Pile Group: All piles to support a foundation element or column within a specified area, or all piles to support a linear unit of retaining wall. Pile groups are shown on the Contract Drawings.
  2. Production Piles: All piles that are driven after the installation of required test piles in accordance with the contract documents and which upon approval by the Engineer, become part of the permanent structure.
  3. Indicator Pile: Indicator piles are shown on the Contract Drawings. These piles shall be tested with the Dynamic Testing Apparatus. Static load tests shall be conducted on the indicator piles shown on the Contract Drawings or as directed by the Engineer. The Engineer may direct that additional indicator piles be driven and that dynamic or static testing be conducted on them to verify the load capacity.
  4. Reaction Piles: Piles driven by the Contractor to provide reaction for Static Pile Load Tests.
  5. Predicted Maximum Tip Elevation: The elevation below which indicator pile tips must penetrate by at least one foot.

6. Production Maximum Tip Elevation: The elevation below which production pile tips must penetrate by at least one foot, based on the indicator pile test program.
  7. Pile Design Load: The load each pile is designed to carry.
  8. Ultimate Bearing Capacity: The maximum bearing capacity that the pile can sustain without rapid progressive settlement of the pile under constant load.
- C. Pile Type:
1. Prestressed precast concrete piles, driven.
- D. Related Information:
1. Grading, Excavating, and Backfilling: Section 02320.
  2. Support of Excavation: Section 02260.
  3. Concrete Formwork: Section 03100.
  4. Concrete Reinforcement: Section 03200.
  5. Cast-in-Place Structural Concrete: Section 03300.
  6. Structural Precast Concrete: Section 03400.
  7. Prestressed Concrete: Section 03415.

## 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
1. Codes and regulations of the jurisdictional authorities.
  2. ASTM Standards:
    - a. D1143 - Test Method for Piles Under Static Axial Compressive Load.
    - b. D4945 - Test Method for High Strain Dynamic Testing of Piles.

## 1.03 SUBMITTALS:

- A. Submit the following for the Engineer's approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings:
    - a. For Static Pile Load Tests, provide drawings that show load test apparatus setup including the method of applying the load. Drawings must show devices to be used to measure pile top movement.
    - b. For Dynamic Pile Testing, provide manufacturer's or vendor's data on transducers, computer, wiring, and schematic drawings for testing specified piles.
    - c. For Static Pile Load Test and Dynamic Pile Testing programs, provide detailed sequence of testing, evaluation of results and planned reports.
    - d. Pile splicing is not desired and shall be avoided. In the event that concrete piles are driven below the elevation of bottom of cap, build-ups, precast or cast-in-place splicing may be used when approved by the Engineer. The pile submittal shall include splice details, build-up details and any other details necessary to satisfy the requirements of these specifications.
    - e. The pile submittal shall show prestressing methods, tendon arrangement, working stresses, and methods for pick-up and handling of piles.
    - f. Submit certification of accuracy for all gauges and test equipment.
  2. Documentation:
    - a. Driving Equipment/Accessories List:
      - 1) Submit details of proposed driving equipment to include cranes, leads, hammer, compressors, powerpacks, driving caps, hammer cushions and pile cushions. Data on hammer shall include as a minimum the manufacturer's model number, estimate of efficiency,

- energy ratings and ram details, including operation certification performed within the last 90 days.
- 2) Submit details of accessory equipment to be used including service cranes, hoses, throttles, and pile handling rigging.
- b. Submit procedures and details for installation of reinforcement and prestressing.
  - c. Submit materials certifications and concrete mix designs for all concrete products to be used during the pile installation.
  - d. Indicator Pile Order List:
    - 1) Submit a list of piles to be installed as part of the indicator pile test program. List shall show type, size, number, location, indicator pile order length, predicted maximum tip elevation, allowable driving stress related to hammer blows, and blow count needed to attain twice the pile design load. If locations for indicator piles differ from those shown on the drawings, provide reasons for change. The proposed revised location will be reviewed and, if appropriate, approved by the Engineer.
    - 2) Submit list prior to ordering indicator piles.
  - e. Test Documentation and Reports:
    - 1) The Contractor shall retain an experienced Engineer employed by a Dynamic Testing Consultant. The Dynamic Testing Consultant's Engineer shall be an integral part of the Contractor's Quality Control Program. Submit the qualifications of the Dynamic Testing Consultant's Registered Maryland Professional Engineer responsible for monitoring Static and Dynamic Pile Testing. The Dynamic Testing Consultant's Engineer shall have a minimum of five (5) years experience in similar work, of which two (2) years shall be field experience with the monitoring of pile driving operations. The Dynamic Testing Consultant shall provide the following:
      - a) Results of all Wave Equation Analyses using the GRLWEAP program, Dynamic tests, Static tests and the Case Pile Wave Analysis Program (CAPWAP). The GRLWEAP and CAPWAP program is a product of Globe Rausche Likins and Associates, Inc., 4535 Renaissance Parkway, Cleveland, OH 44128. Telephone (216)831-6131.
    - 2) Sample pile driving record/report and sample sketch proposed to show any necessary deviations from planned locations.
    - 3) An annotated sample of the dynamic testing apparatus output. Output shall include recorded input, reduced data and analysis.
    - 4) After completion of each Static and/or Dynamic Pile Test, submit a test report for review and approval by the Engineer. The test report shall include reporting information specified in ASTM D1143 and D4945, results of the refined wave equation analyses, and recommendations for the Production Pile Order List.
    - 5) Prepare a summary report of all the wave equation analyses, CAPWAP, and results of the dynamic and static pile tests. The report shall include test details, hammer and driving system details, soil conditions, instrumentation, test sequence and observations, discussions of test results (including hammer performance, driving stresses, pile integrity and pile capacity), and conclusions and recommendations for the Production Pile Order List.
  - f. Production Pile Order List:

- 1) After review and approval of the results of the Static Pile Load Test and Dynamic Pile Testing, submit an "Order List" of production piles proposed to be installed in each pile group. The list shall show type, size, number, location, sequence of installation, length, production maximum tip elevation, allowable driving stress related to hammer blows and blow count needed based on end of initial driving results to attain twice the pile design load for all piles in each pile group.
- g. Pile Driving Record:
- 1) Maintain a record throughout the indicator pile test program and production pile driving operations and submit to the Engineer upon completion of each pile group. The record shall show the applicable established driving criteria developed by the Static Load Test, as modified by Dynamic Testing, for each pile. As a minimum include the following information:
    - a) Sequence in which piles were driven.
    - b) Equipment: type, model, serial number.
    - c) Required blow count per approved driving criteria, allowable driving stress related to hammer blows, production maximum tip elevation and final pile tip elevation.
    - d) Blow count for each foot of driven length.
    - e) For all piles, the number of blows per inch of penetration for last 12 inches.
    - f) Unusual conditions encountered during driving of each pile.
    - g) Immediately after final pile driving, record top elevation of pile to nearest 0.01 inch. Provide as built pile information after all piles in a pile group have been driven.

#### **1.04 PRODUCT DELIVERY AND HANDLING:**

- A. Lifting loops shall be used as provided by the precaster. Lifting loops shall not be tied in any way to the pile reinforcement. Loops may remain in place during driving. When handling and delivering precast piles, avoid bending and breaking or chipping of piles.

#### **PART 2 - PRODUCTS**

##### **2.01 MATERIALS:**

- A. Precast concrete piles:
  1. Prestressed precast concrete piles in accordance with Sections 03100, 03200, 03300, 03400, and 03415 of these specifications as applicable, shaped as shown.
- B. Miscellaneous Driving Accessories: Including driving heads, collars, bands, shoes, and other driving devices in accordance with pile manufacturer's recommendations.
- C. Lean concrete: Section 02260.

## **PART 3 - EXECUTION**

### **3.01 DRIVING EQUIPMENT:**

- A. The Engineer will review submitted data on driving equipment, accessories and methods for adequacy in conditions expected.
- B. Adequacy of equipment and accessories remains the responsibility of the Contractor.
- C. Should the equipment used by the Contractor prove inadequate to drive scheduled types of piles at the locations shown, or should progress schedule not be maintained, the Engineer may require replacement of equipment or different expendable accessories or additional equipment.
- D. If the hammer, driving block, cushion or any other part of the driving system is changed for any reason, the system must be calibrated by conducting Dynamic Pile Testing to prove the new system is equal to the original system. This work shall be made at no additional time to the Contract and at no cost to the Authority.

### **3.02 INDICATOR PILE TEST PROGRAM:**

- A. Installation:
  - 1. No later than twenty-one (21) days prior to driving indicator piles, conduct initial wave equation analysis that represents the subsurface conditions on this project, the pile properties and driving equipment provided. This analysis shall be submitted along with the required pile and driving equipment data to the Engineer.
  - 2. Provide and install indicator piles where shown, to determine lengths of production piles to be furnished to achieve twice the pile design load in the scheduled pile groups. If twice the design load is not attained when the top of the pile is one-foot above planned cut off, discontinue driving for a period of 24 hours or as directed by the Engineer. After the specified period, restrike pile in accordance with Article 3.2.B.1.b. If twice the design load is not attained after restrike, splice the pile, if necessary, and drive it until the specified bearing value is obtained.
  - 3. Locate piles at contract pile locations so they can become part of the completed structure provided they are approved as conforming to requirements specified for production piles. Install indicator piles to achieve pile tips below the predicted maximum tip elevation, in the presence of the Engineer. Assist the Engineer in verifying measurements and driving characteristics as necessary to evaluate the adequacy of the foundation system.
  - 4. The indicator piles scheduled for Static Pile Load Tests are shown on the Contract Drawings. The Engineer may designate alternate or additional indicator piles that exhibit the weakest bearing capacity for Static Pile Load Tests.
  - 5. Piles which are subjected to Static Pile Load Tests which do not pass the acceptance requirements shall be restruck, per 3.2. B.1.b with Dynamic Testing Apparatus installed and functioning, within 48 hours after completion of the Static Pile Load Test to reestablish the minimum required pile length and blow counts.
  - 6. Additional piles may be driven, at the Contractor's option, in the area of the Static Load Test Piles to be used as reaction piles. All piles driven as indicator piles or reaction piles for load tests in accordance with the plans and specifications and meeting specified requirements for production piles can, upon approval, be cut off and become a part of the permanent structure.
  - 7. Install all indicator piles that are intended to become part of the permanent structure with the same type and model of equipment and methods to be used to install production piles. Perform work in the presence of the Engineer.

8. Remove piles which are not incorporated into the completed structure or which do not satisfy test requirements. Alternatively, if rejected piles are not removed then cut off at least three (3) feet below finished grade and backfill resulting hole with lean concrete.

B. Pile Testing:

1. Dynamic Pile Testing:

- a. Perform Dynamic Pile Testing in accordance with ASTM D4945.
- b. Install indicator piles where shown with the Dynamic Testing Apparatus installed and functioning to measure performance of the driving system and the bearing capacity. Begin dynamic testing during initial driving when the pile tip achieves the predicted maximum tip elevation. Drive indicator piles to a bearing capacity of at least twice the pile design load based on initial driving. Restrike all indicator piles, with Dynamic Testing Apparatus installed and functioning to verify results from initial driving of these piles. Restrike indicator piles with the hammer at normal operating temperature for a maximum penetration of twelve inches, a maximum of 60 hammer blows, or to less than the driving stress limits established by Article 3.3.B, whichever occurs first. Pile driving shall resume as if it was the initial strike conditions per Article 1.1.A.1.c to obtain the correct pile driving criteria
- c. Perform CAPWAP analyses using the Dynamic Pile Testing data from the end of initial driving and the beginning of restrike of all indicator piles.
- d. Perform refined wave equation analyses using the dynamic test results of each indicator pile. Incorporate the results of the refined wave equation analyses in driving of subsequent indicator piles. Refined wave equation analyses shall be based upon the variations in the subsurface conditions and/or drive system performance measured by the dynamic testing apparatus.

2. Static Pile Load Tests:

- a. Static Pile Load Test equipment and testing procedures shall be in accordance with ASTM D1143, Quick Load Test Method, except as modified herein.
- b. Provide test equipment with capacity greater than three times the pile design load and having means of determining applied load to within five (5) percent of test load. Provide test equipment capable of measuring total settlement at the top of the pile to nearest 0.001 inch.
- c. Perform Static Pile Load Tests. Commence loading the pile no sooner than 72 hours after installation of the pile. The maximum test load shall be equal to three times the pile design load or the ultimate bearing capacity, whichever occurs first.
- d. The ultimate bearing capacity under axial comprehensive load is that load which produces a settlement of the pile head equal to:  
$$S_u = S + (0.15 + 0.008D)$$
Where:  
 $S_u$  = Settlement at ultimate bearing capacity in inches  
S = Elastic deformation of total unsupported pile length in inches  
D = Pile diameter or width in inches
- e. The safe bearing capacity is defined as 50 percent of the maximum test load. Static load test results will be acceptable when the safe bearing capacity equals or exceeds the design bearing capacity.

- f. Restrike piles for monitoring with Dynamic Testing Apparatus in accordance with Articles 3.2.A.5 and 3.2.B.1.

### 3.03 PRODUCTION PILE DRIVING:

#### A. Bearing Value, Length and Penetration:

1. Provide production piles of length necessary to attain production maximum tip elevation, twice the pile design load, and to extend into cap or footing block as shown.
2. Determine lengths of production piles by analysis of data obtained from Static Pile Load Tests, Dynamic Pile Testing and refined wave equation analyses.
3. Any pile that does not reach twice the pile design load by approved blow count or attain the minimum penetration will be rejected. Rejected piles will be restruck after 48 hours in accordance with Article 3.2.B.1 and ,if necessary tested using Dynamic Pile Testing equipment as directed by the Engineer to prove attained capacity at no additional cost to the Authority.
4. The Contractor may install additional test piles, make borings or make such other investigations as he may desire at no additional time to the Contract and no cost to the Authority.

#### B. Pile Driving Stresses:

1. Indicator and production piles shall not be driven above the hammer energy and blow count shown by the wave equation analyses to produce stresses above the point of impending damage. For concrete piles limit the tensile (TS) and compressive (CS) driving stresses to:

$$TS \leq 3\sigma' f'_c + EPV$$

$$CS \leq 0.85 f'_c - EP$$

Where:

$f'_c$  = The 28-day design compressive strength of the concrete

EPV = The effective prestress value

2. Cut off grade: At the Contractor's option, production piles reaching design bearing capacity and production maximum tip elevation with tops above the cut off grade may be driven to the cut off grade providing the required bearing capacity is maintained, allowable driving stresses within the pile have not been exceeded and no damage to the pile occurs. Piles damaged or suspected of damage due to driving to achieve a cut off grade shall be pulled and/or replaced at the Contractor's expense.

#### C. General Requirements:

1. Drive piles only after completion of required excavation or construction of indicated embankments.
2. Stage driving within supported excavation areas so as not to damage internal bracing.
3. For production piles in permanent embankments, pre-drill through fill or embankment to natural ground or bottom of embankment.
4. Drive each pile in a continuous operation until required penetration and twice the pile design load have been attained. If driving is stopped before required blow count and penetration have been reached, drive the pile one foot upon resumption of driving before resuming blow count for bearing value determination.
5. Redrive each pile which is lifted 1/4 inch or more by ground heave during driving of adjacent piles to at least the original tip elevation or as directed.

6. Remove loose and displaced material forced up around piles during driving.
7. In Terrace deposits and directly above the Monmouth Formation, cobbles, boulders and cemented sand/silt deposits were found. Penetrate into and through these deposits as necessary to attain twice the pile design load and required maximum tip elevation.
8. Achieve pile penetration through miscellaneous fill, rubble concrete, tires, hardpan, cemented sands/silts, and any other obstruction, natural or man-made, by means of pre-drilling or other approved excavation methods.
9. Hold pile tops in position with steel driving block or anvil.
10. Do not drive piles with free swinging hammer.
11. Pull and replace piles which are not within specified tolerances or, if approved, redesign pile cap as specified. Costs associated with the redesign and construction of modified pile caps will be borne by the Contractor and no additional time to the Contract will be allowed.

D. Pre-drilled Holes:

1. Where shown on the Contract Drawings, drill holes to diameter of greatest cross section dimension of the pile to be installed in accordance with the notes and schedules on the drawings and with Section 204.
2. Set pile in pre-drilled hole and drive to predicted or production maximum tip elevation and twice the pile design load, but in all cases to a minimum depth of five (5) feet below bottom of pre-drilled hole.
3. Fill voids between pre-drilled hole and pile with lean concrete immediately upon completion of the driving sequence, as approved.
4. Dispose of material resulting from drilling holes in accordance with the requirements of Section 204.
5. Fill rejected pre-drilled holes with lean concrete and redrill at approved location.

E. Concrete Piles:

1. Cut off piles at such elevation that they will extend into cap or footing as shown. Saw cut piles with equipment capable of providing a flat smooth surface without spalling or damaging pile below cutoff. Replace or repair piles that are damaged when cut off.
2. Where reinforcing steel dowels are shown, dowels may be anchored in cast or drilled holes in concrete pile. If holes are drilled, drill by methods that will not damage concrete, reinforcing steel or prestressing steel. Drill minimum diameter consistent with placing approved epoxy adhesive and dowel. Leave holes free of dust, moisture or other deleterious material. Place sufficient epoxy in holes before inserting dowels leaving no voids afterwards. Leave dowels undisturbed until epoxy has developed 100 percent of its strength capacity.

### 3.04 FIELD QUALITY CONTROL:

A. Concrete Pile Allowable Tolerances:

1. Ensure straightness and cross-sectional dimensions of precast piles so that a line stretched from butt to tip on any face is not more than one inch from face of pile at any point.
2. Install piles within the following tolerances:
  - a. Axis of pile within six inches of design location at cutoff elevation.
  - b. Axis of pile not out of plumb or batter by more than one percent of its driven length.
  - c. No encroachment of piles upon neat lines of Authority structures.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.01 BASIS:**

- A. Compensation for work specified in this section will be made in the following manner:
1. Furnishing and installing piles: Linear foot in place in the completed work measured from the tip of the pile to the plane of the cut off (top of pile). This price shall include conducting and reporting the initial wave equation analysis, furnishing piles; driving piles; splices; concreting; achieving specified load and tip elevations.
  2. Static Pile Load Test: This work will be measured and paid for at the Contract unit price per each static pile load test performed. The payment will be full compensation for furnishing and setup of test equipment, providing reaction piles, conducting test, reporting and incidentals necessary to complete the work. If load test is terminated by the Engineer because of insufficient bearing capacity, test will be measured for payment. If the test is terminated because of malfunction of Contractor's equipment or other reasons that are the fault of the Contractor, the test will not be measured for payment.
  3. Dynamic Pile Testing: This work will be measured and paid for at the Contract unit price per dynamic test performed. The payment will be full compensation for furnishing and setup of dynamic testing equipment and conducting test during initial and restrrike driving of each indicator pile, performing CAPWAP analyses, performing the refined Wave Equation Analysis, reporting and incidentals necessary to complete the work. Incomplete tests and terminations treated in accordance with Article 4.A.2.
  4. Pile restrrike: This work will be measured and paid for at the Contract unit price, per each restrrike performed. The payment will be full compensation for furnishing and setup of pile driving equipment required for restrriking piles with dynamic equipment installed and functioning in accordance with Article 3.2. If test is terminated by Engineer because of insufficient bearing capacity pile restrrike will be measured for payment. If the test is terminated because of malfunction of Contractor's equipment or other reasons that are the fault of the Contractor, pile restrrike will not be measured for payment.
  5. Pre-drilled holes shown and specified in Article 3.3 will be paid for at the Contract unit price per linear foot measured from the plane of the cut off (top of pile) to the level of the pre-drilled elevation specified. This price shall include providing the equipment, material and labor necessary to drill holes to the scheduled elevation, disposal of materials, placing lean concrete and incidentals necessary to complete the work.

**END OF SECTION**

## SECTION 02515

### WATER DISTRIBUTION SYSTEM

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing water mains.
- B. Related Work Specified Elsewhere
  - 1. Grading, excavating and backfilling: Section 02320.
  - 2. Maintenance, support and restoration of utility facilities: Section 02270.
  - 3. Grounding and bonding: Section 16060.

##### 1.02 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Certification:
  - 1. Proof that the water sampling and testing laboratory satisfies the requirements of the American Council of Independent Laboratories' Recommended Requirements for Independent Laboratory Qualification. Laboratory need not be a member of the American Council of Independent Laboratories
  - 2. Proof that the independent laboratory is approved by the EPA or jurisdictional health authority.
  - 3. Certified results of the specified Post-Sterilization Water Test.
- B. Documentation:
  - 1. Bill of materials for material which will be supplied by operating agency. <sup>\*1</sup>
- C. Working Drawings: <sup>\*2</sup>
  - 1. Complete detailed working drawings of the proposed fire hydrants. Approval of drawings submitted does not constitute a waiver of the requirements of the Contract, nor is the Authority compelled to accept hydrants unless they pass specified tests and requirements.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. AASHTO: M36, M153. <sup>\*3</sup>
  - 3. AASHTO: M153. <sup>\*4</sup>
  - 4. ANSI/AWWA: C104/A21.4, C110/A21.10, C111/A21.11, C151/A21.11, C151/A21.51.
  - 5. ASTM: A36, A48, A53, B88, C33.
  - 6. ASTM: A36, A48, C33, C76. <sup>\*5</sup>
  - 7. ASTM: A36, A48, C33. <sup>\*6</sup>
  - 8. ANSI/AWWA: C108, C151, C500, C502. <sup>\*7</sup>

9. ANSI/AWWA: C151, C200. <sup>\*8</sup>
10. EPA: National Primary Drinking Water Standards.
11. WSSC: General Conditions and Standard Specifications, Standard Fire Hydrant Drawings. <sup>\*9</sup>

B. Allowable Tolerances:

1. Leakage not to exceed figures given in Table 02515-1.
2. Lead concentration in specified water samples less than 15 micrograms per liter of water, and water quality meets the requirements of EPA National Primary Drinking Water Standards.

C. Testing Laboratory:

1. Furnish services of an EPA-certified or jurisdictional health agency-certified independent laboratory for sampling and testing water quality. Employment of an independent laboratory does not relieve Contractor of the obligation to perform work in accordance with Contract requirements.

**1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Upon approval of bill of materials, pick up material at designated storage facility and transport to job site. <sup>\*9</sup>
- B. To reduce handling to a minimum, coordinate pipe delivery with installation.
- C. Distribute pipe along line of work and outside trench as near as practicable to point of placement. Do not deposit material on or against pipe.
- D. Arrange and install skids and wedges to prevent damage to pipe. Do not roll or drag pipe.
- E. Avoid damage to coating and lining; use handling equipment designed for the purpose. Where approved, pipe may be handled by hand.
- F. When pipe installation is not actually in progress, place watertight caps or plugs on open pipe ends.

**PART 2 - PRODUCTS**

**2.01 MATERIALS:**

- A. Aggregate for Subgrade Foundation: ASTM C33, coarse aggregate No. 4 or where directed No. 4 and No. 67 in combination and proportions to suit field conditions.
- B. Aggregate for Fire Hydrant Dry Wells: ASTM C33, coarse aggregate, No. 67.
- C. Ductile Iron Pipe:
  1. ANSI/AWWA C151/A21.51. With standard cement-mortar lining with bituminous seal coat conforming to ANSI/AWWA C104/A21.4.
  2. Furnished in uniform standard lengths. Short pipe lengths and fittings are permitted where line, grade and closure requirements necessitate.

- D. Joints:
1. ANSI/AWWA C151/A21.11.
  2. Where shown as DILM, use mechanical joint ductile iron pipe. Where shown as DILS, use push-on joint. Unless otherwise shown, ductile iron pipe joints may be either mechanical joints or push-on joints.
- E. Fittings:
1. ANSI/AWWA C110/A21.10 as modified.
  2. Suitable for use with ductile-iron pipe; designed for 250 psi working pressure.
  3. Furnished with coating and lining as for ductile iron pipe, with mechanical joint, except that offsets will have one plain spigot end.
- F. Gasket Lubricant: For mechanical joints: Approved vegetable oil soap. For push-on joints: Approved gasket lubricant supplied by the pipe manufacturer and conforming to ANSI/AWWA C111/A21.11.
- G. Concrete: Section 03300, Class 3500.
- H. Mortar: Section 02535.
- I. Brick: Section 02535.
- J. Reinforcing Steel and Welded Steel Wire Fabric: Section 03200.
- K. Precast Concrete Elements: Section 03400, Class 4000, air-entrained concrete.
- L. Steps: ASTM A48, Class 30.
- M. Manhole Frame and Cover; And Other Castings For Service With Utility Systems:
1. Authority manhole: Cast-iron, ASTM A48, Class 30, with METRO logo.
  2. Utility company manhole: Manhole frame and cover furnished as part of the Contract or furnished by the utility as shown on the drawings.
  3. Rust-resistant cast iron or rust-resistant malleable cast iron.
  4. True to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blowholes and defects affecting strength.
  5. Fillets at angles in casting with arises sharp and perfect.
  6. Sandblasted to effectively remove scale and sand, presenting smooth, clean and uniform surfaces. Coated with bituminous coating.
  7. Metro logo: For utility components which will remain METRO property and are not within boundaries of utility easements as shown: Cast METRO logo as shown.
  8. Covers that receive paver tile:
    - a. Omit bituminous coating.
    - b. Provide positioning lug and lug receptor as a permanent part of the cover and frame rim so that the cover can only be installed (flush) in one position
- N. Piling for Thrust Blocks and Steel for Structural Use: ASTM A36.

- O. Resilient Material at Pipe Penetrations: AASHTO M153, Type II. See Section 02320.
- P. Vitrified Clay Pipe: Section 02535.
- Q. Backfill: Section 02320.
- R. Valves: Built and tested in accordance with ANSI/AWWA C500.
1. Cast-iron body, bronze-mounted, parallel-seat, double-disc gate valves with nonrising stems, nut-operated to open counterclockwise to withstand and operate under a working pressure of 150 pounds per square inch.
  2. Mechanical joint or flanged ends as shown and manufactured by American Darling Valve and Manufacturing Company, Ludlow-Rensselaer Valve Company or equal.
  3. No gearing or bypass will be required on valves smaller than 16 inches.
  4. Valves 16 inches and larger equipped with a bypass and bevel gearing for horizontal installations or spur gearing for vertical installations.
- S. Valves: In accordance with requirements of the operating agency. <sup>\*10 and \*9</sup>
- T. Materials Supplied by the Operating Agency: <sup>\*11 and \*9</sup> 1.
1. Except for those items which bear the METRO logo, the WSSC furnishes the following:
    - a. Water meter, meter frame and cover, meter housing, copper and brass pipe and fittings for meter settings, and adjustable valve box.
- U. Materials Supplied by Operating Agency: As specified. <sup>\*12 and \*9</sup>
- V. Yard Hydrant: Cast-iron box with lid, freeze proof valve with removable handle and threaded hose connection, hose bib size 2-1/2 inches, service pipe size as shown, Josam Series 71600 or equal.  
Coal-tar epoxy: Section 02535.
- W. Bituminous Coating: ANSI/AWWA C151. <sup>\*13</sup>
- X. Steel Pipe Casing: ASTM A53, Grade B, ungalvanized. <sup>\*14</sup>
- Y. Casing pipe: <sup>\*15</sup>
1. Reinforced concrete: ASTM C76, Class IV.
  2. Corrugated metal: AASHTO M36, 8-gauge, galvanized, asphalt coated.
  3. Seamless steel: Black, welded, mill type, ANSI/AWWA C200.
- Z. Fire Hydrants: Conforming to ANSI/AWWA C502, and WSSC's Standard Fire Hydrant Drawings with the following additional requirements: <sup>\*16</sup>
1. Interchangeable with existing WSSC fire hydrant. A sample fire hydrant similar to those now in use will be available at the Warehouse at 3500 Kenilworth Avenue, Bladensburg, Maryland, for inspection and comparison.
  2. Manufactured by Kennedy Valve Mfg. Company, Elmira, N.Y. or equal, including name of manufacturer and year of manufacture cast in raised letters.

3. Barrel sections:
  - a. Two cast-iron sections, with hollow or breakable flange at least two inches above finished grade line, cast iron conforming to ANSI/AWWA A21.8/C108).
  - b. Lower section of barrel: Static casting with an integral tapered top flange seat. Nozzle section attached to lower barrel section by means of a tapered flange ring held in place by six hydrant-head bolts and nuts.
  - c. Flange and flange rings: Top or nozzle section, including bonnet and operating nut, revolving 360 degrees for facing without disturbing bottom section of barrel. The use of split bronze insert ring is prohibited.
  - d. Hydrant: Barrel, complete with the working parts, including main and drain valve seats, removable for inspection or repair and replaceable without disturbing the ground.
  - e. Depth of bury of the hydrant indicated in raised figures on barrel, showing depth in feet. Figure on barrel just below the swivel flange and above protective case, visible when installed. Figure raised at least 1/8-inch above barrel surface and height of the figure at least one inch, integrally cast with barrel.
4. Frost case:
  - a. Cast-iron, two-piece lower section may be centrifugally cast and 12 inches shorter than depth of bury.
  - b. The upper section of frost casing normally furnished in lengths of nine inches, but sections both 15 and 21 inches long furnished as required to be used for maintenance purposes where longer hydrant barrels have to be replaced on existing installations.
5. Main valve:
  - a. Main valve seat: Compression type, opening against pressure.
  - b. Valve: Faced with Balata.
6. Discharge nozzles:
  - a. One 4-1/2 inch pumper and two 2-1/2 inch hose nozzles, both pumper and hose nozzle threads conforming to the requirements of ANSI specifications for National (American) Standard fire hose coupling screw thread.
  - b. Nozzle caps: For outlets, attached to the fire hydrant by means of suitable chains.
  - c. Hose nozzles of bronze and leaded into the barrel.
7. Elbow or inlet connections:
  - a. Cast-iron hydrant barrel to screw into the elbow. Elbow fitted with removable or replaceable threaded bronze ring to receive hydrant barrel.
  - b. Inlet connection: Six inches, Class 350, mechanical joint bell, meeting the general requirement for Standard Mechanical Joint Cast-Iron Pipe and Fittings with the necessary accessories for each such mechanical joint.
  - c. Bolts: Low-alloy steel, Corten, Usaloy or equal.
  - d. Gaskets: Rubber.
  - e. Glands: High-strength cast iron consistent in design with elbows with which they are to be used.

AA Copper Tubing: ASTM B88, Class I, Type K, hard-drawn. \*17

- BB Metro Logo: For utility components which remain property of the Authority and are not within the boundaries of utilities' easements indicated in the Right-of-Way drawings, use cast METRO logo as shown. <sup>\*18</sup>
- CC Oak Chock: Undressed, clear, four inches wide by 18 inches long, height variable, with recessed groove, 1-1/16 inches by 1/4-inch deep, centered across four-inch dimension. <sup>\*19</sup>
- DD Metal Band: Steel, one inch by 0.035 inch. <sup>\*20</sup>

### **PART 3 - EXECUTION**

#### **3.01 MAINTAINING WATER SERVICES:**

- A. Maintain water service in accordance with Section 02270. In furtherance of this requirement, conduct operations at times selected to minimize duration and inconvenience of service interruption.
- B. At least 24 hours prior to cutting or abandoning an existing water main, notify the Engineer and operations division of operating agency and obtain approval of schedule for performance of work. <sup>\*9</sup>
- C. Keep existing water mains parallel to new water mains in service until new water mains are ready for service.
- D. Where existing water main must be cut for connection to new water main, provide necessary facilities and prosecute work on 24-hour basis.
- E. Water valves in service will only be operated by personnel of the agency owning main. <sup>\*9</sup>

#### **3.02 EXCAVATION:**

- A. Perform excavation to line and grade in accordance with Section 02320 with the following additional requirements:
  - 1. Excavate test pits sufficiently in advance of construction so that reasonable changes in line and grade can be made where the location of existing structures varies from that shown.
  - 2. Excavate below horizontal plane extending two feet above top of water main structure to such width that construction may be properly performed, but not less than six inches nor more than nine inches from outside of proposed structure.
  - 3. Excavation above such plane may exceed specified dimensions where approved.
  - 4. If excavation exceeds permissible dimensions, install pipe of higher strength as directed.
  - 5. Unless otherwise shown, install pipe in excavated trenches. Trench to have such depth that there will be at least two feet of trench of required width above top of pipe.
  - 6. Where necessary to place backfill or embankment so that trench can be excavated, extend and compact backfill or embankment to full depth and laterally at least 2-1/2 times diameter of pipe on each side measured from centerline of pipe.

#### **3.03 SUBGRADE:**

- A. Prepare subgrade so that pipe will rest solidly throughout its length. Excavate recesses to accommodate joints and fittings.

**3.04 BACKFILL:**

- A. Backfill excavation upon completion of construction in accordance with Section 02320.
- B. Perform backfilling after inspection and approval of pipe laying.

**3.05 LAYING PIPES:**

- A. Take proper measures to keep pipe clean. Immediately prior to placing, clean inside and ends of outside surfaces of pipe. Keep interior surfaces clean throughout construction.
- B. Prior to placing pipe in trench, have interior and exterior inspected. Where there is damage that the Engineer determines repairable, make repairs as directed. Replace pipe damaged beyond acceptable repair.
- C. Complete excavation and placing of subgrade before pipe is placed. Place pipe solidly true to line and grade shown. Do not subject pipe to blows or shocks to achieve solid bedding or proper line and grade.
- D. Make change in line with fittings. Do not spring joints to effect change of direction.
- E. Do not field cut pipe unless necessary. Make such necessary cuts by means of equipment designed for purpose, ensuring smooth square end.
- F. For connection to existing pipe, provide pipe with suitable ends or adaptors, after verification of size and type of existing pipe.
- G. For railroad and highway crossings, lay casing and water mains as shown. <sup>\*21</sup>
- H. Place oak chocks as shown, fasten metal band to chocks as approved. Space chock arrangements on water mains at six feet zero inches on center. <sup>\*22</sup>
- I. After water main is in place, fill void between main and casing with sand. <sup>\*23</sup>
- J. Close ends of casing pipe with brick masonry enclosure as approved. <sup>\*24</sup>

**3.06 ASSEMBLING MECHANICAL JOINTS:**

- A. Assemble mechanical joints to provide tight, flexible joints that safely permit expansion, contraction and ground movement.
- B. Prior to assembling mechanical joints, wire brush surfaces of pipe sections in contact with gasket so that surfaces are clean, smooth and free of rust and other foreign substances. Clean and lubricate contact surfaces with vegetable oil.
- C. Assemble mechanical joints in accordance with ANSI/AWWA C111/ A21.11.

- D. Furnish to the Engineer calibrated torque wrenches in sufficient number to permit complete inspection of work. Provide satisfactory means of recalibration.
- E. If satisfactory seating of joint is not obtained at maximum permissible torque, disassemble joint, reclean and reassemble with new gasket.

**3.07 ASSEMBLING PUSH-ON JOINTS:**

- A. Assemble push-on joints to provide tight, flexible joints that safely permit expansion, contraction and ground movement.
- B. Assemble joints using lubricant in accordance with recommendations by pipe manufacturer.
- C. File or grind spigot of field-cut pipe lengths to resemble manufactured pipe so that spigot end will slip into socket without hindrance or gasket damage.
- D. Place identifying mark on pipe not bearing depth mark on spigot to show depth of socket.

**3.08 VALVES:**

- A. Install valves in accordance with recommendations of the valve manufacturer.
- B. Where valves are provided by operating agency, provide suitable access for performance of work. <sup>9</sup>
- C. Where necessary, alter typical valve manhole to suit actual conditions.

**3.09 SUCTION OUTLETS:**

- A. Construct suction outlets where shown.
- B. Provide necessary materials not furnished by operating agency to complete installation. <sup>9</sup>

**3.10 DEAD-END BLOWOFFS:**

- A. Provide tapped and drilled caps for dead-end blowoffs where shown.
- B. Complete construction of dead-end blowoffs. Provide materials not furnished by operating agency but necessary to complete installation. <sup>9</sup>

**3.11 FIRE HYDRANTS:**

- A. Construct fire hydrant installations as shown.
- B. Provide necessary materials not furnished by operating agency to complete installation. <sup>9</sup>
- C. Shop Painting: <sup>25</sup>
  - 1. Clean outside of hydrant above finished ground line and give two coats of paint as manufactured by Grow Chemical Coating Corp., Tropical Paint Division, 1250 West 70th Street, Cleveland, Ohio 44102, or equal. The bonnet of the hydrant painted with Rhinamel Forest Green No. 202-97-I.F. or equal and the body and outside of the top section frost casing painted with Rhinamel Gray No. 202-21-00 or equal

2. Bituminous Coating: Paint the barrel below the ground line, the bottom section of the frost casing and the cast-iron elbow, inside and outside. Paint only the inside of the top section of frost casing.
  - a. The bituminous coating to be smooth, tough and tenacious coating, neither so soft as to flow when exposed to sun nor so brittle as to crack and scale off when exposed to temperature below freezing, and not deleterious to potable water.
  - b. Apply the bituminous coating hot or cold either by brushing, dipping or spraying. The coating material to be subjected to chemical and physical tests by the Engineer to confirm its uniformity and quality.
  - c. Examine surfaces for peeling or scaling. Repair damage to the coating because of rough handling or rubbing in shipping and restore coating to its original condition.

**3.12 THRUST BLOCKS AND HARNESSING:**

- A. Make provision for counteracting thrust caused by static and dynamic forces including water hammer at bends, tees, reducers, valves and dead-ends by installing ductile iron retainer glands with mechanical joints. For other methods submit details for approval prior to use.
- B. Install concrete thrust blocks as shown where harnessing is not practicable.
- C. Where shown provide piles and reinforcing steel in concrete thrust blocks. Install piles for thrust blocks to bearing of 15 tons.

**3.13 CAST-IN-PLACE CONCRETE CONSTRUCTION:**

- A. Conform to applicable requirements of Sections 03100, 03200 and 03300.

**3.14 PRECAST CONCRETE CONSTRUCTION:**

- A. When installing precast sections, prevent damage to seals and sealants.

**3.15 BRICK CONSTRUCTION:**

- A. Conform to applicable requirements of Section 04215.

**3.16 WATER SERVICE CONNECTIONS:**

- A. Construct water mains and water service connections in accordance with the codes and regulations of the jurisdictional agency. <sup>\*26</sup>
- B. Make water service connections, where necessary, in accordance with applicable plumbing code. <sup>\*27</sup>
- C. Pay the required by the jurisdictional agency, except the water availability charge, which will be paid by the Authority. <sup>\*28</sup>
- D. Pay the water consumption charges until the time of final substantial completion for this Contract. <sup>\*29</sup>

- E. Do not connect water service to WSSC system until application for the connection has been approved by the WSSC. <sup>\*30</sup>
- F. Pay the water consumption charges until the time of final substantial completion for this Contract. <sup>\*31</sup>

**3.17 TUNNELING AND JACKING:**

- A. Perform tunneling and jacking as approved.
- B. Where open cut is specified and the Engineer permits work to be done by tunneling or jacking, perform such work as specified and as approved.
- C. Make horizontal borings for laying pipe lines true to line and grade.
- D. Where pipes are laid in borings, completely fill void between pipe and the boring with sand, using water pressure to ensure that voids are filled.
- E. Methods of boring and filling of voids between pipe and boring and subject to approval.

**3.18 BONDING AND CATHODIC PROTECTION:**

- A. Bond ferrous pipe in accordance with Section 16060.
- B. Where cathodic protection of piping system is shown, apply coal-tar epoxy coating as specified in Section 02535 and test as specified in Section 13115.

**3.19 FIELD QUALITY CONTROL:**

- A. Notice of Testing:
  - 1. Coordinate with and assist the WSSC in testing water mains. Provide equipment necessary for and adequate to maintain required pressures for the required period. Do the work, such as making connections, operating pump, providing piping, valves and other materials necessary for making tests. Pressure recorder, charts and water meter for testing will be furnished by the WSSC. <sup>\*32</sup>
  - 2. Give two days notice of intention of testing to operating agency which will furnish, install and operate pumps, gauges, meters and individual pipe connections to test openings. <sup>\*33 and \*9</sup>
  - 3. Designate largest sections feasible for testing and sterilizing. One testing and sterilizing operation will be performed at no expense to the Contractor; the cost of subsequent testing and sterilizing, if necessary, will be borne by the Contractor. <sup>\*9</sup>
- B. Tests:
  - 1. General requirements:
    - a. Prior to coating and backfilling, isolate system by use of approved valves, caps and plugs or other means.
    - b. Maintain such isolation throughout performance of leakage and pressure testing.

- c. Where valves are used for isolation, eliminate leakage through such valves if it occurs. Maintain new work isolated from existing water mains, except for test connections, until testing and sterilization have been completed.
- 2. Leakage test:
  - a. For leakage tests, provide approved caps and plugs in sections to be tested and remove them after testing.
  - b. Prevent leakage in pipes and fittings at openings.
  - c. Block temporarily plugged and capped ends to prevent displacement.
  - d. Install water source connection for testing isolated section; the Engineer may permit the use of tap which will be furnished and installed by operating agency. <sup>9</sup>
  - e. Perform work and furnish materials incidental to leakage testing, including excavation for installation and removal of pumps, gauges, meters and water source connections. Operating agency will apply 125-psig test-pressure section under test for 24 hours minimum. <sup>9</sup>
  - f. Where leakage exceeds the amount specified in Table 02515-1, perform necessary corrective measures.
  - g. Pressure test:
    - 1) After completion of leakage test, remove temporary caps and plugs and connect new water main into system. With new work valved off or otherwise isolated from system by approved means, assist with pressure test.
    - 2) Operating agency will apply 175-psig test-pressure to section under test for one-hour minimum. <sup>9</sup>
    - 3) Take corrective measures necessary to provide system free of leaks. Remove and replace defective pipes, jointings, fittings, valves and other appurtenances. Reset such items, if displaced.

**3.20 STERILIZING:**

- A. Operating agency will sterilize work during leakage test. <sup>9</sup>
- B. Provide access to opening used for sterilizing.
- C. Provide Post-Sterilization Water Sampling and Testing Services: Have EPA-approved or jurisdictional health authority-certified laboratory sample and test water, and submit certified test results that water quality and lead concentration in samples meet EPA standards.

**3.21 COMPLETION:**

- A. Upon completion of leakage testing and sterilizing remove temporary construction and complete connection of new work to system.
- B. Bond ferrous pipe in accordance with Section 16060.
- C. Have EPA-approved or jurisdictional health authority-certified laboratory sample and final proof-test water, and submit certified test results that water quality and lead concentration in samples meet EPA standards.

THIS SPACE NOT USED.

TABLE 02515-1												
MAXIMUM ALLOWABLE LEAKAGE IN CUBIC FEET PER 24 HOURS PER JOINT												
Test Pressure	Pipe Size											
	Nominal											
psi	6"	8"	12"	16"	20"	24"	30"	36"	48"	60"	66"	72"

100	.052	.069	.104	.139	.173	.208	.260	.312	.416	.520	.572	.624
110	.054	.073	.109	.145	.181	.217	.272	.326	.435	.544	.598	.652
120	.057	.076	.114	.152	.190	.228	.285	.342	.456	.570	.627	.684
130	.059	.079	.119	.158	.197	.237	.296	.356	.474	.593	.652	.711
140	.062	.082	.123	.164	.205	.246	.308	.369	.492	.615	.677	.738
150	.064	.085	.127	.170	.212	.255	.318	.382	.509	.637	.701	.764
160	.066	.088	.132	.175	.219	.263	.329	.395	.526	.658	.724	.789
170	.068	.090	.136	.181	.226	.271	.339	.407	.542	.678	.746	.814
180	.070	.093	.140	.186	.232	.279	.349	.419	.558	.698	.767	.837
190	.072	.096	.143	.191	.238	.287	.358	.430	.573	.717	.788	.860
200	.074	.098	.147	.196	.245	.294	.368	.441	.588	.735	.809	.882
psi	6"	8"	12"	16"	20"	24"	30"	36"	48"	60"	66"	72"
Above tabulation is based on leakage at maximum rate of 23.3 gallons per inch of pipe diameter per mile per 24 hours at 150 psi for pipe in 18-foot lengths.												

**SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.**

**ENDNOTES:**

- \*1. Delete or modify this paragraph as appropriate when project does not involve an operating agency.
- \*2. Add 1.2 C. including 1. for contracts where water distribution work is performed within the jurisdiction of WSSC.
- \*3. Use first version of 1.3 A.2. modification for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.
- \*4. Use second version of 1.3 A.2. for contracts where water distribution work is performed in all other jurisdictions.
- \*5. Use second version of 1.3 A.4. modification for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.
- \*6. Use third version of 1.3 A.4. modification for contracts where water distribution work is performed in all other jurisdictions.

- \*7. Add first version of 1.3 A.5. for contracts where water distribution work is performed within the jurisdiction of WSSC.
- \*8. Add second version of 1.3 A.5. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.
- \*9. Add 1.3 A.7. for contracts where water distribution work is performed within the jurisdiction of WSSC.
- \*10. Use second version of 2.1 R. for contracts where water distribution work is performed outside the jurisdiction of WSSC.
- \*11. Use first version of 2.1 S. including 1.a. modification for contracts where water distribution work is performed within the jurisdiction of WSSC.
- \*12. Use second version of 2.1 S. for contracts where water distribution work is performed outside the jurisdiction of WSSC.
- \*13. Add 2.1 V. for contracts where water distribution work is performed within the jurisdiction of WSSC and where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.
- \*14. Add first version of 2.1 W. for contracts where water distribution work is performed within the jurisdiction of WSSC.
- \*15. Add second version of 2.1 W. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.
- \*16. Add first version of 2.1 X. including 1.-7.e. for contracts where water distribution work is performed within the jurisdiction of WSSC.
- \*17. Add second version of 2.1 X. including 1.-3. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.
- \*18. Add first version of 2.1 Y. for contracts where water distribution work is performed within the jurisdiction of WSSC.
- \*19. Add second version of 2.1 Y. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.
- \*20. Add 2.1 Z. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.
- \*21. Add 3.5 G. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.
- \*22. Add 3.5 H. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.
- \*23. Add 3.5 I. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

- \*24. Add 3.5 J. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.
- \*25. Add 3.11 C. including 1.-2.c. for contracts where water distribution work is performed within the jurisdiction of WSSC.
- \*26. Use first version of 3.16 A. modification for contracts where water distribution work is performed within the jurisdiction of WSSC and where water distribution work is performed within the jurisdiction of Fairfax County, Virginia and Falls Church, Virginia.
- \*27. Use second version of 3.16 A. modification for contracts where water distribution work is performed in all other jurisdictions.
- \*28. Add 3.16 B. for contracts where water distribution work is performed within the jurisdiction of WSSC and where water distribution work is performed within the jurisdiction of Fairfax County, Virginia and Falls Church, Virginia.
- \*29. Add first version of 3.16 C. where water distribution work is performed within the jurisdiction of Fairfax County, Virginia and Falls Church, Virginia.
- \*30. Add second version of 3.16 C. for contracts where water distribution work is performed within the jurisdiction of WSSC.
- \*31. Add 3.16 D. for contracts where water distribution work is performed within the jurisdiction of WSSC.
- \*32. Use first version of 3.19 A.1. modification for contracts where water distribution work is performed within the jurisdiction of WSSC.
- \*33. Use second version of 3.19 A.1. modification for all other contracts where water distribution work is performed.

**END OF SECTION**

## SECTION 02535

### SANITARY SEWER

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies installing sanitary sewers.
- B. Related Work Specified Elsewhere:
  - 1. Grading, excavating and backfilling: Section 02320.
  - 2. Maintenance, support and restoration of utility facilities: Section 02270.
  - 3. Stray current and cathodic protection: Section 13110 and 13115.
- C. Material Furnished By Others: <sup>\*1</sup>
  - 1. Except for those items which bear the METRO logo, WSSC furnishes the following:
    - a. Manhole frames and covers: 22-inch diameter.
    - b. Manhole steps, except where precast manholes are used.
- D. Definitions: <sup>\*2</sup>
  - 1. Granular bedding required by WSSC is equivalent to aggregate for pipe cradle as specified.
  - 2. WSSC: Washington Suburban Sanitary Commission.
  - 3. WASA: Water and Sewer Authority.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Drawings for each size and configuration of precast manhole with details of accessories and joints.
    - b. Diagrams showing dimensioned locations for openings in precast concrete manhole walls.
  - 2. Documentation:
    - a. Submit calculations for modified or special designs to demonstrate compliance with required load-bearing capacity, certified by a professional engineer registered in the jurisdiction where the work is to be installed.
  - 3. Samples:
    - a. Sewer brick: Ten.
    - b. Manhole brick: Ten.
  - 4. Certification.
  - 5. Documentation: <sup>\*3</sup>
    - a. Submit two copies of records of inspection of new and relocated sewers, one copy to WSSC and one copy to the Engineer. Include video-tape cassette of television inspections and logs, photographs and other records specified by WASA for visual walk-through inspections.
    - b. Obtain and submit a written approval and acceptance from WASA.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
  2. Building Stone Institute: Stone Catalog
  3. CISPI: HSN 85.
  4. AASHTO: M33, M153, T85, T96, T104. <sup>\*4</sup>
  5. AASHTO: H20, M33, M36, M153, M175, M176, M190, M252, M288, T85, T96, T104. <sup>\*5</sup>
  6. ANSI/ASME: B16.1. <sup>\*6</sup>
  7. ACI: 318.
  8. ASTM: A36, A48, A53, A74, A167, C14, C32, C33, C76, C144, C150, C207, C361, C425, C443, C478, C700, D698, D1682, D3034. <sup>\*7</sup>
  9. ASTM: A36, A48, A53, A74, A167, C14, C32, C33, C76, C144, C150, C207, C361, C425, C443, C478, C700, D698, D3034, D5034. D5035. <sup>\*8</sup>
  10. MS: MIL-P-23236.
  11. SSPC: SP-6.
  12. WSSC: General Conditions and Standard Specifications. <sup>\*9</sup>
- B. Allowable Tolerances:
1. Rate of infiltration into sanitary sewer lines not to exceed 100 gallons per inch diameter per 24 hours per mile of sewer.
  2. Subgrade: Plus-or-minus 1/2 inch of elevation shown.
- C. Inspection: <sup>\*10</sup>
1. Prior to paving or other construction over new or relocated sewers, conduct visual walk-through inspection of sewers larger than 36 inches in diameter and of associated structures and internal television inspection of sewers 36 inches and smaller in diameter.
  2. Employ the services of a sewer inspection company which has been regularly engaged in television sewer inspections and which is acceptable to WASA to perform preconstruction and post-construction inspections of sewers 36 inches and smaller in diameter.
    - a. Submit to WASA for prior approval one sample of the cassettes to be used.

## PART 2 - PRODUCTS

### 2.01 MATERIALS:

- A. Formwork: Section 03100.
- B. Reinforcing Steel: Section 03200.
- C. Portland Cement Concrete: Section 03300, Class 3500, unless otherwise shown.
- D. Aggregate for Subgrade Foundation: ASTM C33, coarse aggregate, No. 4. Where shown use layers of No. 4 and No. 67 in combinations and proportions determined by field conditions and as approved.
- E. Aggregate for Pipe Cradle: ASTM C33, coarse aggregate No. 67.
- F. Concrete Pipe:
1. 10-inch diameter and smaller:
    - a. STM C14, Class 2, nonreinforced concrete pipe.
    - b. Bell-and-spigot type.

- c. Joints fabricated in accordance with ASTM C361. Physical characteristics for rubber gaskets in accordance with ASTM C443.
    - 2. 12-inch diameter and larger:
      - a. ASTM C76, bell-and-spigot or tongue-and-groove, Class IV, unless otherwise shown.
      - b. Radius (bevel) pipe, with drop between two pipe sections not exceeding the common wall thickness.
      - c. Rubber gasket joints, when required, fabricated in accordance with ASTM C361. Physical characteristics for rubber gaskets in accordance with ASTM C443.
      - d. Acceptance tests as specified in ASTM C76 form basis of acceptance for concrete pipe in accordance with the following:
        - 1) 72-inch diameter and smaller: Acceptance on the Basis of Plant Load Bearing Test, Material Tests and Inspection of Manufactured Pipe for Visual Defects and Imperfections.
        - 2) Larger than 72 inches in diameter: Acceptance on the Basis of Material Tests and Inspection of Manufactured Pipe for Defects and Imperfections.
        - 3) Minimum laying lengths:
          - (a) Sanitary sewer and combined system construction:
          - (b) 72-inch diameter and smaller: Eight feet.
          - (c) Larger than 72-inch diameter: Six feet.
      - e. Rubber gaskets: ASTM C361. <sup>\*11</sup>
      - f. Rubber gaskets: ASTM C443. <sup>\*12</sup>
      - g. Jointing mastic: Elastic, water-resistant, formulation of plastic bituminous materials, nonflammable solvent and inert fillers so combined that:
        - 1) When applied to a vertical metal surface and heated to 120F, jointing mastic will neither slump nor lose plasticity.
        - 2) When applied directly from container without further fixing, jointing mastic can be applied in even, adherent coat within temperature range of 20F to 100F.
- G. Plastic Pipe:
  - 1. Polyvinyl chloride (PVC) pipe: ASTM D3034, SDR-35.
- H. Vitrified Clay Pipe: ASTM C700; Joints, ASTM C425, using plastic materials.
- I. Cast-Iron Soil Pipe and Fittings: ASTM A74, extra-heavy (XH), with hub and spigot ends so constructed that joints may be made with gaskets conforming to CISPI Designation HSN 85 and the requirements of the relevant plumbing codes.
- J. Lubricant for Rubber Gasket Pipe Joints: Vegetable oil soap.
- K. Mortar Materials:
  - 1. Portland cement: ASTM C150, Type I.
  - 2. Sand: ASTM C144, natural sand.
  - 3. Lime: Pressure-hydrated, ASTM C207, Type S.
  - 4. Water: Potable.
  - 5. Pigment: As approved.
- L. Brick: ASTM C32; solid brick; Grade MS for manhole brick, Grade SS for sewer brick; 2-1/4 inches by 3-3/4 inches by eight inches.
- M. Precast Concrete Manhole Sections: <sup>\*13</sup>
  - 1. ASTM C478.
  - 2. Joint entry seal gasket: A-LOK as manufactured by Atlantic Precast Concrete, Inc.; A-LOCK gaskets, manufactured by A-LOK Products Corporation, Trenton,

N.J.; DURAC-SEAL gaskets, manufactured by DURA-CRETE, Inc., Dayton, Ohio; or equal.

- N. Precast Concrete Manholes: \*14
  - 1. Cylindrical, eccentric and conical: ASTM C478.
  - 2. Other configurations: ACI 318, AASHTO H20.
- O. Manhole Steps:
  - 1. Cast iron: ASTM A48 Class 30 A.
  - 2. Rebar: No. 4 reinforcing bar with molded polypropylene or rubber encasement.
- P. Manhole Frame and Cover; And Other Castings For Service With Utility Systems:
  - 1. Authority manhole: Cast-iron, ASTM A48, Class 30, with METRO logo.
  - 2. Utility company manhole: Manhole frame and cover furnished as part of the Contract or furnished by the utility as shown on the drawings.
  - 3. Rust-resistant cast iron or rust-resistant malleable cast iron.
  - 4. True to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blowholes and defects affecting strength.
  - 5. Fillets at angles in casting with arises sharp and perfect.
  - 6. Sandblasted to effectively remove scale and sand, presenting smooth, clean and uniform surfaces. Coated with bituminous coating.
  - 7. Metro logo: For utility components which will remain METRO property and are not within boundaries of utility easements as shown: Cast METRO logo as shown.
  - 8. Covers that receive paver tile:
    - a. Omit bituminous coating.
    - b. Provide positioning lug and lug receptor as a permanent part of the cover and frame rim so that the cover can only be installed (flush) in one position.
- Q. Metal Water Seals for Basin Connections: Neenah Foundry Model No. R-3707 or equal.
- R. Structural Steel Members: ASTM A36.
- S. Steel Pipe: ASTM A53, black finish, extra strong wall class.
- T. Stainless Steel Angle: ASTM A167, Type 304.
- U. Jute for Caulking: Good quality jute, free from tar, oil, or grease and dry when installed.
- V. Preformed Expansion Joint Fillers: AASHTO M153, Type I, Type II or Type III.
- W. Bituminous Expansion Joint Filler: AASHTO M33.
- X. Galvanizing: Section 05120.
- Y. Miscellaneous Metal: Section 05500.
- Z. Coal-Tar Epoxy Coating:
  - 1. Two-component.
  - 2. Chemically cured.
  - 3. Conforming to MS MIL-P-23236 (Ships), Type I, Class 2.
  - 4. Thinner: As recommended by manufacturer of coating and as approved.
- AA. Pipe Supports: \*15
  - 1. Pipe: Three-inch diameter, ASTM A53, Weight B, Class 1.

2. Flanges: ANSI/ASME B16.1, 125-pound Class, galvanized after fabrication.

## **2.02 MORTAR AND GROUT MIXES:**

- A. General Requirements:
  1. Mix dry in specified proportions by volume. Control and maintain accurate measurement throughout progress of work.
  2. Add sufficient water as specified to produce approved consistency.
  3. Do not mix in amount exceeding that which can be used within one hour after introduction of water.
  4. Do not retemper mix that has begun to set nor use such mix in the work.
  5. Where shown, specified or directed, mix pigment into dry mix to attain color selected by the Engineer. Pigment not to exceed 10 percent of dry batch weight of cement.
- B. Proportions:
  1. Mortar: One part portland cement, 2-1/2 parts sand and water sufficient to produce stiff workable mix.
  2. Grout: One part portland cement, 2-1/2 parts sand and water sufficient to produce plastic flowable mix.
  3. Mortar for setting and pointing granite: One part portland cement, four to five parts sand, one part lime and water sufficient to produce approved consistency.
  4. Mortar for setting granite paving and grouted granite blocks: One part portland cement, four parts sand, with water sufficient to produce approved consistency.

## **PART 3 - EXECUTION**

### **3.01 EXCAVATION FOR SEWER:**

- A. Perform excavation for sewers line and grade shown in accordance with Section 02320 and the following additional requirements:
  1. Excavate test pits sufficiently in advance of construction of sewers so that reasonable changes in line and grade can be made where location of existing structures varies from that shown.
  2. Excavate below horizontal plane extending two feet above top of sewer to maximum width of trench pay width shown. Where dimensions are not shown, make maximum horizontal width of excavation 18 inches from outside of sewer and minimum six inches. Where approved, excavation above such plane may exceed specified dimensions.
  3. If excavation exceeds permissible dimensions, encase pipe or install pipe of higher strength.
  4. Where necessary to place backfill or embankment so that trench can be excavated, extend backfill or embankment full depth laterally at least 2-1/2 times diameter of pipe on each side measured from centerline of pipe.

### **3.02 PIPE CRADLE:**

- A. Place pipes on cradle of aggregate or concrete where shown.
- B. Place aggregate so as to avoid segregation; compact to maximum practicable density so that pipe can be laid to required tolerances.

### **3.03 LAYING PIPE:**

- A. General Requirements:

1. Excavate to lines and grades shown in accordance with Sections 02320 and herein. Excavate depressions for bells.
  2. Protect pipe and fittings during handling to prevent damage.
  3. Place, shape and compact bedding material to receive barrel of pipe. Type and thickness of bedding material as shown.
  4. Start laying pipe at lowest point; lay true to line and grade shown.
  5. Install pipe to bear on bedding material along entire length. Shape bedding material to fit bells and flanges.
  6. Install pipe so that bells and grooves are on upstream end.
  7. Align each section of pipe with adjoining section with uniform annular space between bell and spigot and so as to prevent sudden offsets in flow line.
  8. As each section of pipe is laid, place sufficient backfill to hold it firmly in place.
  9. Keep interior of sewer clean as work progresses. Where small pipe size makes cleaning difficult, keep suitable swab or drag in pipe and pull through each joint immediately after jointing is completed.
  10. Keep trenches and excavations free of water during construction and until backfilled. Each day, excavate only as much trench as needed to lay pipe.
  11. When work is not in progress, securely plug ends of pipe and fittings to prevent trench water or other substances from entering pipes and fittings.
  12. Where length of stub is not shown, install four-foot length and seal free end with brick masonry bulkhead or approved stopper.
  13. Have work approved prior to covering pipe.
  14. Where shown, place additional aggregate filter around and over pipe in lifts not exceeding six inches loose. Compact each lift before placement of next lift.
  15. Backfill in accordance with Section 02320.
  16. Accomplish compaction by method that will avoid damage to pipe and will not disturb its alignment and grade. The use of vibratory rollers is prohibited until compacted cover over pipe has reached three feet or half the pipe diameter, whichever is greater.
  17. Where cathodic protection is shown, apply coal-tar epoxy coating.
- B. Vitrified Clay Pipe:
1. Nonperforated pipe:
    - a. Use pipe hoist, crane or other approved device when laying pipe greater than 18 inches diameter.
    - b. Prevent damage to premolded joint rings or attached couplings.
    - c. Clean joint contact surfaces immediately prior to jointing. To complete joint, use lubricants, primers or adhesives as recommended by pipe or joint manufacturer.
- C. Concrete Pipe:
- a. Bell-and-spigot joints:
    - b. Lay bell-and-spigot joint pipe as specified for vitrified clay pipe.
  1. Tongue-and-groove joints:
    - a. Clean groove end of preceding pipe with wet brush and apply soft mortar to lower 1/4 of groove. Clean tongue end of succeeding pipe with wet brush and position it. Remove mortar from interior surface if squeezed out of joint.
    - b. Complete mortaring interior and exterior portions of joint for entire circumference, extending from previously placed mortar. Perform final exterior mortaring of joints three lengths of pipe behind laying.
- D. Plastic Pipe:
1. Nonperforated pipe:
  2. Join sections of pipe with couplings recommended by pipe manufacturer.

- E. Inspections Of Sewers: <sup>\*16</sup>
1. Perform all work in accordance with current requirements of WASA.
  2. Perform inspections on new or relocated storm, sanitary and combined sewers within or adjacent to the zone of influence, as defined by the limits of a theoretical slope of 1:1 from the bottom edges of tunneling and cut-and-cover excavations, as follows:
    - a. Make inspections upon completion of tunneling and cut-and-cover operations, but prior to paving.
    - b. Obtain video-tape television inspection records of sewers 36 inches and smaller in diameter.
    - c. By means of visual walk-through inspection, obtain coordinated logs, photographs and other records specified by WASA sewers larger than 36 inches in diameter and of associated structures.
  3. Coordinate all television and walk-through inspection field operations with WASA. All such work to be performed in the presence of a WASA representative.

**3.02 BACKFILL:**

- A. Perform backfilling only after inspection and approval of pipe laying.
- B. On completion of construction, backfill excavation in accordance with Section 02320.

**3.03 JOINTS FOR COMBINED SEWER SYSTEM CONCRETE PIPE:**

- A. Use rubber gasket and bell-and-spigot pipe as specified.
- B. Prior to jointing pipe, liberally coat pipe joints with lubricant.
- C. Fit bell or spigot with gasket in accordance with manufacturer's instructions.
- D. Joint pipes with equipment designed for purpose.
- E. Before joint is completely home, check position of gasket using suitable gauge. If gasket is found to be dislocated, repeat entire joining process using new gasket.

**3.04 JOINTS FOR VITRIFIED CLAY PIPE:**

- A. Immediately before joining vitrified pipe, liberally coat bell with lubricant and fit spigot with gasket.
- B. Join pipes using equipment designed for purpose.

**3.05 JOINTS FOR CAST-IRON SOIL PIPE AND FITTINGS:**

- A. Immediately before joining cast-iron soil pipe and fittings, liberally coat hub with lubricant and fit spigot with pipes using equipment designed for purpose.

**3.06 CONNECTIONS WITH EXISTING SEWERS:**

- A. Make connections with existing public sewers in accordance with requirements of the jurisdictional authority.
- B. Connect house sewers in accordance with local plumbing code.

- C. Connect house sewers by means of Y-branches. Approved cast-iron thimble may be used, provided it is bonded into sewer pipe wall with approved epoxy at manufacturer's plant.
- D. Do not connect existing sewer to sewer under construction unless approved.
- E. Do not connect sanitary sewers to the WSSC system until application for such connections has been approved by WSSC. <sup>\*17</sup>

**3.07 TUNNELING AND JACKING:**

- A. Perform tunneling and jacking by approved methods.
- B. Where open cut is specified and the Engineer permits the work to be done by tunneling or jacking, perform such work as specified and as approved.
- C. Cost of material substitutions required by change of methods will be borne by the Contractor.
- D. Make horizontal borings necessary to lay pipe lines true to line and grade.
- E. When sewers are laid in borings, completely fill void between outside barrel of pipe and boring with cement grout pumped into place.
- F. When drainage pipes are laid in borings, completely fill void between pipe and boring with sand, using water pressure to ensure that voids are filled.
- G. Methods of boring and filling of voids between pipe and boring are subject to approval.

**3.08 CAST-IN-PLACE CONCRETE CONSTRUCTION:**

- A. Conform to applicable requirements of Sections 03100, 03200 and 03300. Section designer to specify the type of cement to be used. The type of cement will vary depending upon the jurisdiction where the work is performed.
  - 1. Cement. <sup>\*18</sup>
- B. Construct concrete support systems where shown. Section designer to specify the type of mortar to be used. Mortar type will vary depending upon jurisdiction in which the work is performed.
  - 1. Mortar and cement. <sup>\*19</sup>

**3.09 BRICK CONSTRUCTION:**

- A. Perform brick construction as specified in Section 04215, with the following additional requirements:
  - 1. Use sewer brick wherever brick construction is exposed to flow; otherwise, use manhole brick.
  - 2. Lay sewer brick on edge so that 2-1/4 by 8-inch side is exposed to flow.
  - 3. Lay manhole brick so that every sixth course is a header course.
  - 4. Where practicable, lay each course with a line. For curved courses or those in nonparallel planes, use bonded-and-keyed construction.
  - 5. Do not exceed joint thickness of 3/8 inch in straight courses in parallel planes; for courses curved or in nonparallel planes, make thickest part of joint as thin as practicable.

6. Rack or tooth uncompleted brick construction and parge unexposed surfaces with 1/2 inch of mortar.

### **3.10 MANHOLES:**

- A. Construct manholes of precast sections, cast-in-place concrete or brick as shown.
- B. Provide base of precast or cast-in-place construction. Make watertight connection between base and risers.
- C. Unless otherwise shown, place axes of manholes directly over centerlines of pipes.
- D. Construct appropriate flow channels in bottom of manholes.
- E. Where necessary, build connections for public and residential sewers into manholes. Cut pipe flush with inside wall of structure. Do not build pipe into wall; provide mortar joint between pipe and structure.
- F. Install manhole steps and cast iron frame and cover for each manhole; adjust frame and cover to proper grade by brick construction.
- G. Install joint entry seal gaskets in openings in the walls of 48-inch precast manholes with O-ring joint. <sup>\*20</sup>
- H.

### **3.11 COATING APPLICATION AND REPAIR:**

- A. Preparation of surface: Perform the following in order given:
  1. Clean surfaces contaminated with oil or grease using naphtha or xylol.
  2. Remove rust and mill scale from surfaces by dry abrasive blasting to commercial finish in accordance with SSPC SP-6.
  3. Coat surfaces within 24 hours and before dew point is reached.
  4. Apply coating only to surfaces which are dry and free of contaminants. Whip blast surfaces not coated within specified time limit.
- B. Application of coating:
  1. Mix coating in quantity which can be applied within its pot life if in accordance with manufacturer's recommendation. Thin only with approval.
  2. Apply coating to exterior surfaces of pipes and fittings in accordance with recommendations of coating manufacturer and as follows:
    - a. Two coats of equal thickness.
    - b. Total dry film thickness: 20 mils.
    - c. Pretreat first coat as required prior to application of second coat.
    - d. Apply second coat before first coat has dried tack-free but not later than 24 hours after application of first coat, unless otherwise recommended by coating manufacturer.
    - e. Inspect coating prior to burial. Repair damages in accordance with recommendations for field corrections by coating manufacturer.
  3. Test cathodic protection as specified in Section 13115.

### **3.12 FIELD QUALITY CONTROL:**

- A. Maximum Surface Variation Tolerances:
  1. Grouted riprap: 1-1/4 inches in four feet from true plane.
  2. Bituminous concrete: Plus-or-minus 1/4 inch from specified grade in 25 feet.

3. Cast-in-place concrete: Plus-or-minus 1/4 inch from specified grade in 15 feet.
  4. Precast concrete block: Plus-or-minus 1/2 inch from specified grade in 25 feet.
  5. Paving brick: Plus-or-minus 1/2 inch from specified grade in 25 feet.
- B. Leakage Tests:
1. Perform leakage tests on sanitary sewer lines to verify compliance with allowable tolerances specified.
- C. Obstruction Tests:
1. Perform field tests to verify that installed storm and sanitary systems are free from obstructions.
  2. Remove obstructions by excavating at the apparent obstruction and repairing or replacing the defective pipe as directed by the Engineer.
- D. Low-Pressure Air Testing Of Sanitary Sewers. \*21
1. Test sanitary sewers with air under low pressure in accordance with WSSC procedures. The tests will not be accepted by the WSSC until the sewers meet the criteria enumerated. Pressure gauges, stop watches and test supervision will be provided by the WSSC. Provide air compressor, hose, plugs, labor and such materials, equipment and assistance required to perform the tests. Conduct tests in the presence of representatives of the WSSC. Do not place air under pressure in any sewer under any condition except those specified by WSSC.
  2. Inspect sanitary sewers, including manholes, prior to air testing. Prior to undertaking the low-pressure air tests, correct and eliminate any water leakage into the system sufficient to constitute a noticeable trickle or dribble.
  3. Wherever underdrains have been constructed or gravel placed under pipelines to dewater the trench during construction of the sewers, do not make air test until pumps used in the dewatering process have been removed from the site.
  4. Before air tests are scheduled, complete backfill operations and compaction tests. Have compaction test approved before air tests are scheduled.
  5. Schedule air tests with the WSSC at least 48 hours in advance. Test each section of completed sewers. Test sewers from manhole to manhole, or from manhole to terminus of the sewer if there is not a manhole at the other extremity. Do not exclude any sewers or sewer connections from this testing procedure.

### **3.13 TRANSPORTATION AND INSTALLATION OF MATERIALS FURNISHED BY OTHERS: \*22**

- A. Transport and install materials furnished at the WSSC's storeyard at Bladensburg or other delivery points designated by the WSSC.
- B. Use only suitable equipment, tools, and appliances for the safe and convenient handling and hauling of materials.
- C. Check that all materials furnished by the WSSC are in satisfactory condition.
- D. Materials damaged, lost or wasted after acceptance will be replaced by the WSSC at the expense of the Contractor.
- E. Material showing inherent defects will be replaced by the WSSC without charge.

### **SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.**

**\*1.** Add 1.1 C. including 1.a.-b. for contracts where sanitary systems work is performed within the jurisdiction of WSSC.

- \*2.** Add 1.1 D. including 1. for contracts where sanitary systems work is performed within the jurisdiction of WSSC.
- \*3.** Add 1.2 E. including 1.-2. for contracts where sanitary systems work is performed within the jurisdiction of WASA.
- \*4.** Use first version of 1.3 A.4. modification for contracts where sanitary systems work is performed within the jurisdiction of WSSC.
- \*5.** Use second version of 1.3 A.4. for contracts where sanitary systems work is performed outside the jurisdiction of WSSC.
- \*6.** Use first version of 1.3 A.5. modification for contracts where sanitary systems work is performed within the jurisdiction of WSSC.
- \*7.** Use first version of 1.3 A.6. modification for contracts where sanitary systems work is performed within the jurisdiction of WSSC.
- \*8.** Use second version of 1.3 A.6. for contracts where sanitary systems work is performed outside the jurisdiction of WSSC.
- \*9.** Add 1.3 A.9. for contracts where sanitary systems work is performed within the jurisdiction of WSSC.
- \*10.** Add 1.3 C. including 1.-2.a. for contracts where sanitary systems work is performed within the jurisdiction of WSSC.
- \*11.** Use first version of 2.1 F.2.f. modification for contracts where sanitary systems work is performed within the jurisdiction of WSSC.
- \*12.** Use second version of 2.1 F.2.f. for contracts where sanitary systems work is performed outside the jurisdiction of WSSC.
- \*13.** Use first version of 2.1 N. including 1.-2. modification for contracts where sanitary systems work is performed within the jurisdiction of WSSC.
- \*14.** Use second version of 2.1 N. including 1.-2. for contracts where sanitary systems work is performed outside the jurisdiction of WSSC.
- \*15.** Add 2.1 DD. including 1.-2. for contracts where sanitary systems work is performed within the jurisdiction of WSSC.
- \*16.** Add 3.4 E. including 1.-3. for contracts where sanitary systems work is performed within the jurisdiction of WASA.
- \*17.** Add 3.11 E. for contracts where sanitary systems work is performed within the jurisdiction of WSSC.
- \*18.** Specify the type of cement to be used. The type of cement will vary depending on the jurisdiction and the use of the sanitary system.
- \*19.** Specify the type of mortar and cement to be used. They will vary depending on the jurisdiction and the use of the sanitary system.
- \*20.** Add 3.15 G. for contracts where work is performed within the jurisdiction of WSSC.

- \*21. Add 3.21 D. including 1.-5. for contracts where work is performed within the jurisdiction of WSSC.
- \*22. Add 3.22 including A.-E. for contracts where work is performed within the jurisdiction of WSSC.

**END OF SECTION**

## SECTION 02585

### UNDERGROUND ELECTRICAL AND COMMUNICATIONS DISTRIBUTION SYSTEMS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

This section specifies providing new ducts, manholes and handholes for electrical and communications facilities.

- A. Related Work Specified Elsewhere:
  - 1. Grading, excavating and backfilling: Section 02320.
  - 2. Support of excavation: Section 02260.
  - 3. Maintenance, support and restoration of utility facilities: Section 02270.
  - 4. Grounding and bonding: Section 16060.
  - 5. Concrete formwork: Section 03100.
  - 6. Concrete reinforcement: Section 03200.
  - 7. Cast-in-place structural concrete: Section 03300.
  - 8. Structural precast concrete: Section 03400.
  
- B. Definitions:
  - 1. Conduit: Individual raceway.
  - 2. Ductbank: Assembly of conduits in configurations shown, with concrete encasement, with or without reinforcement.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Drawings for each cast-in-place manhole and handhole.
    - b. Drawings for each size and configuration of precast manhole and handhole with details of accessories and joints.
    - c. Diagrams showing dimensioned locations for openings and knockout panels for ductbank penetrations of manhole and handhole walls.
  - 2. Documentation:
    - a. Submit calculations to demonstrate compliance with required load-bearing capacity, certified by a professional engineer registered in the jurisdiction where the work is to be installed.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. AASHTO: H15-44, H20-44.
  - 3. ANSI: C80.1.
  - 4. ASTM: A36, A48, A123, A185, A615, C33, C109, C173, C231, D570, D638, D790, F512.
  - 5. NEMA: TC-14.
  - 6. UL: 6.

##### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Transport those materials supplied by utility companies from companies' storage facilities to construction site.
- B. Protect materials stored on site from damage prior to incorporation into work and during handling.

**1.05 JOB CONDITIONS:**

- A. Coordination with Utility Companies:
  - 1. Arrange with the Engineer to contact utility companies early enough to allow sufficient time for them to accomplish work they are required to perform, giving special consideration to lead times required for cable work.
  - 2. Establish liaison with utility companies furnishing materials for the work in order to determine availability, locations, methods of storage and care of materials prior to incorporation into work.

**PART 2 - PRODUCTS**

**2.01 MATERIALS:**

- A. Concrete Formwork: Section 03100.
- B. Reinforcing Steel: Section 03200.
- C. Concrete:
  - 1. Cast-in-place: Section 03300, Class 3500 or as required by the power company for its facilities.
  - 2. Precast: Section 03400, Class 5000, unless otherwise shown on the drawings.
- D. Materials Supplied by Utility Company: As listed.
- E. Conduit and Fittings:
  - 1. PVC conduit and fittings: ASTM F512; modulus of elasticity, 500,000 psi.
  - 2. Concrete encased: Schedule 40.
    - a. Direct burial: Schedule 80 heavy wall.
    - b. Solvent cement: As recommended by conduit manufacturer.
  - 3. Galvanized rigid steel conduit and fittings: UL 6 and ANSI C80.1.
  - 4. Fiberglass conduit and fittings:
    - a. Rigid fiberglass reinforced epoxy conduit, UL 1684, IPS (Iron Pipe Size) based conduit.
    - b. Rigid fiberglass-reinforced epoxy, filament wound with minimum fiberglass content of 65 percent by weight and no fillers.
    - c. Type SW (Standard Wall) of IPS based standard conduit with nominal wall thickness of .09 inch for five-inch nominal conduit size, and nominal wall thickness of 0.07 inch for two through four-inch nominal conduit size.
    - d. Conduits, elbows and fittings manufactured from the same material and using the same manufacturing process.
    - e. Conduit sections formed with integral bell-and-spigot type couplings. Rubber sealing gasket at bell end is prohibited.
    - f. Conduits, elbows and fittings shall be specified for use throughout a temperature range of -40°F to 230°F and protected from exposure to sunlight by pigmentation uniformly dispersed through resin material.
    - g. Adhesive as recommended by conduit manufacturer.
    - h. Conduit, elbows and fittings shall be suitable for encasement in concrete below grade and conform to UL 1684, and listed and labeled by UL, meeting

- the requirement of NEC Article 347 for Rigid Nonmetallic Conduit and its use.
- i. Conduit for above ground surface mounted duct systems shall pass the UL1684 mandatory flame test (UL 1684, Section 5.12.1) and be certified by the manufacturer as such.
  - j. Each piece of the straight length conduit and each piece of the elbow and other bend made from and for use with such conduit is to be labeled with the following information, marked clearly legible and durably every 10 feet or as recommended by the manufacturer:
    - a. "Reinforced Thermosetting Resin Conduit", "RTRC", or equivalent wording such as "FRE" (Fiberglass Reinforced Epoxy) conduit.
    - b. Nominal size: (IPS)
    - c. Manufacturer's name and trademark.
    - d. Temperature range for conduit application.
    - e. "Above ground", "AG", "Below ground", "BG", or equivalent wording.
    - f. "FT4" when flame test is required for above ground conduit.
5. Conduit seal fittings:
- a. To provide watertight seal between concrete and conduit where it penetrates wall, floor or ceiling.
  - b. Size as shown or necessary.
  - c. Materials: Body and pressure clamp of malleable or cast iron with a neoprene sealing grommet and PVC-coated or galvanized-steel pressure rings, oversized sleeve of PVC or galvanized steel.
  - d. Seal between conduit and concrete to withstand pressure from 50-foot head of water without leakage.
- F. Channel Inserts: Stainless steel, size and shape as shown, 12-gauge minimum thickness, with 7/8-inch slot; surface-mounted; slotted-base channel with 9/16-inch by 3/16-inch nominal mounting slots on eight-inch centers.
- G. Cable Pulling Eye: Fabricated of plain steel reinforcement bar, ASTM A615, Grade 60; welded; size as shown. Hot-dip galvanized after fabrication, ASTM A123. Pulling tension: 5,000 pounds.
- H. Manhole Frame and Cover:
- 1. Authority manhole: Cast-iron, ASTM A48, Class 30, with METRO logo.
  - 2. Utility company manhole: Manhole frame and cover furnished as part of the Contract or furnished by the utility as shown on the drawings.
  - 3. Rust-resistant cast iron or rust-resistant malleable cast iron.
  - 4. True to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blowholes and defects affecting strength.
  - 5. Fillets at angles in casting with arises sharp and perfect.
  - 6. Sandblasted to effectively remove scale and sand, presenting smooth, clean and uniform surfaces. Coated with bituminous coating.
  - 7. Covers to receive paver tile:
    - a. Omit bituminous coating.
    - b. Provide positioning lug and lug receptor as a permanent part of the cover and frame rim so that the cover can only be installed (flush) in one position.
- I. Manhole Steps:
- 1. ASTM A48, cast-iron, Class 30A.
  - 2. Molded rubber or plastic on cast-iron or reinforcing steel core.
- J. Handhole and Manhole: Option of cast-in-place or precast.
- 1. Cast-in-place concrete handhole and manhole: As shown and specified.
  - 2. Precast concrete:

- a. Shape shown. If precast manholes are selected and size shown is not standard, use nearest larger standard precast unit; where added size will conflict with other utilities or structures, use cast-in-place unit.
  - b. Designed for AASHTO H20-44 truck loading.
  - c. Manhole: Include lifting rings, manhole steps, pulling eyes, sump, hole through floor for ground rod, and seal or sealant for sealing joints between sections, precast extensions included where required by utility.
3. Precast concrete handhole: Compressive strength 3,500 psi, air entrainment six-percent minimum, ASTM C173 or ASTM C231; Section 03300 and Section 03400 and in accordance with the following:
- a. Box: Concrete formed with closed bottom and sides and recess at top of box or at edge of cover to provide mating surfaces to prevent lateral movement of flush-mounted cover. Knockouts provided to accommodate conduits as shown on the drawings..
  - b. Cover:
    - a. Material same as for box. Use of metallic cover and cover frame prohibited.
    - b. Metro Type "B" logo with 3-1/8 inch by 4-inch envelope and service designation recessed in center of cover.
    - c. Non-protruding provisions provided for lifting.
  - c. Reinforcement:
    - a. Sidewalk and landscape locations: Welded-wire fabric, ASTM A185.
    - b. Areas subject to vehicular traffic: Deformed steel bars, ASTM A615.
  - d. Loading:
    - a. Sidewalk and landscape locations: AASHTO H15-44.
    - b. Areas subject to vehicular traffic: AASHTO H20-44.
  - e. Hardware: Stainless steel.
  - f. Size: As shown or next available larger size.

K. Precast composite material handhole: Sand and gravel bound together with a polymer and reinforced with continuous woven glass strands and in accordance with the following:

Physical Properties	Values	Methods
Compressive strength	11,000 psi	ASTM C109
Tensile strength	1,700 psi	ASTM D638
Flexural strength	7,500 psi	ASTM D790
Water absorption (24 hours)	0.5 percent	ASTM D570

- 1. Box: Gray-color material formed with closed bottom and sides and flange with recess at top of box to accommodate flush-mounted cover.
- 2. Cover:
  - a. Material same as for box.
  - b. Skid-resistant top surface with minimum 0.5 coefficient of friction.
  - c. Metro Type "B" logo with 3-1/8 inch by 4-inch envelope and service designation recessed in center of cover.
  - d. Secured to box with bolts.
  - e. Non-protruding provisions provided for lifting.
  - f. Loading:
    - g. Sidewalk and landscape locations: AASHTO H15-44.
    - h. Areas subject to vehicular traffic: AASHTO H20-44.

- i. Hardware: Stainless steel.
- j. Size: As shown or next available larger size.
- L. Aggregate for Subgrade Foundation: ASTM C33, coarse aggregate No. 4 and No. 67.
- M. Spacer: As shown or recommended by conduit manufacturer.
- N. End Bells: Flared, smooth-surfaced fittings of same material as conduit; if of different material, include adaptor for connection to conduit.
- O. Grounding: Section 16060.
- P. Brick: Section 04215.
- Q. Mortar: Section 04050.

### **PART 3 - EXECUTION**

#### **3.01 EXCAVATING AND BACKFILLING:**

- A. Excavating and backfilling: In accordance with Section 02320.
- B. If ducts and manholes are to be installed on backfill over subway structure, place and compact backfill up to grade shown for ductbanks, conduits, manholes and handholes; compact as specified in Section 02320; ensure the manhole sets level. Schedule completion of backfilling to allow sufficient time for installation of ductbanks, conduits, manholes and handholes.
- C. Where shown for subgrade foundation, use layers of coarse aggregate No. 4 and No. 67 in combinations and proportions determined by field conditions.

#### **3.02 PAVEMENTS, SIDEWALKS, CURBS AND GUTTERS:**

- A. Remove pavements, sidewalks, curbs and gutters where necessitated by construction of ductbanks, manholes and handholes in accordance with Section 02220.
- B. Place temporary bituminous pavement in accordance with Section 02740, when necessary because of sequence of operations.
- C. On completion of construction, replace pavements, sidewalks, curbs and gutters in accordance with Section 02205.

#### **3.03 INSTALLATION:**

- A. General:
  - 1. Use size, type, general routing and locations of ductbanks, conduits, manholes and handholes as shown and specified.
- B. Ductbanks:
  - 1. Place conduits in ductbanks on spacers or construct concrete base prior to placing bottom row of conduits.
  - 2. Use spacers to provide conduit spacing and support as recommended by conduit manufacturer.
  - 3. Make conduit joints watertight by complying with recommendations of conduit manufacturers and as follows:

- a. PVC conduit: Use solvent cement to join conduits, elbows and fittings.
  - b. Galvanized steel rigid conduit: Use lead-free conductive anti-seize compound on threaded conduit joints.
  - c. Fiberglass conduit: Use adhesive to join conduits, elbows and fittings for water tightness and pull out strength. Follow instructions of conduit manufacturer for using adhesive during periods below the recommended temperature range. Use of rubber sealing gaskets and interference type joints is prohibited.
4. Use Schedule 40 PVC conduit for underground ductbanks except as follows:
- a. Use galvanized steel rigid conduit only in specific locations as shown.
  - b. Use fiberglass conduit only for providing utility company's 13.8 kv electric services.
5. Place and compact concrete around conduits in accordance with Section 03300.
6. Where shown, install reinforcing steel in concrete encasement in accordance with Section 03200.
7. Bends:
- a. Unless otherwise shown or specified, install conduit bends in accordance with reference codes.
  - b. Install bends in buried conduit in accordance with the following:

Size of conduit in inches	Minimum radius of factory-bend in inches	Minimum radius of field-bend in inches
3	18	24
4	24	30
5	48	48
6	48	48

- c. Total bends in each conduit run for traction-power cable: 225 degrees maximum.
  - d. Bend conduit so that field-made bend is free from cuts, dents and other surface damage.
  - e. Field-made bends in fiberglass conduits are prohibited.
8. Support conduit during construction using compatible conduit supports and spacers to maintain positions of conduit during placement of concrete and to ensure independent support.
9. Install conduit so that it drains to adjacent manhole or handhole.
10. Prevent concrete and other foreign materials from entering, obstructing or deflecting conduit. Cap or plug conduit ends prior to pouring concrete.
11. Remove burrs from conduit ends, clean and dry before applying solvent cement to PVC conduit joints or adhesive to fiberglass conduit joints.
12. Pull approved test mandrel and swab through each conduit after installation. Cap or plug conduit ends. If mandrel cannot be pulled through conduit, replace conduit.
13. Leave approved nylon or polyester pull-line in each conduit.
14. At the ends of each conduit, use corrosion-resistant metallic tags with stamped markings to establish identification in accordance with designations shown. Install tags securely to permanent structure near each conduit as approved by the Engineer.
15. Install caps at empty conduit ends for future use.

C. Conduits Without Concrete Encasement:

- 1. Use Schedule 80 for direct-buried train control conduit.

2. Install caps on ends of empty train control conduits and identify locations of conduit ends with stakes.

### **3.04 CONSTRUCTION OF MANHOLES AND HANDHOLES:**

- A. Provide drainage facilities for manholes and handholes where shown. If connection is made to existing sewer line, install connection in accordance with applicable local regulations
- B. Erect formwork in accordance with Section 03100.
- C. Place reinforcing in accordance with approved shop drawings.
- D. Provide for location of ductbank entrances and inserts in walls as shown.
- E. Place concrete as specified in Section 03300.
- F. Install conduits of material shown.
- G. Install end bells on conduits where ductbanks terminate in manholes and handholes.
- H. Build ductbank formation into walls of manholes and handholes and seal around opening.
- I. If location of manholes and handholes openings will be obstructed, so inform the Engineer.
- J. Install frame and cover, adjusting to finished grade, building brick chimney as specified in Section 02535.
- K. Seal conduit openings with approved conduit plugs.
- L. Install cable pulling eyes and steps as shown. Test pulling eye for compliance with specified pullout load rating.
- M. Install ground rods, 2-inch by 1/4-inch by 12-inch long ground bus bar and insulated grounding conductors where shown. If soil conditions prevent driving rod to required depth, install alternative grounding system as approved. Provide grounding for personnel protection as specified in Section 16060.
- N. When installing sections of precast manholes and handholes, prevent damage to joints seals.
- O. Provide full-height stainless steel channel inserts approximately two feet on center along interior walls, spaced to clear ductbank entrances and steps. Use expansion bolt anchors to secure channel inserts to walls. Install and test channel inserts in accordance with Section 16130.

### **3.05 INSTALLATION OF HANDHOLES:**

- A. Bury precast concrete or composite material handholes with cover mounted flush with finish grade or pavement. Comply with installation procedures furnished by manufacturer.

### **3.06 CLEAN UP:**

- A. Remove debris from manholes and handholes and ensure complete installation is left in neat and finished condition.

**3.07 FIELD QUALITY CONTROL:**

- A. Arrange with the Engineer for inspection and approval of conduits in ductbank and cast-in-place manholes and handholes prior to concrete placement.
- B. Arrange with the Engineer for a representative of the utility company to inspect and approve service conduits for Authority facilities, relocated utility conduits, manholes and handholes prior to concrete placement.
- C. Arrange with the Engineer for inspection and approval of direct-buried conduits for future train control circuits, prior to backfilling.

**END OF SECTION**

## SECTION 02625

### SUBWAY DRAINAGE SYSTEM

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing subway drainage system except drainage pumping system.
- B. Related Work Specified Elsewhere:
  - 1. Grading, excavating and backfilling: Section 02320.
  - 2. Concrete work: Sections 03100, 03200 and 03300.
  - 3. Drainage pumping station: Section 15444.
  - 4. Piping systems: Section 15205.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Samples:
    - a. Submit proposed materials not less than ten days prior to date of expected first shipment.
  - 2. Shop Drawings:
    - a. Include complete catalog information and shop drawings for material and equipment.
  - 3. Certification.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. AASHTO: M352.
  - 3. ASTM: A48, B271, B584, C33, C131, C654, C700, D1785, D2729.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. Porous Concrete Pipe:
  - 1. Extra strength: ASTM C654.
  - 2. Tongue-and-groove joints formed of solid concrete.
- B. Vitrified Clay Pipe: ASTM C700, standard strength, extra strength, as shown.
- C. Plastic Pipe and Fittings:
  - 1. PVC pipe: ASTM D2729 or ASTM D1785.
  - 2. Polyethylene corrugated pipe: AASHTO M352. Individual lengths not less than 10 feet. Coil pipe not permitted for pipe eight inches in diameter or larger.
  - 3. Fittings:
    - a. Polyvinyl chloride: ASTM D2729 or ASTM D1785.
    - b. Polyethylene, corrugated: AASHTO M352.
- D. Manholes:

1. Formwork: Section 03100.
  2. Concrete reinforcement: Section 03200.
  3. Concrete: Section 03300, Class 3500. Manhole frames and covers, inlet frames and grates:
    - a. Authority manhole: Cast-iron, ASTM A48, Class 30, with METRO logo. Size as shown.
    - b. Rust-resistant cast iron or rust-resistant malleable cast iron, fabricated as shown.
    - c. True to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blowholes and defects affecting strength.
    - d. *Fillets at angles in casting with arises sharp and perfect.*
    - e. Sandblasted to effectively remove scale and sand, presenting smooth, clean and uniform surfaces. Coated with bituminous coating.
    - f. Covers to receive paver tile.
      - 1) Omit bituminous coating.
      - 2) Provide positioning lug and receptor permanently part of cover and frame rim so that cover can only be installed (flush) in one position.
- E. Drainage Castings:
1. Drain inlets, cleanouts, floor and scupper drains fabricated from cast iron: ASTM A48, Class 25 with brass parts, Alloy Number 844.
  2. Copper alloy sand castings: ASTM B584.
  3. Copper base alloy centrifugal castings: ASTM B271.
- F. Drainage Casting Covers:
1. Cast iron: ASTM A48, Class 30.
  2. Copper alloy: ASTM 584.
- G. Wire Mesh Screen:
1. Bronze or stainless steel wire, minimum .047-inch diameter, 1/4-inch mesh.
- H. Porous Subgrade Material:
1. Coarse aggregate: ASTM C33, Size No. 67.
  2. Maximum percentage of wear: 45 percent when tested in accordance with ASTM C131.
- I. Drainage Pumping Station: Section 15444.

## **PART 3 - EXECUTION**

### **3.01 EXCAVATION:**

- A. Excavate to lines and grades shown in accordance with Section 02320.

### **3.02 POROUS MATERIAL PLACEMENT:**

- A. Place porous material for subgrade around main track drain and drain pipes and for trench backfill as shown.
- B. In rock excavation, do not place porous subgrade material on excavated rock surface until surface has been flushed with water to remove fine dust and sludge.
- C. Place material only on stable rock surfaces.

### **3.03 VITRIFIED CLAY PIPE:**

- A. Place vitrified clay pipe to lines and grades shown.
- B. Make joints in accordance with manufacturer's instructions.
- C. Place concrete encasement where shown in accordance with Section 03300. Secure pipe to avoid displacement during concrete placement.

**3.04 POROUS CONCRETE PIPE:**

- A. Lay pipe on porous subgrade material so as to provide full bearing and grades shown.
- B. Install joints in accordance with the manufacturer's instructions.
- C. Place porous material over and around the pipe as shown.
- D. Place perforated pipe as specified with the perforations downward.
- E. Place concrete for encasement in accordance with Section 03300.
- F. Place and brace pipe for encasing to prevent displacement during placing of concrete.

**3.05 PLASTIC PIPE:**

- A. Lay plastic pipe as specified for porous concrete pipe.
- B. Use nonpressure pipe for drainage.
- C. Use cast iron, concrete or vitrified clay pipe for last two feet at exposed termination points. Provide standard adaptor fittings for connections between differing pipe materials.
- D. Plastic pipe may be used only if buried or encased in concrete. Its use is prohibited in exposed locations.

**3.06 MANHOLES:**

- A. Construct cast-in-place concrete manholes as shown.
- B. Construct flow channel in manhole where shown.
- C. Place axis of manholes directly over centerlines of pipes unless otherwise shown.
- D. Set manhole frame and cover or grate to required elevation. Set ballast screen where shown.

**3.07 INSTALLATION OF PIPE AND CASTINGS:**

- A. Install cast-iron, ductile-iron, nickel-copper alloy steel pipe and fittings meeting the requirements of Section 15205.
- B. Install drainage piping to the lines and grades shown.
- C. Locate drainage castings and set to the finished floor elevation, slabs or inverts.
- D. Install cleanouts at the locations shown.

**3.08 PROTECTION OF DRAINAGE SYSTEM:**

- A. During the course of construction, maintain drainage lines free of debris and in undamaged condition.
- B. Plug or close ends of completed runs of piping until the Engineer approves their use.
- C. Cover the inlet end of drainage piping used to convey water to wet wells at the existing drainage pumping stations with wire mesh screen.

**3.09 FIELD QUALITY CONTROL:**

- A. Where drainage piping is located below invert slabs, conduct a ball, shuttlecock, or mandrel test to ensure that the line is free of obstructions subsequent to the placing of porous subgrade material over the line and prior to the placement of the concrete invert slab.
- B. Upon completion of the test and determination that the line is free of obstructions, plug, cap or otherwise close the open end or ends of the installed piping to prevent the entrance of debris into the lines.
- C. Immediately prior to final inspection of the work, remove debris from manholes, drain inlets, and floor scupper drains. In the presence of the Engineer, prove by one of the methods specified above that the piping is free of obstructions.

**END OF SECTION**

## SECTION 02635

### STORM SEWER

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies installing storm sewers, roadway drains, roadway underdrains, ditch lining and slope protection.
- B. Related Work Specified Elsewhere:
  - 1. Grading, excavating and backfilling: Section 02320.
  - 2. Maintenance, support and restoration of utility facilities: Section 02270.
  - 3. Stray current and cathodic protection: Section 13110 and 13115.
- C. Material Furnished By Others: \*1
  - 1. Except for those items which bear the METRO logo, WSSC furnishes the following:
    - a. Manhole frames and covers: 22-inch diameter.
    - b. Manhole steps, except where precast manholes are used.
- D. Definitions: \*2
  - 1. Granular bedding required by WSSC is equivalent to aggregate for pipe cradle as specified.
  - 2. WSSC: Washington Suburban Sanitary Commission.
  - 3. WASA: Water and Sewer Authority.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Drawings for each size and configuration of precast manhole with details of accessories and joints.
    - b. Diagrams showing dimensioned locations for openings in precast concrete manhole walls.
  - 2. Documentation:
    - a. Submit calculations for modified or special designs to demonstrate compliance with required load-bearing capacity, certified by a professional engineer registered in the jurisdiction where the work is to be installed.
  - 3. Samples:
    - a. Sewer brick: Ten.
    - b. Manhole brick: Ten.
    - c. Slope protection materials:
      - 1) Concrete blocks: Ten each.
      - 2) Paving bricks: Ten each.
      - 3) Riprap: 1.5 cubic yards.
      - 4) Gabions: Two each, complete.
    - d. Geotextile filter fabric: Two, 12 inches long by 12 inches wide, minimum.
  - 4. Certification.
  - 5. Documentation: \*3
    - a. Submit two copies of records of inspection of new and relocated sewers, one copy to WSSC and one copy to the Engineer. Include video-tape

- cassette of television inspections and logs, photographs and other records specified by WASA for visual walk-through inspections.
- b. Obtain and submit a written approval and acceptance from WASA.

### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  1. Comply with codes and regulations of the jurisdictional authorities.
  2. Building Stone Institute: Stone Catalog.
  3. CISPI: HSN 85.
  4. AASHTO: M33, M36, M153, M175, M176, M190, M252, M288, T85, T96, T104. <sup>\*4</sup>
  5. AASHTO: H20, M33, M36, M153, M175, M176, M190, M252, M288, T85, T96, T104. <sup>\*5</sup>
  6. ANSI/ASME: B16.1. <sup>\*6</sup>
  7. ACI: 318. <sup>\*7</sup>
  8. ASTM: A36, A48, A53, A74, A167, C14, C32, C33, C76, C144, C150, C207, C361, C425, C443, C478, C507, C700, D698, D1682, D3034, D5034, D5035. <sup>\*8</sup>
  9. ASTM: A36, A48, A53, A74, A167, C14, C32, C33, C76, C144, C150, C207, C361, C425, C443, C478, C700, D698, D1682, D3034, D5034, D5035. <sup>\*9</sup>
  10. MS: MIL-P-23236.
  11. SSPC: SP-6.
  12. WSSC: General Conditions and Standard Specifications. <sup>\*10</sup>
- B. Source Quality Control:
  1. Ditch lining and slope protection materials:
    - a. After approval, do not change source.
    - b. Replace defective material.
- C. Allowable Tolerances:
  1. Subgrade: Plus-or-minus 1/2 inch of elevation shown.
- D. Inspection: <sup>\*11</sup>
  1. Prior to paving or other construction over new or relocated sewers, conduct visual walk-through inspection of sewers larger than 36 inches in diameter and of associated structures and internal television inspection of sewers 36 inches and smaller in diameter.
  2. Employ the services of a sewer inspection company which has been regularly engaged in television sewer inspections and which is acceptable to WASA to perform preconstruction and post-construction inspections of sewers 36 inches and smaller in diameter.
    - a. Submit to WASA for prior approval one sample of the cassettes to be used.

## PART 2 - PRODUCTS

### 2.01 MATERIALS:

- A. Formwork: Section 03100.
- B. Reinforcing Steel: Section 03200.
- C. Portland Cement Concrete: Section 03300, Class 3500, unless otherwise shown.
- D. Aggregate for Subgrade Foundation: ASTM C33, coarse aggregate, No. 4. Where shown use layers of No. 4 and No. 67 in combinations and proportions determined by field conditions and as approved.

- E. Aggregate for Pipe Cradle: ASTM C33, coarse aggregate No. 67.
- F. Concrete Pipe:
  - 1. 10-inch diameter and smaller:
    - a. ASTM C14, Class 2, nonreinforced concrete pipe.
    - b. Bell-and-spigot type.
    - c. Joints fabricated in accordance with ASTM C361. Physical characteristics for rubber gaskets in accordance with ASTM C443.
  - 2. 12-inch diameter and larger:
    - a. ASTM C76, bell-and-spigot or tongue-and-groove, Class IV, unless otherwise shown.
    - b. Radius (bevel) pipe, with drop between two pipe sections not exceeding the common wall thickness.
    - c. Rubber gasket joints, when required, fabricated in accordance with ASTM C361. Physical characteristics for rubber gaskets in accordance with ASTM C443.
    - d. Acceptance tests as specified in ASTM C76 form basis of acceptance for concrete pipe in accordance with the following:
      - 1) 72-inch diameter and smaller: Acceptance on the Basis of Plant Load Bearing Test, Material Tests and Inspection of Manufactured Pipe for Visual Defects and Imperfections.
      - 2) Larger than 72 inches in diameter: Acceptance on the Basis of Material Tests and Inspection of Manufactured Pipe for Defects and Imperfections.
    - e. Minimum laying lengths: Four feet.
    - f. Rubber gaskets: ASTM C361. <sup>\*12</sup>
    - g. Rubber gaskets: ASTM C443. <sup>\*13</sup>
    - h. Jointing mastic: Elastic, water-resistant, formulation of plastic bituminous materials, nonflammable solvent and inert fillers so combined that:
      - 1) When applied to a vertical metal surface and heated to 120F, jointing mastic will neither slump nor lose plasticity.
      - 2) When applied directly from container without further fixing, jointing mastic can be applied in even, adherent coat within temperature range of 20F to 100F.
    - i. Reinforced concrete elliptical pipe: ASTM C507. <sup>\*14</sup>
  - 3. Perforated nonreinforced concrete pipe: AASHTO M175, Type 1 or 2, bell-and-spigot or tongue-and-groove type.
  - 4. Porous concrete pipe: AASHTO M176, tongue-and-groove.
- G. Plastic Pipe:
  - 1. Polyvinyl chloride (PVC) pipe: ASTM D3034, SDR-35.
  - 2. Polyethylene corrugated pipe: AASHTO M252.
- H. Bituminous-Coated Corrugated Metal Pipe: AASHTO M190, Type A or C, with connecting bands, AASHTO M36.
- I. Vitrified Clay Pipe: ASTM C700; Joints, ASTM C425, using plastic materials.
- J. Cast-Iron Soil Pipe and Fittings: ASTM A74, extra-heavy (XH), with hub and spigot ends so constructed that joints may be made with gaskets conforming to CISPI Designation HSN 85 and the requirements of the relevant plumbing codes.
- K. Lubricant for Rubber Gasket Pipe Joints: Vegetable oil soap.
- L. Mortar Materials:

1. Portland cement: ASTM C150, Type I.
  2. Sand: ASTM C144, natural sand.
  3. Lime: Pressure-hydrated, ASTM C207, Type S.
  4. Water: Potable.
  5. Pigment: As approved.
- M. Brick: ASTM C32; solid brick; Grade MS for manhole brick, Grade SS for sewer brick; 2-1/4 inches by 3-3/4 inches by eight inches.
- N. Precast Concrete Manhole Sections: <sup>\*15</sup>
1. ASTM C478.
  2. Joint entry seal gasket: A-LOK as manufactured by Atlantic Precast Concrete, Inc.; A-LOCK gaskets, manufactured by A-LOK Products Corporation, Trenton, N.J.; DURAC-SEAL gaskets, manufactured by DURA-CRETE, Inc., Dayton, Ohio; or equal.
- O. Precast Concrete Manholes: <sup>\*16</sup>
1. Cylindrical, eccentric and conical: ASTM C478.
  2. Other configurations: ACI 318, AASHTO H20.
- P. Manhole Steps:
1. Cast iron: ASTM A48 Class 30 A.
  2. Rebar: No. 4 reinforcing bar with molded polypropylene or rubber encasement.
- Q. Manhole Frame and Cover; Inlet Frame and Grate; and Ballast Screen;
1. Authority manhole: Cast-iron, ASTM A48, Class 30, with METRO logo.
  2. *Rust-resistant cast iron or rust-resistant malleable cast iron.*
  3. *True to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blowholes and defects affecting strength.*
  4. *Fillets at angles in casting with arises sharp and perfect.*
  5. *Sandblasted to effectively remove scale and sand, presenting smooth, clean and uniform surfaces. Coated with bituminous coating.*
  6. *Covers that receive paver tile:*
    - a. *Omit bituminous coating.*
    - b. *Provide positioning lug and lug receptor as a permanent part of the cover and frame rim so that the cover can only be installed (flush) in one position.*
- R. Metal Water Seals for Basin Connections: Neenah Foundry Model No. R-3707 or equal.
- S. Structural Steel Members: ASTM A36.
- T. Steel Pipe: ASTM A53, black finish, extra strong wall class.
- U. Stainless Steel Angle: ASTM A167, Type 304.
- V. Jute for Caulking: Good quality jute, free from tar, oil, or grease and dry when installed.
- W. Preformed Expansion Joint Fillers: AASHTO M153, Type I, Type II or Type III.
- X. Bituminous Expansion Joint Filler: AASHTO M33.
- Y. Galvanizing: Section 05120.
- Z. Ditch Lining and Slope Protection:
1. Riprap: Material meeting the following requirements:

- a. Hard, durable and free of fractures; angular in shape; weather-resistant; and free from overburden, spoil, shale and organic material.
  - b. Size: Weight distribution of pieces provided in accordance with the following:
    - 1) Class I: From 50 to 150 pounds with 60-percent minimum weighing 100 pounds or more; approximately 10 percent may weigh 50 pounds or less.
    - 2) Class II: From 150 to 500 pounds with 50-percent minimum weighing more than 300 pounds; approximately 10 percent may weigh 150 pounds or less.
  - c. Quality:
    - 1) Water absorption: 3.0-percent maximum when tested in accordance with AASHTO T85.
    - 2) Specific gravity: 2.5 minimum when tested in accordance with AASHTO T85.
    - 3) Resistance to abrasion: Grade B maximum when tested in accordance with AASHTO T96.
    - 4) Soundness: Loss 20-percent maximum when tested in accordance with AASHTO T104.
  - 2. Aggregate filter:
    - a. Coarse aggregate, ASTM C33, Size 357.
    - b. Use only tough, durable materials free of thin, flat, elongated or soft friable particles and free of organic matter.
  - 3. Granite block facing: Type 4, quarry split finish on face and edges.
  - 4. Sand cushion for concrete block: Section 03300, fine aggregate.
- AA. Geotextile Filter Fabric: AASHTO M288 and the following additional requirements:
- 1. Woven or non-woven pervious filter fabric weighing approximately 0.03 to 0.05 pounds per square foot; free of defects.
  - 2. Fabric: Long chain synthetic polymer composed of at least 85 percent by weight of propylene, ethylene, ester, amide or vinyl-chloride and with stabilizers or inhibitors to make fabric resistant to deterioration due to ultraviolet and heat exposure.
  - 3. Fabric formed or treated so that filaments retain their positions relative to each other.
  - 4. Edges selvaged.
  - 5. Physical strength:
    - a. Tensile strength: 200-pound minimum in each direction, ASTM D1682.
    - b. Elongation at failure: 10 to 30 percent, ASTM D5034 and D5035.
    - c. Puncture strength: 70-pound minimum, ASTM D5034 and D5035.
  - 6. Percent of open area: Not less than five percent nor more than six percent.
  - 7. Equivalent opening size (E.O.S.): 70-100 US Standard Sieve, CW-02215-77.
  - 8. Securing Pins: As recommended by manufacturer of filter fabric.
- BB. Gabions:
- 1. Wire mesh: Galvanized steel wire 0.105 minimum diameter, 60,000 pounds per square inch tensile strength, galvanized at rate of 0.80 ounces per square foot. Wires twisted to form nonraveling hexagonal openings of uniform size, not to exceed 4-1/2 inches in length nor eight square inches in area of mesh opening. Horizontal dimension uniform, not to exceed 36 inches. Gabion dimensions not to vary more than three percent from manufacturer's stated size.
  - 2. Tie devices: Malleable iron or steel, producing frictional force of 160 pounds per foot of spacing. Sized to conform to requirements of jurisdictional agency.
  - 3. Stone: Durable, free from cracks and seams, unweathered, weighing between four pounds (four-inch average diameter) and 30 pounds (eight-inch average diameter) except five percent may vary more or less and 50 percent to exceed 10 pounds.
    - a. Stone size:

Basket Thickness (Inches)	Size of Stones (Inches)
6	3 to 5
9, 12, 18	4 to 7
36	4 to 12

- CC. Coal-Tar Epoxy Coating:
1. Two-component.
  2. Chemically cured.
  3. Conforming to MS MIL-P-23236 (Ships), Type I, Class 2.
  4. Thinner: As recommended by manufacturer of coating and as approved.
- DD. Pipe Supports: <sup>\*17</sup>
1. Pipe: Three-inch diameter, ASTM A53, Weight B, Class 1.
  2. Flanges: ANSI/ASME B16.1, 125-pound Class, galvanized after fabrication.
- EE. Underdrain Filter Material: ASTM C33, Size 57. <sup>\*18</sup>

**2.02 MORTAR AND GROUT MIXES:**

- A. General Requirements:
1. Mix dry in specified proportions by volume. Control and maintain accurate measurement throughout progress of work.
  2. Add sufficient water as specified to produce approved consistency.
  3. Do not mix in amount exceeding that which can be used within one hour after introduction of water.
  4. Do not retemper mix that has begun to set nor use such mix in the work.
  5. Where shown, specified or directed, mix pigment into dry mix to attain color selected by the Engineer. Pigment not to exceed 10 percent of dry batch weight of cement.
- B. Proportions:
1. Mortar: One part portland cement, 2-1/2 parts sand and water sufficient to produce stiff workable mix.
  2. Grout: One part portland cement, 2-1/2 parts sand and water sufficient to produce plastic flowable mix.
  3. Mortar for setting and pointing granite: One part portland cement, four to five parts sand, one part lime and water sufficient to produce approved consistency.
  4. Mortar for setting granite paving and grouted granite blocks: One part portland cement, four parts sand, with water sufficient to produce approved consistency.

**PART 3 - EXECUTION**

**3.01 EXCAVATION FOR SEWER AND DRAINAGE STRUCTURES:**

- A. Perform excavation for sewers and drainage structures to line and grade shown in accordance with Section 02320 and the following additional requirements:
1. Excavate test pits sufficiently in advance of construction of sewers and drainage structures so that reasonable changes in line and grade can be made where location of existing structures varies from that shown.
  2. Excavate below horizontal plane extending two feet above top of sewer or drainage structures to maximum width of trench pay width shown. Where dimensions are not shown, make maximum horizontal width of excavation 18 inches from outside of

sewer or drainage structure and minimum six inches. Where approved, excavation above such plane may exceed specified dimensions.

3. If excavation exceeds permissible dimensions, encase pipe or install pipe of higher strength.
4. Where necessary to place backfill or embankment so that trench can be excavated, extend backfill or embankment full depth laterally at least 2-1/2 times diameter of pipe on each side measured from centerline of pipe.

### **3.02 GEOTEXTILE FILTER FABRIC:**

- A. Prepare surface to receive fabric to relatively smooth condition free of obstructions, depressions, debris and soft or low density pockets of material.
  1. Place fabric with long dimension parallel to centerline of trench and lay smooth and free of tension, stress, folds, wrinkles or creases with sufficient excess to allow for minimum overlap of 12 inches.
  2. Place strips in trench to provide minimum width of 12 inches of overlap for each joint.
  3. Insert securing pins with washers through both strips of overlapped fabric at not greater than 3-foot intervals along a line through the midpoint of overlap at joints.
  4. Where this method of placement conflicts with manufacturer's instructions, the manufacturer's instructions prevail.
- B. At time of installation fabric to be rejected if it has defects, rips, holes, flaws, deterioration or damage incurred during manufacture, transportation, storage or handling.
- C. Place fabric in manner and at location shown.

### **3.03 PIPE CRADLE:**

- A. Place pipes on cradle of aggregate or concrete where shown.
- B. Place aggregate so as to avoid segregation; compact to maximum practicable density so that pipe can be laid to required tolerances.

### **3.04 LAYING PIPE:**

- A. General Requirements:
  1. Excavate to lines and grades shown in accordance with Sections 02320 and herein. Excavate depressions for bells.
  2. Protect pipe and fittings during handling to prevent damage.
  3. Place, shape and compact bedding material to receive barrel of pipe. Type and thickness of bedding material as shown.
  4. Start laying pipe at lowest point; lay true to line and grade shown.
  5. Install pipe to bear on bedding material along entire length. Shape bedding material to fit bells and flanges.
  6. Install perforated pipe with perforations downward.
  7. Install pipe so that bells and grooves are on upstream end.
  8. Align each section of pipe with adjoining section with uniform annular space between bell and spigot and so as to prevent sudden offsets in flow line.
  9. As each section of pipe is laid, place sufficient backfill to hold it firmly in place.
  10. Keep interior of sewer clean as work progresses. Where small pipe size makes cleaning difficult, keep suitable swab or drag in pipe and pull through each joint immediately after jointing is completed.
  11. Keep trenches and excavations free of water during construction and until backfilled. Each day, excavate only as much trench as needed to lay pipe.

12. When work is not in progress, securely plug ends of pipe and fittings to prevent trench water or other substances from entering pipes and fittings.
  13. Where length of stub is not shown, install four-foot length and seal free end with brick masonry bulkhead or approved stopper.
  14. Have work approved prior to covering pipe.
  15. Where shown, place additional aggregate filter around and over pipe in lifts not exceeding six inches loose. Compact each lift before placement of next lift.
  16. Backfill in accordance with Section 02320.
  17. Accomplish compaction by method that will avoid damage to pipe and will not disturb its alignment and grade. The use of vibratory rollers is prohibited until compacted cover over pipe has reached three feet or half the pipe diameter, whichever is greater.
  18. Where cathodic protection is shown, apply coal-tar epoxy coating.
- B. Vitrified Clay Pipe:
1. Nonperforated pipe:
    - a. Use pipe hoist, crane or other approved device when laying pipe greater than 18 inches diameter.
    - b. Prevent damage to premolded joint rings or attached couplings.
    - c. Clean joint contact surfaces immediately prior to jointing. To complete joint, use lubricants, primers or adhesives as recommended by pipe or joint manufacturer
  2. Perforated pipe:
    - a. Firmly position spigot in bell of preceding pipe. Saturate jute gasket in cement grout and caulk into annular space. Ensure that jute is long enough to reach entirely around pipe and is of such thickness to bring pipe sections to same grade.
    - b. After pipe sections have been caulked and centered, fill annual space with cement mortar.
    - c. After mortar joints have set, place additional aggregate filter material as specified.
- C. Concrete Pipe:
1. Bell-and-spigot joints:
    - a. Lay bell-and-spigot joint pipe as specified for vitrified clay pipe.
  2. Tongue-and-groove joints:
    - a. Clean groove end of preceding pipe with wet brush and apply soft mortar to lower 1/4 of groove. Clean tongue end of succeeding pipe with wet brush and position it. Remove mortar from interior surface if squeezed out of joint.
    - b. Complete mortaring interior and exterior portions of joint for entire circumference, extending from previously placed mortar. Perform final exterior mortaring of joints three lengths of pipe behind laying.
- D. Plastic Pipe:
1. Perforated pipe:
    - a. Use sleeve couplings designed to hold pipe in alignment without use of sealing compound or gaskets.
    - b. Place additional aggregate filter material as specified.
    - c. Cap open ends of underdrains.
  2. Nonperforated pipe:
    - a. Join sections of pipe with couplings recommended by pipe manufacturer.
- E. Corrugated Metal Pipe:
1. Perforated pipe:
    - a. Place additional aggregate filter material as specified
  2. Nonperforated pipe:

- a. When pipe is shown to be bituminous paved, place paved area on bottom.
  - 3. Connections for corrugated metal pipe:
    - a. Join sections of pipe with coupling bands arranged to fit corrugations accurately.
    - b. Do not damage protective coating when tightening bolts.
    - c. After final tightening of connection bolts, apply brush coat of bituminous paint to bands and bolts.
- F. Porous Concrete Pipe:
  - 1. Fill joints with mortar as specified for tongue-and-groove joints of concrete pipe.
  - 2. After pipe joints have been made, place additional filter material as specified.
- G. Inspections Of Sewers: <sup>\*19</sup>
  - 1. Perform all work in accordance with current requirements of WASA.
  - 2. Perform inspections on new or relocated storm sewers within or adjacent to the zone of influence, as defined by the limits of a theoretical slope of 1:1 from the bottom edges of tunneling and cut-and-cover excavations, as follows:
    - a. Make inspections upon completion of tunneling and cut-and-cover operations, but prior to paving.
    - b. Obtain video-tape television inspection records of sewers 36 inches and smaller in diameter.
    - c. By means of visual walk-through inspection, obtain coordinated logs, photographs and other records specified by WASA of sewers larger than 36 inches in diameter and of associated structures.
  - 3. Coordinate all television and walk-through inspection field operations with WASA. All such work to be performed in the presence of a WASA representative.

**3.05 BACKFILL:**

- A. Perform backfilling only after inspection and approval of pipe laying.
- B. On completion of construction, backfill excavation in accordance with Section 02320.

**3.06 JOINTS FOR CONCRETE STORM SEWER: <sup>\*20</sup>**

- A. Use cold-applied jointing mastic for joints of storm sewer.
- B. Bell-and-Spigot Joints:
  - 1. Clean interior surface of bell and fill lower portion with mastic of sufficient thickness to make inner surfaces of abutting sections flush.
  - 2. Install spigot end of adjoining pipe into bell so that sections are closely fitted and aligned.
  - 3. Apply sufficient jointing mastic to fill remaining void in joint.
  - 4. Remove excess mastic from interior of pipe.
- C. Tongue-and-Groove Joints:
  - 1. Clean groove. Apply mastic to lower half of groove.
  - 2. Clean tongue of next pipe and apply layer of mastic to upper half.
  - 3. Fit tongue into groove until pipes are closely fitted and aligned and mastic covers inner and outer surfaces.
  - 4. Remove excess mastic from interior of pipe.

**3.06 JOINTS FOR CONCRETE STORM SEWER 12 INCHES TO 33 INCHES: <sup>\*21</sup>**

- A. Use cold applied jointing mastic for joints of storm sewer 12 inches to 33 inches in diameter.

- B. Bell-and-Spigot Joints:
  1. Clean interior surface of bell and fill lower portion with mastic of sufficient thickness to make inner surfaces of abutting sections flush.
  2. Install spigot end of adjoining pipe into bell so that sections are closely fitted and aligned.
  3. Apply sufficient jointing mastic to fill remaining void in joint.
  4. Remove excess mastic from interior of pipe.
- C. Tongue-and-Groove Joints:
  1. Clean groove. Apply mastic to lower half of groove.
  2. Clean tongue of next pipe and apply layer of mastic to upper half.
  3. Fit tongue into groove until pipes are closely fitted and aligned and mastic covers inner and outer surfaces.
  4. Remove excess mastic from interior of pipe.

### **3.06 JOINTS FOR CONCRETE STORM SEWER 36 INCHES AND LARGER. \*22**

- A. Where not prohibited by jurisdictional agencies, Use mortar for joints of storm sewers 36 inches diameter and larger.
- B. Bell-and-Spigot Joints:
  1. Where pipe cradle is aggregate, place shallow bed of mortar under joint.
  2. Thoroughly wet bell and fill lower half with mortar.
  3. Thoroughly wet spigot and uniformly fit into bell so that sections are closely fitted and aligned.
  4. Fill remaining annular space in bell with mortar sufficient to form bead around outside of spigot end of pipe.
  5. Remove excess mortar from interior of pipe and finish exterior and interior to smooth surfaces.
- C. Tongue-and-Groove Joints:
  1. Thoroughly wet groove; apply mortar to lower half of groove.
  2. Thoroughly wet tongue of next pipe and apply a layer of mortar to top half.
  3. Fit tongue into groove until pipes are closely fitted and aligned and mortar covers inner and outer surfaces of the joint.
  4. Clean inner surface of pipes at joint and point up outside with bead of mortar.

### **3.07 JOINTS FOR VITRIFIED CLAY PIPE:**

- A. Immediately before joining vitrified pipe, liberally coat bell with lubricant and fit spigot with gasket.
- B. Join pipes using equipment designed for purpose.

### **3.08 JOINTS FOR CAST-IRON SOIL PIPE AND FITTINGS:**

- A. Immediately before joining cast-iron soil pipe and fittings, liberally coat hub with lubricant and fit spigot with pipes using equipment designed for purpose.

### **3.09 CONNECTIONS WITH EXISTING SEWERS:**

- A. Make connections with existing public sewers in accordance with requirements of the jurisdictional authority.

- B. Do not connect existing sewer to sewer under construction unless approved.

### **3.10 TUNNELING AND JACKING:**

- A. Perform tunneling and jacking by approved methods.
- B. Where open cut is specified and the Engineer permits the work to be done by tunneling or jacking, perform such work as specified and as approved.
- C. Cost of material substitutions required by change of methods will be borne by the Contractor.
- D. Make horizontal borings necessary to lay pipe lines true to line and grade.
- E. When sewers are laid in borings, completely fill void between outside barrel of pipe and boring with cement grout pumped into place.
- F. When drainage pipes are laid in borings, completely fill void between pipe and boring with sand, using water pressure to ensure that voids are filled.
- G. Methods of boring and filling of voids between pipe and boring are subject to approval.

### **3.11 CAST-IN-PLACE CONCRETE CONSTRUCTION:**

- A. Conform to applicable requirements of Sections 03100, 03200 and 03300. Section designer to specify the type of cement to be used. The type of cement will vary depending upon the jurisdiction where the work is performed.
  - 1. Cement. <sup>\*23</sup>
- B. Construct concrete support systems where shown. Section designer to specify the type of mortar to be used. Mortar type will vary depending upon jurisdiction in which the work is performed.
  - 1. Mortar and cement. <sup>\*24</sup>

### **3.12 BRICK CONSTRUCTION:**

- A. Perform brick construction as specified in Section 04215, with the following additional requirements:
  - 1. Use sewer brick wherever brick construction is exposed to flow; otherwise, use manhole brick.
  - 2. Lay sewer brick on edge so that 2-1/4 by 8-inch side is exposed to flow.
  - 3. Lay manhole brick so that every sixth course is a header course.
  - 4. Where practicable, lay each course with a line. For curved courses or those in nonparallel planes, use bonded-and-keyed construction.
  - 5. Do not exceed joint thickness of 3/8 inch in straight courses in parallel planes; for courses curved or in nonparallel planes, make thickest part of joint as thin as practicable.
  - 6. Rack or tooth uncompleted brick construction and parge unexposed surfaces with 1/2 inch of mortar.

### **3.13 MANHOLES:**

- A. Construct manholes of precast sections, cast-in-place concrete or brick as shown.
- B. Provide base of precast or cast-in-place construction. Make watertight connection between base and risers.

- C. Unless otherwise shown, place axes of manholes directly over centerlines of pipes.
- D. Construct appropriate flow channels in bottom of manholes.
- E. Where necessary, build connections for public and residential sewers into manholes. Cut pipe flush with inside wall of structure. Do not build pipe into wall; provide mortar joint between pipe and structure.
- F. Install manhole steps and cast iron frame and cover for each manhole; adjust frame and cover to proper grade by brick construction.
- G. Install joint entry seal gaskets in openings in the walls of 48-inch precast manholes with O-ring joint. <sup>\*25</sup>

### 3.14 CATCH BASINS AND INLETS:

- A. When grading has been substantially completed as approved, construct catch basins of cast-in-place concrete using Class 3500 concrete and steel reinforcement as shown, precast sections or brick as shown.
- B. Cut pipe flush with inside wall of structure. Provide mortar joint between pipe and structure or install water seal as shown.
- C. Install cast iron frame and grate or cover and adjust to proper grade.
- D. Install pipe supports as shown. Fill with concrete after installation. <sup>\*26</sup>

### 3.15 DITCH LINING AND SLOPE PROTECTION:

- A. Slope Preparation:
  - 1. Excavate or fill slopes to the required cross section, lines and grades.
  - 2. Compact earth slopes to not less than 95 percent of the maximum dry density for a depth of not less than 12 inches, as specified in Section 02725.
  - 3. Where lining or protection is to be applied to rock surfaces, clean off mud, debris and loose fragments.
  - 4. Construct toe or cut off walls where shown.
  - 5. Remove loose material and buried debris protruding from subgrade.
  - 6. Placement of aggregate filter:
    - a. Place filter aggregate where shown to depth shown.
    - b. Compact each layer of aggregate filter in accordance with ASTM D698, Method D, to 100 percent at plus-or-minus one percent of optimum moisture content.
- B. Ungrouted Riprap:
  - 1. Place aggregate filter as specified.
  - 2. Place riprap by machine to full course thickness in one operation upward from bottom of slope. Prevent displacement of underlying materials. Dumping of riprap is prohibited.
  - 3. Fill spaces between larger stones to produce nearly even surface with minimum of voids. Manually supplement machine placement of stone to choke in voids.
  - 4. Rearrange individual stones as necessary to ensure that finished configuration conforms to lines, grades and thickness shown.
- C. Bituminous Concrete Paving:

1. Place bituminous concrete where shown to the lines, grades, thickness and shapes shown.
  2. Give base course prime coat of medium-curing, cutback asphalt and allow to cure before hot bituminous concrete is placed.
  3. Place hot-mix bituminous concrete by hand or by machine.
  4. When hand methods are used, place mixture by means of hot shovels or forks and spread with hot rakes to thickness required to obtain specified compacted thickness. Thoroughly rake loose material throughout its depth, to eliminate honeycombing. Use screed boards of width equal to required thickness of lining.
  5. After spreading, compact until specified compacted thickness is obtained.
  6. Place mixture as continuously as practicable to eliminate joints. Where joints are required at end of a day's work or when the placing is discontinued for such period of time that material becomes chilled, form joints as specified.
- D. Cast-in-Place Concrete:
1. Use Class 3500 concrete unless otherwise shown.
  2. Use wood or steel forms.
  3. Place reinforcing steel or wire mesh as shown.
  4. Provide and install dowel bars where shown in accordance with Section 02750.
  5. Locate expansion and contraction joints where shown in accordance with Section 02750.
  6. Unless otherwise shown, give surface wood float finish.
  7. Protect and cure concrete in accordance with Section 03300.
- E. Concrete Masonry Units:
1. Place two-inch layer of sand cushion on previously prepared slope.
  2. Set units firmly by hand in sand cushion with long dimension parallel to base of slope so as to produce even surface.
  3. Lay blocks with open 3/8-inch joints and with joints staggered as shown.
  4. Completely fill joints with mortar.
  5. Protect and cure newly laid blocks for seven days using wet cotton mats or wet burlap.
  6. Lay blocks when the temperature is 40F or above.
- F. Paving Brick:
1. On the previously prepared slope, place concrete base of thickness shown.
  2. Give concrete smooth screed finish.
  3. Clean base, dampen and lay one-inch thick mortar bed.
  4. Lay bricks with long dimension parallel to base of slope, with open 3/8-inch joints and with joints staggered.
  5. Bed bricks firmly in mortar bed so as to produce even surface free from depressions or high spots.
  6. Fill joints completely with mortar.
  7. Protect and cure newly laid brick for a period of seven days using wet cotton mats or wet burlap.
- G. Sodding: Section 02920.
- H. Concrete Pavement:
1. Lay plastic pipe as shown.
  2. Place aggregate filter as specified.
  3. Place concrete base in accordance with specified requirements for cast-in-place concrete.
- I. Concrete with Granite Block Facing:
1. Lay plastic pipe as shown.

2. Place aggregate filter as specified.
3. Place concrete base in accordance with specified requirements for cast-in-place portland cement concrete.
4. Installation of granite block facing:
  - a. Set granite blocks in bedding course, one-inch minimum depth with 3/4-inch joint width.
  - b. Slope bedding to true surface parallel to finished surface of blocks; strike off bedding until true alignment is attained.
  - c. After final sloping, do not disturb bedding prior to laying blocks.
  - d. Lay blocks on bedding course in successive courses with quarry split finish up.
  - e. Align each course, lay true and even and bring to true grade by use of wood mallets or similar tools.
  - f. Lay blocks in continuous sequence.
  - g. Lay no more mortar than can be covered with blocks before end of work day.
  - h. Point voids in joints with preshrunk mortar. Do not point when ambient temperature is 50F and falling. After pointing, scrub surfaces with soap solution and remove stains. Rinse immediately with clean water. Leave work in first class condition, free from mortar stain and other defacement as approved.

J. Gabions:

1. Prepare ground surface smooth and even where gabions will be installed.
2. Assemble gabions and tie together in accordance with manufacturer's instructions.
3. Fill gabions in lifts of 12 inches maximum. Install tie devices in all units with exposed faces, spaced in accordance with requirements of jurisdictional agency.
4. Ensure stone fill is placed without voids larger than approximately smaller stones. Hand-place stones in exposed faces.

### 3.16 CONCRETE HEADWALLS AND WINGWALLS:

A. Excavation:

1. Excavate for foundations and walls to lines and grades shown in accordance with Section 02320.

B. Formwork and Reinforcement:

1. Erect formwork and install reinforcement as shown and in accordance with Sections 03100 and 03200.

C. Concrete Work:

1. Place concrete of class shown and protect and cure in accordance with Section 03300.

D. Backfilling:

1. Backfill and compact in accordance with Section 02320.

### 3.17 COATING APPLICATION AND REPAIR:

A. Preparation of surface: Perform the following in order given:

1. Clean surfaces contaminated with oil or grease using naphtha or xylol.
2. Remove rust and mill scale from surfaces by dry abrasive blasting to commercial finish in accordance with SSPC SP-6.
3. Coat surfaces within 24 hours and before dew point is reached.

4. Apply coating only to surfaces which are dry and free of contaminants. Whip blast surfaces not coated within specified time limit.
5. Application of coating:
  - a. Mix coating in quantity which can be applied within its pot life if in accordance with manufacturer's recommendation. Thin only with approval.
  - b. Apply coating to exterior surfaces of pipes and fittings in accordance with recommendations of coating manufacturer and as follows:
    - 1) Two coats of equal thickness.
    - 2) Total dry film thickness: 20 mils.
    - 3) Pretreat first coat as required prior to application of second coat.
    - 4) Apply second coat before first coat has dried tack-free but not later than 24 hours after application of first coat, unless otherwise recommended by coating manufacturer.
    - 5) Inspect coating prior to burial. Repair damages in accordance with recommendations for field corrections by coating manufacturer.
6. Test cathodic protection as specified in Section 13115.

**3.18 SUBWAY DRAINAGE SYSTEM: Section 02625.**

**3.19 FIELD QUALITY CONTROL:**

- A. Maximum Surface Variation Tolerances:
  1. Grouted riprap: 1-1/4 inches in four feet from true plane.
  2. Bituminous concrete: Plus-or-minus 1/4 inch from specified grade in 25 feet.
  3. Cast-in-place concrete: Plus-or-minus 1/4 inch from specified grade in 15 feet.
  4. Precast concrete block: Plus-or-minus 1/2 inch from specified grade in 25 feet.
  5. Paving brick: Plus-or-minus 1/2 inch from specified grade in 25 feet.
- B. Obstruction Tests:
  1. Perform field tests to verify that installed storm systems are free from obstructions.
  2. Remove obstructions by excavating at the apparent obstruction and repairing or replacing the defective pipe as directed by the Engineer.

**3.20 TRANSPORTATION AND INSTALLATION OF MATERIALS FURNISHED BY OTHERS: \*27**

- A. Transport and install materials furnished at the WSSC's storeyard at Bladensburg or other delivery points designated by the WSSC.
- B. Use only suitable equipment, tools, and appliances for the safe and convenient handling and hauling of materials.
- C. Check that all materials furnished by the WSSC are in satisfactory condition.
- D. Materials damaged, lost or wasted after acceptance will be replaced by the WSSC at the expense of the Contractor.
- E. Material showing inherent defects will be replaced by the WSSC without charge.

**SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.**

\*1. Add 1.1 C. including 1.a.-b. for contracts where storm systems work is performed within the jurisdiction of WSSC.

- \*2. Add 1.1 D. including 1. for contracts where storm systems work is performed within the jurisdiction of WSSC.
- \*3. Add 1.2 E. including 1.-2. for contracts where storm systems work is performed within the jurisdiction of WASA.
- \*4. Use first version of 1.3 A.4. modification for contracts where storm systems work is performed within the jurisdiction of WSSC.
- \*5. Use second version of 1.3 A.4. for contracts where storm systems work is performed outside the jurisdiction of WSSC.
- \*6. Use first version of 1.3 A.5. modification for contracts where storm systems work is performed within the jurisdiction of WSSC.
- \*7. Use second version of 1.3 A.5. for contracts where storm systems work is performed outside the jurisdiction of WSSC.
- \*8. Use first version of 1.3 A.6. modification for contracts where storm systems work is performed within the jurisdiction of WSSC.
- \*9. Use second version of 1.3 A.6. for contracts where storm systems work is performed outside the jurisdiction of WSSC.
- \*10. Add 1.3 A.9. for contracts where storm systems work is performed within the jurisdiction of WSSC.
- \*11. Add 1.3 D. including 1.-2.a. for contracts where storm systems work is performed within the jurisdiction of WASA.
- \*12. Use first version of 2.1 F.2.f. modification for contracts where storm and sanitary systems work is performed within the jurisdiction of WSSC.
- \*13. Use second version of 2.1 F.2.f. for contracts where storm systems work is performed outside the jurisdiction of WSSC.
- \*14. Add 2.1 F.2.h. for contracts where storm systems work is performed within the jurisdiction of WSSC.
- \*15. Use first version of 2.1 N. including 1.-2. modification for contracts where storm systems work is performed within the jurisdiction of WSSC.
- \*16. Use second version of 2.1 N. including 1.-2. for contracts where storm systems work is performed outside the jurisdiction of WSSC.
- \*17. Add 2.1 DD. including 1.-2. for contracts where storm systems work is performed within the jurisdiction of WSSC.
- \*18. Add 2.1 EE. for contracts where storm systems work is performed within the jurisdiction of Prince Georges County.
- \*19. Add 3.4 G. including 1.-3. for contracts where storm systems work is performed within the jurisdiction of WASA.
- \*20. Use first version of 3.6 including A.-C.4. modification for contracts where storm systems work is performed within the jurisdiction of Fairfax County, Virginia.

**\*21.** Use second version of 3.6 including A.-C.4. for contracts where storm systems work is performed outside the jurisdiction of Fairfax County, Virginia.

**\*22.** Use second version of 3.7 including A.-C.4. for contracts where storm systems work is performed outside the jurisdiction of Fairfax County, Virginia.

**\*23.** Specify the type of cement to be used. The type of cement will vary depending on the jurisdiction and the use of the storm system.

**\*24.** Specify the type of mortar and cement to be used. They will vary depending on the jurisdiction and the use of the storm system.

**\*25.** Add 3.15 G. for contracts where work is performed within the jurisdiction of WSSC.

**\*26.** Add 3.16 D. for contracts where work is performed within the jurisdiction of WSSC.

**\*27.** Add 3.22 including A.-E. for contracts where work is performed within the jurisdiction of WSSC.

**END OF SECTION**

**SECTION 02725  
(Version 1)<sup>\*1</sup>**

**BASE FOR PAVEMENTS**

**PART 1 - GENERAL**

**1.01 DESCRIPTION:**

- A. This section specifies furnishing, placing, shaping and compacting aggregate base on previously constructed subgrades.
- B. Related Work Specified Elsewhere:
  - 1. Grading, excavating and backfilling: Section 02320.
  - 2. Concrete pavement: Section 02750.

**1.02 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ASTM: D1241, D1557.
- B. Source Quality Control:
  - 1. Not less than 10 days prior to the beginning of work, inform the Engineer of source of material to be used.
  - 2. Once approved, do not change source of supply.
  - 3. Do not construe approval as approval of the entire location but as approval only insofar as material continues to conform to specified requirements.
  - 4. Cooperate with the Engineer so that the Engineer may take samples and make tests as often as he deems necessary.
  - 5. The Engineer has the right to reject material at the job site by visual inspection, pending sampling and testing.

**PART 2 - PRODUCTS**

**2.01 MATERIALS:**

- A. Aggregate Base Materials:
  - 1. ASTM D1241.
  - 2. Grading requirements <sup>\*2</sup>:

Sieve Designation	Percentage By Weight Passing Square Mesh Sieves
2 inches	100
1 inch	70 - 95
3/8 inch	35 - 75
Size 4	20 - 60
Size 10	15 - 45
Size 40	10 - 30
Size 200*	0 - 15

\*Fraction passing the Size 200 sieve to be not greater than 2/3 of the fraction passing the Size 40 sieve.

3. Grading requirements \*3:

Sieve Designation	Percentage By Weight Passing Square Mesh Sieves
2-1/2 inches	100
1 inch	85 - 100
1/2 inch	50 - 92
Size 10	35 - 65
Size 40	15 - 45
Size 200*	3 - 15

\*Fraction passing the Size 200 sieve to be not greater than 2/3 of the fraction passing the Size 40 sieve.

**PART 3 - EXECUTION**

**3.01 EQUIPMENT:**

- A. Place material using equipment designed for the purpose. Use equipment of size and weight necessary to shape material as shown and to compact material to specified minimum density.
- B. Provide sufficient equipment to achieve specified compaction at rate consistent with rate of placement of base material.
- C. Obtain approval of equipment prior to use on the work.
- D. Maintain equipment in first class operating condition while in operation.

**3.02 PLACING MATERIAL:**

- A. Subgrade Preparation: In accordance with Section 02320.
- B. Place material in its final location so as to provide uniformity of grading throughout work.
- C. Use graders for touching up and for working materials into areas which do not permit use of other equipment providing there is continuing conformance to specified requirements and providing approval is obtained.
- D. Place material in uniform layers so that each layer has compacted lift thickness of six inches maximum and three inches minimum.
- E. Where thickness is shown or specified is more than six inches, place material in two or more layers of equal thickness so that specified requirements are met.

**3.03 COMPACTION:**

- A. During placing and compacting, obtain moisture content and dry density within the allowable tolerances specified.

- B. Compact each layer to required density before placing next layer.
- C. Compact areas not accessible to rollers to required density by means of approved mechanical tampers.
- D. Puddling or jetting is prohibited.
- E. Density:
  - 1. Compact material under curbs and gutters, gutters, curbs and pavement to 98 percent of maximum density at proper moisture content.
  - 2. Compact material under sidewalks to 95 percent of maximum density at proper moisture content.

**3.04 FIELD QUALITY CONTROL:**

- A. Allowable Tolerances:
  - 1. Construct base to the following tolerances:
    - a. Thickness of base: Plus zero or minus 3/8 inch.
    - b. Surface of base:
      - 1) Plus 1/8 inch or minus 3/8 inch of elevation shown.
      - 2) Deviation not more than 1/2 inch from steel straightedge as specified in Section 02750.
  - 2. Maintain moisture content within two percent of optimum moisture content.
- B. Tests: Determine optimum moisture content and maximum density in accordance with ASTM D1557.

**3.05 MAINTENANCE:**

- A. Throughout placing and compacting, and until the placing of the succeeding pavement course, maintain base for pavement in specified condition.

**3.06 DEFICIENT BASES:**

- A. Where directed, repair or remove and replace, with new material, pavement base that does not meet requirements.

**SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.**

**ENDNOTES:**

**\*1.** Use first version of SECTION 02725 BASE FOR PAVEMENTS for contracts where pavement base work is performed outside the jurisdiction of the District of Columbia except as noted. (Use second version for contracts where pavement base work is performed within the jurisdiction of the District of Columbia.)

**\*2.** Use first version of 2.1 A.2. for contracts where pavement base work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland.

**\*3.** Use second version of 2.1 A.2. modification for contracts where pavement base work is performed within the jurisdiction of Prince Georges County, Maryland.

**END OF SECTION**

**SECTION 02725  
(Version 2)<sup>\*1</sup>**

**BASE FOR PAVEMENTS**

**PART 1 - GENERAL**

**1.01 DESCRIPTION:**

- A. This section specifies providing base for pavements as shown, complete in place on previously constructed subgrades.
- B. Related Work Specified Elsewhere:
  - 1. Grading, excavating and backfilling: Section 02320.
  - 2. Concrete pavement: Section 02750.

**1.02 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. AASHTO: M147, T180, T191.
- B. Source Quality Control:
  - 1. Not less than 10 days prior to the beginning of work, inform the Engineer of proposed source of supply of materials, for testing by the Engineer.
  - 2. Once approved, do not change source of supply.
  - 3. Do not construe approval as approval of the entire location but as approval only insofar as material continues to conform to specified requirements.
  - 4. Cooperate with the Engineer so that the Engineer may take samples and make tests as often as he deems necessary.
  - 5. The Engineer has the right to reject material at the job site by visual inspection, pending sampling and testing.

**PART 2 - PRODUCTS**

**2.01 MATERIALS:**

- A. Aggregate Base Material, General: AASHTO M147, Materials for Aggregate and Soil-Aggregate Base and Surface Courses, as amended in this section.
- B. Use material which is free from frozen material.
- C. Grading requirements:

Sieve Designation	Percentage By Weight Passing Square Mesh Sieves
2 inches	100
1 inch	70 - 100
3/4 inch	60 - 95
No. 4	40 - 75
No. 10	25 - 65
No. 40	10 - 45
No. 200*	2 - 15

\* Fraction passing the No. 200 sieve to be not greater than 2/3 of the fraction passing the No. 40 sieve.

### **PART 3 - EXECUTION**

#### **3.01 EQUIPMENT:**

- A. Place material using equipment designed for the purpose. Use equipment of size and weight necessary to shape material as shown and to compact material to specified minimum density.
- B. Provide sufficient equipment to achieve specified compaction at rate consistent with rate of placement of base material.
- C. Obtain approval of equipment prior to use on the work.
- D. Maintain equipment in first class operating condition while in operation.
- E. At the Engineers discretion, the Engineer may permit the use of graders for touching up and for working materials into areas not amenable to placing by other equipment, providing there is continuing conformance to the requirements.
- F. Use approved mechanical tampers to compact material to the required density in areas that are not accessible to rollers.

#### **3.02 PLACING MATERIAL:**

- A. Subgrade Preparation: In accordance with Section 02320.
- B. Prior to placing the material, check the subgrade, make necessary repairs, and secure the Engineer's approval of the subgrade. Do not place on frozen subgrade. Do not dump the material directly on the subgrade.
- C. Place material in its final location so as to provide uniformity of grading throughout work.
- D. Use graders for touching up and for working materials into areas which do not permit use of other equipment providing there is continuing conformance to specified requirements and providing approval is obtained.
- E. Place material in uniform layers so that each layer has compacted lift thickness of six inches maximum and three inches minimum.
- F. Where thickness is shown or specified is more than six inches, place material in two or more layers of equal thickness so that specified requirements are met.

#### **3.03 COMPACTION:**

- A. During placing and compacting, obtain moisture content and dry density within the allowable tolerances specified.
- B. Compact each layer to required density before placing next layer.
- C. Compact areas not accessible to rollers to required density by means of approved mechanical tampers.
- D. Puddling or jetting is prohibited.

- E. Density:
  - 1. Compact material under curbs and gutters, gutters, curbs and pavement to 100 percent of maximum density at proper moisture content.
  - 2. Compact material under sidewalks to 95 percent of maximum density at proper moisture content.

**3.04 FIELD QUALITY CONTROL:**

- A. Allowable Tolerances:
  - 1. Construct base to the following tolerances:
    - a. Thickness of base: Plus zero or minus 3/8 inch.
    - b. Surface of base:
      - 1) Plus 1/8 inch or minus 3/8 inch of elevation shown.
      - 2) Deviation not more than 3/8 inch from steel straightedge as specified in Section 02750.
  - 2. Maintain moisture content within one percent of optimum moisture content.
- B. Tests: Determine optimum moisture content and maximum density in accordance with AASHTO T180, Moisture and Density Relations of Soils Using a 10-lb. Hammer and an 18-inch Drop, and tested in accordance with AASHTO T191, Density of Soil In-Place by the Sand-Cone Method.

**3.05 MAINTENANCE:**

- A. Throughout placing and compacting, and until the placing of the succeeding pavement course, maintain base for pavement in specified condition.

**3.06 DEFICIENT BASES:**

- A. Where directed, repair or remove and replace, with new material, pavement base that does not meet requirements.

**SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.**

**ENDNOTES:**

- \*1. Use second version of SECTION 02725 BASE FOR PAVEMENTS for contracts where pavement base work is performed within the jurisdiction of the District of Columbia except as noted. (Use first version for contracts where pavement base work is performed outside the jurisdiction of the District of Columbia.)

**END OF SECTION**

## SECTION 02726

### SUB-BALLAST

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies furnishing, placing and compacting sub-ballast on previously constructed subgrade.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
  2. ASTM: C88, C117, C127, C131, C136, C142, D698, ~~D2922~~ replaced by D6938, ~~D3017~~ replaced by D6938 (duplicate).
- B. Source of Materials:
1. Obtain approval of sub-ballast prior to commencing installation.
  2. Do not change material or source of supply without approval.
- C. Inspection:
1. The Engineer has the right to stop delivery of material to the job site based on visual inspection pending sampling and testing.
  2. If material loaded, being loaded or installed does not conform to specified requirements, the Engineer will reject the material and no further delivery will be accepted until the deficiency is corrected.
  3. Replace defective material.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Certification.
  2. Samples and Documentation:
    - a. Qualification: Submit samples and source of supply sufficiently in advance to obtain approval not less than 30 days prior to anticipated date of commencing installation.

#### PART 2 - PRODUCTS

##### 2.01 MATERIALS:

- A. Sub-Ballast: Crushed stone, with the following additional requirements:
1. Gradation: ASTM C136 and ASTM C117 with the following additional requirements:

Sieve Size	Percent Passing By Weight
1 inch	100
3/8 inch	50 to 85
4	35 to 65
10	25 to 50
40	15 to 25
200	5 to 15

- a. Fraction passing the Size 200 sieve less than two thirds of fraction passing Size 40 sieve.
2. Clay lumps and friable particles: ASTM C142, 0.5 percent maximum.
3. Wear: ASTM C131, 40 percent maximum.
4. Absorption: ASTM C127, 0.5 percent maximum.
5. Soundness: ASTM C88, weighted average loss 15 percent maximum after five cycles of magnesium sulfate tests.

### **PART 3 - EXECUTION**

#### **3.01 PLACING MATERIAL:**

- A. The subgrade shall have been graded, shaped and compacted as required by the plans and specifications. The top of the subgrade required special attention to obtain uniform density. A uniformly smooth surface compacted to specifications is required, containing no ruts, pot holes, loose soil or any imperfection retaining water on the surface. The surface shall be inspected by the engineer and if surface fails to conform to specifications the engineer may require blading, rolling and compacting to provide a satisfactory surface.
- B. Do not place material on subgrade that is muddy, rutted or frozen or has standing water.
- C. The sub-ballast material shall be transported and delivered to the site in a manner that will prevent separation or loss of material. The material shall be placed in layers of 3 inches to 6 inches (or as directed by the engineer) and compacted to a depth and density as required by the plans and specifications.
- D. Prior to placing materials, repair subgrade using sub-ballast.
- E. Place material to provide uniformity of grading throughout work.
- F. If subgrade is dusty, sprinkle it prior to placing sub-ballast.
- G. Install sub-ballast to shape and compacted thickness shown.
  1. Where compacted thickness is six inches or less, place sub-ballast in one layer.
  2. Where compacted thickness is more than six inches, place material in two or more layers of equal thickness of not more than six inches each.
- H. Vehicular traffic is to be kept to a minimum across the newly prepared sub-ballast surface. The contractor shall be responsible for maintaining a firm, true and smooth surface compacted to the required density until track ballast is placed on the sub-ballast.

#### **3.02 COMPACTION:**

- A. During placing and compacting, maintain moisture content within specified tolerance.
- B. Compact material for its full depth to 100 percent of maximum dry density.

#### **3.03 FIELD QUALITY CONTROL:**

- A. Allowable Tolerances:
  1. Construct surface of sub-ballast to the following tolerances:
    - a. Within 0.1 foot of elevation shown.
    - b. Deviation not more than ½ inch from 10-foot straightedge.
  2. During compaction maintain moisture content within two percent of optimum moisture content.
- B. Tests:

1. Determine optimum moisture content and maximum dry density in accordance with ASTM D698.
2. Determine in-place density and moisture content in accordance with ASTM D6938.

#### **PART 4 -MEASUREMENT AND PAYMENT**

##### **4.01 MEASUREMENT**

- A. Measurement of work specified in this Section will be made in the following manner:
  1. No separate measurement.

##### **4.02 PAYMENT**

- A. Compensation for work specified in this Section will be made in the following manner:
  1. Included in the price of the work of which it is a part.

**END OF SECTION**

## SECTION 02727

### BALLAST

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies furnishing mineral aggregate for use as ballast for ballasted track construction.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. CE: CRD-C 119.
  - 3. ASTM: C88, C117, C127, C131, C 136, C142, C535.
  - 4. AREMA: Chapter 1-2-1, (Volume 1), **latest edition**.
- B. Source:
  - 1. Obtain approval prior to installation.
  - 2. Do not change ballast or source without approval.
- C. Inspection:
  - 1. The Engineer has the right to stop delivery of material to job site by visual inspection, pending sampling and testing.
  - 2. If material loaded, being loaded or installed does not conform to specified requirements, the Engineer will reject the material and no further delivery will be accepted until the deficiency has been corrected.
  - 3. Replace defective material.
- D. Testing **and Sampling**:
  - 1. Subject ballast to specified tests, except gradation test, at an approved independent testing facility.
  - 2. Conduct testing, except gradation test, to determine if ballast meets specified requirements.
  - 3. Visual inspection and gradation testing will be made by the Engineer:
    - a. 30 days prior to initial delivery.
    - b. Immediately prior to placement on the track bed.
    - c. Each 4,000 tons of ballast delivered.

**WMATA, or its representatives, reserve the right to visit the producers facility during usual business hours unscheduled to a) observe sampling and testing procedures, b) obtain samples of the prepare material being produced and shipped, and c) review plant inspection methods, quality control procedures, equipment and examine test results of current and previous tests.**
  - 4. **Prior to installation, the supplier shall provide the Engineer with certified results of ballast quality and gradation as conducted by a testing laboratory accepted by the Engineer. The supplier shall receive approval of the Engineer for the Testing Laboratory prior to performing the aforementioned tests.**

4. Recommended limiting values of testing for ballast material:

Property	Ballast Material							
	Granite	Traprock	Quartzite	Limestone	Dolomitic Limestone	Blast Furnace Slag	Steel Furnace Slag	ASTM Test
% Material Passing No. 200 Sieve	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	C 117
Bulk Specific Gravity (See Note 2)	2.60	2.60	2.60	2.60	2.65	2.30	2.90	C 127
Absorption %	1.0	1.0	1.0	2.0	2.0	5.0	2.0	C127
Clay Lumps & Friable Particles	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	C 142
Degradation	35%	25%	30%	30%	30%	40%	30%	See Note 1
Soundness (Sodium Sulfate) 5 cycles	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	C 88
Flat and/or Elongated Particles	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	D 4791
<p>Note 1: Materials having gradation containing particles retained on the 1 inch sieve shall be tested by ASTM C 535. Materials having gradations with 100% passing the 1 inch sieve shall be tested by ASTM C 131. Use grading most representative of ballast material gradation.</p> <p>Note 2: The limit for bulk specific gravity is a minimum value. Limits for the remainder of the tests are maximum values.</p>								

**1.03 SUBMITTALS:**

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Samples:
    - a. 200-pound samples for gradation test unless otherwise directed by the Engineer. Submit 30 days prior to shipping ballast to work site.
  2. Certification:
    - a. Certificates:

- 1) Submit source of supply sufficiently in advance to obtain approval not less than 30 days prior to anticipated date of commencing installation.
  - b. At time of delivery, submit certificates attesting that material furnished is typical of that tested and conforms to specified requirements.
3. Certified test results:
  - a. Submit not less than two weeks prior to shipping ballast to work site.
4. Handling Procedures: Submit the proposed method of handling.

#### **1.04 PRODUCT DELIVERY, HANDLING, AND STORAGE:**

- A. Deliver, handle, and store the material by methods which prevent damage, fouling and segregation.
- B. The aggregate production facility shall be of such design to permit production and or blending without excessive working of the materials and the facility must be approved by the purchaser.
- C. Blending, stockpiling and other production and handling operations shall be managed by the producer to minimize segregation of the finished product. Stockpiling operations shall be minimize as practical the breakage or excessive fall in stockpiling operations and the movement of wheeled or tracked machines over stockpiled materials shall be limited.
- D. Processed ballast shall be washed and/or rescreened as necessary to remove fine particle contamination as defined by the specification or as directed by WMATA prior to stockpiling in operations using stockpiles or immediately prior to loading operations.
- E. The following are prohibited:
  1. Storage of ballast in cone-shaped piles.
  2. Subjecting ballast to repeated passes of equipment over same levels in stockpile area.

### **PART 2 - PRODUCTS**

#### **2.01 MATERIALS:**

- A. Ballast: Crushed stone from diabase rock, hard, strong, angular, durable, free from injurious amounts of deleterious substances, with the following additional requirements:

1. Gradation:

SIEVE SIZE	PERCENT PASSING BY WEIGHT	
	AREA SIZE 4 Mainline	AREA SIZE 5 Yard
2 inches	100	-
1-1/2 inches	90 to 100	100
1 inch	20 to 55	30 to 70
3/4 inch	0 to 15	0 to 20
1/2 inch	-	0 to 8
3/8 inch	0 to 5	-
Size 4	-	-

2. Fine particles: Material finer than Size 200 sieve, ASTM C117, one percent by weight maximum.
3. Flat and elongated particles: CE CRD-C 119, five-percent maximum.
4. Clay lumps and friable particles: ASTM C142, 0.5-percent maximum.
5. Wear: ASTM C535, 40-percent maximum.
6. Absorption: ASTM C127, 1.5-percent maximum.
7. Soundness: ASTM C88, 5-percent maximum loss after five cycles of the sodium-sulfate test.

**PART 3 - EXECUTION**

**3.01 INSTALLATION:**

- A. Install ballast in accordance with the ballasted trackwork construction requirements of [WMATA Specification Section 5652](#).

**PART 4 - MEASUREMENT AND PAYMENT**

**4.01 MEASUREMENT**

- A. Measurement of work specified in this Section will be made in the following manner:
  1. No separate measurement.

**4.02 PAYMENT**

- A. Compensation for work specified in this Section will be made in the following manner:
  1. Included in the price of the work of which it is a part.

**END OF SECTION**

**SECTION 02740**  
**(Version 1)<sup>\*1</sup>**

**BITUMINOUS PAVEMENT**

**PART 1 - GENERAL**

**1.01 DESCRIPTION:**

- A. This section specifies providing asphaltic surface, binder and base courses on prepared subgrade or previously constructed base course in conformance with sections, lines and grades shown.
- B. Related Work Specified Elsewhere:
  - 1. Base for pavements: Section 02725.

**1.02 SUBMITTALS:**

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Certification:
    - a. For each delivery of asphaltic material, submit certificate stating type and amount of asphalt and results of specified tests.
  - 2. Documentation:
    - a. Job-mix formula:
      - 1) For each mix to be supplied submit job-mix formula based on expected production averages.
      - 2) In formula establish:
        - a) Weight percent of total aggregate and of aggregate finer than each required sieve size.
        - b) Weight percent of total mix of asphalt cement.
        - c) Temperature of mix when placed.
      - 3) Maintain job-mix formula once approved.
    - b. Weight ticket: For each load of bituminous mixture delivered to the site, submit weight ticket showing the following:
      - 1) Mix type.
      - 2) Mix temperature.
      - 3) Identification of the truck.
      - 4) Tare weight of truck.
      - 5) Loaded weight of truck.
      - 6) Net weight of load.
      - 7) Time of leaving mix plant.
      - 8) Signature of the Engineer's plant representative.

**1.03 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. MSHA. <sup>\*2</sup>
  - 3. VDOT. <sup>\*3</sup>
  - 4. AASHTO: M6, M29, M43, M45, M76, M79, M140, M156, M208, T30, T164, T165, T168. <sup>\*4</sup>
  - 5. AASHTO: M6, M29, M43, M45, M76, M79, M82, M140, M156, M208, T30, T164, T165, T168. <sup>\*5</sup>
  - 6. ASTM: D2950, D3515. <sup>\*6</sup>
  - 7. ASTM: D3515. <sup>\*7</sup>

- B. Sources of Supply:
1. Not less than 20 days prior to beginning the work, inform the Engineer of the source of the materials to be used and obtain approval.
  2. Once approved, do not change source of supply.
  3. Do not construe approval as approval of entire location but as approval only insofar as material continues to meet specified requirements.
  4. Maintain quality of material. Material may be sampled and tested by the Engineer as often as the Engineer deems necessary.
  5. The Engineer has the right to reject material at the job site by visual inspection pending sampling and testing.

#### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Delivery Trucks:
1. For transporting bituminous, mixtures use trucks which show no leakage of oil or grease, have solid metal dump-type beds which are clean and smooth with tight fitting rear gate to prevent loss of materials in transit.
  2. Prior to loading, spray inside surface of truck beds with minimum amount of approved thin oil or mixture of lime and water proportioned 50 gallons of water to 100 pounds of lime necessary to prevent adhesion of the mixture. Do not use kerosene, gasoline or excessive amount of oil.
  3. Equip trucks with coverings to protect loads from weather and with suitable insulation to prevent undue heat loss during transit at temperatures below 40F.
- B. Weighing of Bituminous Mixtures:
1. Provide approved truck scales having both dial and automatic printer or use public scales.
  2. Use scales complying with applicable laws, ordinances and regulations governing use of scales.
  3. Have scales tested and sealed by authorized public official as often as directed to ensure their accuracy.
  4. At least once a week, check tare weight of each truck with full load of fuel and fitted with its equipment.

#### 1.05 JOB CONDITIONS:

- A. Environmental Requirements:
1. Do not place bituminous pavement on wet surfaces.
  2. Place bituminous pavement when temperature of air and base exceed 40F.

### PART 2 - PRODUCTS

#### 2.01 MATERIALS:

- A. Asphalt Cement: AASHTO \_\_\_\_\_.<sup>\*8</sup>
- B. Asphalt Cement: AASHTO \_\_\_\_\_, Table 2, with no requirement for maximum loss on heating.<sup>\*9</sup>
- C. Cut-Back Asphalt for Prime Coat: Equivalent to AASHTO \_\_\_\_\_.<sup>\*10</sup>
- D. Cut-Back Asphalt, AASHTO M82, \_\_\_\_\_. Note 4 option applies.<sup>\*11</sup>

- E. Emulsified Asphalt for Tack Coat: SS-1, SS-1h, CSS-1, or CSS-1h, diluted one-part water to one-part emulsified asphalt. Prior to dilution, emulsified asphalt to comply with AASHTO M140 or AASHTO M208. Apply at rate of 0.05 to 0.15 gallons per square yard.
- F. Aggregate: Coarse and fine aggregate to be free from substantial portions of serpentine or talc materials or carbonate aggregates containing less than 25 percent by weight insoluble residue retained between Size 10 and Size 200 sieves as determined by leaching samples with 6N hydrochloric acid.
1. Coarse aggregate: Crushed stone, AASHTO M79 and AASHTO M76 except for grading. Weight loss not to exceed 15 percent by weight when subjected to five alterations of magnesium sulfate soundness test.
  2. Fine aggregate for hot asphaltic concrete: Consisting of one or a combination of the following materials:
    - a. Material conforming to AASHTO M6 with the following additional requirements:
      - 1) When the material is subjected to five alternations of the magnesium sulfate soundness test, weighted loss not exceeding 12 percent by weight; amount of deleterious substances not exceeding following maximum permissible percent limits by weight:
        - a) Clay lumps: 0.5.
        - b) Coal and lignite: 0.25.
        - c) Material passing size 200 sieve: 3.0.
        - d) Other deleterious substances, such as shale, alkali, mica, coated grains, soft and flaky particles: 2.0.
    - b. Material conforming to specified requirements for No. 10 coarse aggregate in accordance with AASHTO M43.
  3. Fine aggregate for sheet asphalt binder: AASHTO M45, with the following additional requirements:

Sieve Designation	Percentage By Weight Passing Square Mesh Sieves
8	100
50	15 - 40
100	0 - 10
200	0 - 5

4. Fine aggregate for sheet asphalt surface: AASHTO M29, with the following additional requirements:

Sieve Designation	Percentage By Weight Passing Square Mesh Sieves
4	100
10	95 - 100
40	55 - 80
80	15 - 40

5. Mineral filler:

Sieve Designation	Percentage By Weight Passing Square Mesh Sieves
30	100
50	95 - 100
200	70 - 100

**2.02 MIXES:**

- A. Provide mixes in accordance with ASTM D3515 and as specified.
- B. Proportion constituents of job mixes within limits specified in Table 02740-1.
- C. Submit mixes as directed for evaluation of job-mix formula, with bulk specific gravity determined in accordance with AASHTO T165.

**2.03 TEMPERATURE OF MIXES:**

- A. Maintain temperature of mixes within plus-or-minus 25F of that given in job-mix formula. Temperature ranges as specified in Table 02740-2.

**PART 3 - EXECUTION**

**3.01 EQUIPMENT:**

- A. Equipment for Preparing Bituminous Material:
  - 1. Use bituminous paving material prepared in mixing plant conforming to AASHTO M156.
- B. Equipment for Spreading and Finishing Bituminous Material:
  - 1. Use equipment capable of placing material at widths ranging from eight to twelve feet by increments of one foot and at varying thickness.
  - 2. Use machines which spread bituminous mixture without tearing surface. Achieve finish that is smooth, true to cross section, uniform in density and texture and free from hollows, corrugations and other irregularities.
- C. Equipment for Compacting:
  - 1. Provide approved equipment capable of compacting materials to specified Marshall density.

**3.02 BASE PREPARATION:**

- A. Prior to placing bituminous mixture, check line, grade and cross section of underlying course. Repair defective areas.
- B. Have base approved, prior to placement of surface course.
- C. Aggregate and Soil Aggregate Bases:
  - 1. Apply cut-back asphalt primer at rate of 0.2 to 0.5 gallons per square yard when base is damp but with no standing water.

2. Allow 24 hours for base to entirely absorb primer. Blot excess primer with just enough sand to prevent pickup under traffic. Sweep loose sand from base before placing base course.
- D. Portland Cement Concrete, Bituminous and Brick Pavement Bases:
1. Apply tack coat using equipment designed for that purpose.
  2. Apply tack coat uniformly to clean dry base at rate of 0.05 to 0.15 gallons per square yard.
  3. Ensure that surface has cured and is satisfactorily tacky before placing mix.
- E. Immediately prior to placing mix, apply thin coat of hot asphalt cement to contact surfaces of curbs, gutters, manholes and similar structures.

### **3.03 PLACING MIX:**

- A. Place base course mixture in one or more lifts with asphalt paver or spreader to provide nominal compacted thickness as shown. Place surface course mixture with asphalt paver to provide nominal compacted thickness as shown. Minimum lift thickness at least two times maximum particle size. Maximum lift thickness to be that which can be demonstrated to be laid in a single lift and compacted to required uniform density and smoothness. Place material in continuous operation. Correct irregularities before final compaction of mixture.
- B. If equipment being used produces tracks, pulling, indented areas or other permanent blemishes in material being spread, remove such equipment from site and substitute other approved spreading and finishing equipment.
- C. Do not permit direction of movement of paving equipment to be changed by turning on newly completed base, binder or surface courses.
- D. Adjacent to headers, gutters, manholes and similar structures, place surface course so that finished surface is 1/4-inch above edge of structure.
- E. When the Engineer considers it impractical to place mix with two machines, one machine will be permitted. Treat joints created by such operation as cold joints.
- F. Rake joints to eliminate seams between lane passes.

### **3.04 COMPACTION:**

- A. Compact immediately after placing. Initial rolling with steel-wheel tandem roller, steel three-wheel roller, vibratory roller, or pneumatic-tire roller following paver as closely as possible, oriented with drive wheel closest to paver. If intermediate rolling is needed, use pneumatic-tire roller immediately behind initial rolling. Final rolling to eliminate marks from previous rolling. Use vibrating plate compactor or hand tamper to achieve thorough compaction in areas too small for roller. Keep steel wheel rollers wet while rolling.

### **3.05 COLD JOINTS:**

- A. Longitudinal: Apply tack coat to cold material before joining new work.
- B. Transverse: Place bulkhead full depth of course or cut back minimum of three inches from sloping surface with masonry saw. Apply tack coat to cold material.

### **3.06 BULKHEADS:**

- A. Where placement of mix is to be discontinued for such period of time that material will fall below specified street temperature, place suitable bulkhead.
- B. Construct cold joint as specified when work is resumed.

**3.07 HANDWORK:**

- A. When approved, perform bituminous paving work by hand in areas inaccessible to machines.
- B. Undertake handwork using equipment designed and approved for purpose.
- C. Perform handwork so that resulting paving meets specified requirements.

**3.08 FIELD QUALITY CONTROL:**

- A. Allowable Tolerances:
  - 1. Thickness: Place bituminous pavement to within tolerance of plus-or-minus 1/8 inch of thickness shown.
  - 2. Surfaces: Construct surfaces to the following tolerances:
    - a. Base courses to within plus-or-minus 3/8 inch of elevation shown.
    - b. Surface courses to within plus-or-minus 3/16 inch of elevation shown.
    - c. Surfaces to deviate no more than 1/4 inch in the length of 10-foot steel straightedge, not cumulative.
    - d. During compacting, screed surface using straightedge as specified in Section 02750. Adjust rolling procedures so that tolerances are met.
  - 3. Densities required:
    - a. Base courses: 94 percent of Marshall density. <sup>\*12</sup>
    - b. Base courses: 95 percent of Marshall density. <sup>\*13</sup>
    - c. Surface courses: 96 percent of Marshall density.
- B. Testing:
  - 1. Mixes:
    - a. During course of the work submit mixes as directed for testing of gradation and bitumen content in accordance with AASHTO T30 and AASHTO T164 on random samples selected in accordance with AASHTO T168.
  - 2. Determine density of base and surface courses by one of the following methods:
    - a. Test base and surface courses for density and thickness with a nuclear density meter in accordance with ASTM D2950. <sup>\*14</sup>
      - 1) Compute average thickness of base and surface courses from average density and weight per square yard of paving mixture actually used as follows:

$$t = \frac{W}{0.75 d}$$

Where:

t = pavement thickness, in inches.

W = average weight of base or surface mixture actually used, pounds per square yard.

d = compacted density of base or surface course as measured by the nuclear device, pounds per cubic foot.

0.75 = constant.

- b. Not used. <sup>\*\*15</sup>
- c. Test base and surface courses for density by taking test cores at designated locations for testing by the Engineer, number of cores not exceeding one core per 500 square yards of bituminous pavements or two cores per shift, whichever is greater. <sup>\*\*16</sup>
  - 1) Wherever deficient pavement is discovered take such additional cores as directed.
  - 2) Repair core holes promptly using the same mix that was cored; where cores are taken through both base course and surface course simultaneously, use surface course mix for repair work.
- d. Test base and surface courses for density by taking test cores at designated locations for testing by the Engineer, number of cores not exceeding one core per 500 square yards of bituminous pavements or three cores per shift, whichever is greater. <sup>\*\*17</sup>
  - 1) Wherever deficient pavement is discovered take such additional cores as directed.
  - 2) Repair core holes promptly using the same mix that was cored; where cores are taken through both base course and surface course simultaneously, use surface course mix for repair work.

### **3.09 PROTECTION OF BITUMINOUS PAVEMENT:**

- A. Obtain approval for use of pavement by public and construction traffic.
- B. Do not permit traffic to cross uncompleted longitudinal joints.

### **3.10 DEFICIENT PAVEMENT:**

- A. Where directed, replace with new material or repair bituminous pavement that does not meet specified requirements.
- B. Pavement is considered deficient if the densities of three cores from one day's work are below 95 percent or if the density of one core is below 90 percent. <sup>\*\*18</sup>

<b>TABLE 02740-1 CONSTITUENT PROPORTIONS <sup>*19</sup></b>					
<b>GRADING OF TOTAL AGGREGATE (COARSE, FINE, MINERAL FILLER: AS NECESSARY) AMOUNTS FINER THAN LABORATORY SIEVE (SQUARE OPENING) WEIGHT PERCENT</b>					
<b>SIEVE</b>	<b>SHEET ASPHALT</b>		<b>HOT ASPHALTIC CONCRETE</b>		<b>* JOB-MIX FORMULA TOLERANCE: ALL MIXES</b>
	<b>BINDER</b>	<b>SURFACE</b>	<b>BINDER</b>	<b>SURFACE</b>	
1 inch	--	--	100	--	+7
3/4 inch	--	--	90 - 100	--	+7
1/2 inch	100	--	--	100	+7
3/8 inch	85 - 100	--	60 - 85	85 - 100	+7
No. 4	35 - 55	100	45 - 65	55 - 80	+7
No. 10	20 - 35	95 - 100	30 - 50	40 - 65	+6
No. 40	--	55 - 92	10 - 25	10 - 30	+6
No. 80	--	20 - 60	3 - 15	3 - 15	+4
No. 200	0 - 5	9 - 20	2 - 8	2 - 8	+3
	<b>ASPHALTIC CEMENT, WEIGHT PERCENT OF TOTAL MIXTURE</b>				
	4.0 - 7.0	8.5 - 11.5	5.0 - 8.0	5.0 - 8.0	+0.5
* Notwithstanding tolerances, supply mixes within specified grading limits.					

<b>TABLE 02740-1 CONSTITUENT PROPORTIONS *20</b>			
<b>GRADING OF TOTAL AGGREGATE (COARSE, FINE, MINERAL FILLER: AS NECESSARY) AMOUNTS FINER THAN LABORATORY SIEVE (SQUARE OPENING) WEIGHT PERCENT</b>			
<b>SIEVE</b>	<b>HOT ASPHALTIC CONCRETE</b>		<b>* JOB-MIX FORMULA TOLERANCE:</b>
	<b>P.G. CO. P2 BASE</b>	<b>P.G. CO. SN SURFACE</b>	<b>ALL MIXES</b>
1-1/2 inch	100	--	+7
1 inch	93 - 100	--	+7
3/4 inch	82 - 95	100	+7
3/8 inch	60 - 78	90 - 100	+7
# 4	40 - 58	65 - 85	+7
# 8	--	48 - 68	+4
# 10	23 - 40	--	+4
# 16	--	34 - 54	+4
# 20	14 - 29	--	+4
# 30	--	22 - 42	+4
# 40	9 - 21	--	+4
# 50	--	10 - 32	+4
# 80	5 - 13	--	+4
# 100	--	5 - 24	+4
# 200	2 - 6	3 - 12	+2
	<b>ASPHALT CEMENT, WEIGHT PERCENT OF TOTAL MIXTURE</b>		
	4.5 - 6.5	5.0 - 11.0	+0.4
* Notwithstanding tolerances, supply mixes within specified grading limits.			

<b>TABLE 02740-2 MIX TEMPERATURE RANGES</b>				
<b>MIX</b>	<b>TEMPERATURES, DEGREES F</b>			
	<b>PLANT</b>			<b>STREET</b>
	<b>AGGREGATE</b>	<b>ASPHALT CEMENT</b>	<b>TOTAL MIX</b>	
Sheet Asphalt Binder	250 - 325	250 - 325	250 - 325	250 - 325
Sheet Asphalt Surface	300 - 375	250 - 350	300 - 375	275 - 350
Hot Asphaltic Concrete	250 - 325	250 - 325	250 - 325	250 - 325

**SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.**

**ENDNOTES:**

\*1. Use first version of SECTION 02740 BITUMINOUS PAVEMENT for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia except as noted. (Use second version for contracts where bituminous pavement work is performed within the jurisdiction of the District of Columbia.)

\*2. Use first version of 1.3 A.2. for contracts where bituminous pavement work is performed within the jurisdiction of the State of Maryland.

\*3. Use second version of 1.3 A.2. for contracts where bituminous pavement work is performed within the jurisdiction of the Commonwealth of Virginia.

\*4. Use first version of 1.3 A.3. for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland.

\*5. Use second version of 1.3 A.3. modification for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.

\*6. Use first version of 1.3 A.4. for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland.

\*7. Use second version of 1.3 A.4. modification for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.

\*8. Use first version of 2.1 A. for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland

- \*9. Use second version of 2.1 A. modification for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.
- \*10. Use first version of 2.1 B. for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland.
- \*11. Use second version of 2.1 B. modification for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.
- \*12. Use first version of 3.8 A.3.a. for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland.
- \*13. Use second version of 3.8 A.3.a. modification for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.
- \*14. Use first version of 3.8 B.2.a. including (1) for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland.
- \*15. Use second version of 3.8 B.2.a. modification for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.
- \*16. Use first version of 3.8 B.2.b. including (1)-(2) for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland.
- \*17. Use second version of 3.8 B.2.b. including (1)-(2) modification for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.
- \*18. Add 3.10 B. for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.
- \*19. Use first version of TABLE 02740-1 for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland.
- \*20. Use second version of TABLE 02740-1 modification for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.

**END OF SECTION**

**SECTION 02740**  
**(Version 2)<sup>\*1</sup>**

**BITUMINOUS PAVEMENT**

**PART 1 - GENERAL**

**1.01 DESCRIPTION:**

- A. This section specifies providing bituminous pavements complete in place as shown; placed on bases prepared under Section 02725, Base for Pavements and under Section 02750, Concrete Pavement.
- B. Related Work Specified Elsewhere:
  - 1. Base for pavements: Section 02725.
  - 2. Concrete pavement: Section 02750.
- C. Definitions:
  - 1. Equipment: This includes such specialized devices and tools as are customarily used in the construction of bituminous pavements; e.g., lutes, rakes, irons.

**1.02 SUBMITTALS:**

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Certification:
    - a. For each delivery of asphaltic material, submit certificate stating type and amount of asphalt and results of specified tests.
  - 2. Documentation:
    - a. Job-mix formula:
      - 1) For each mix to be supplied submit job-mix formula based on expected production averages.
      - 2) In formula establish:
        - a) Weight percent of total aggregate and of aggregate finer than each required sieve size.
        - b) Weight percent of total mix of asphalt cement.
        - c) Temperature of mix when placed.
      - 3) Maintain job-mix formula once approved.
    - b. Weight ticket: For each load of bituminous mixture delivered to the site, submit weight ticket showing the following:
      - 1) Mix type.
      - 2) Mix temperature.
      - 3) Identification of the truck.
      - 4) Tare weight of truck.
      - 5) Loaded weight of truck.
      - 6) Net weight of load.
      - 7) Time of leaving mix plant.
      - 8) Signature of the Engineer's plant representative.

**1.03 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. AASHTO: M6, M17, M20, M29, M43, M45, M76, M79, M81, M82, M140, T30, T164, T165, T168.

3. ASTM: D3515.
- B. Sources of Supply:
1. Not less than 20 days prior to beginning the work, inform the Engineer of the source of the materials to be used and obtain approval.
  2. Once approved, do not change source of supply.
  3. Do not construe approval as approval of entire location but as approval only insofar as material continues to meet specified requirements.
  4. Maintain quality of material. Material may be sampled and tested by the Engineer as often as the Engineer deems necessary.
  5. The Engineer has the right to reject material at the job site by visual inspection pending sampling and testing.
  6. Provide mix for a given area as defined by the Engineer from one mixing plant.

#### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Delivery Trucks:
1. For transporting bituminous, mixtures use trucks which show no leakage of oil or grease, have solid metal dump-type beds which are clean and smooth with tight fitting rear gate to prevent loss of materials in transit.
  2. Prior to loading, spray inside surface of truck beds with minimum amount of approved thin oil or mixture of lime and water proportioned 50 gallons of water to 100 pounds of lime necessary to prevent adhesion of the mixture. Do not use kerosene, gasoline or excessive amount of oil.
  3. Equip trucks with coverings to protect loads from weather and with suitable insulation to prevent undue heat loss during transit at temperatures below 40F.
- B. Weighing of Bituminous Mixtures:
1. Provide approved truck scales having both dial and automatic printer or use public scales.
  2. Use scales complying with applicable laws, ordinances and regulations governing use of scales.
  3. Have scales tested and sealed by authorized public official as often as directed to ensure their accuracy, and within the six months prior for use for the work. The Engineer has the option to require retesting and resealing.
  4. At least once a week and whenever directed by the Engineer, check tare weight of each truck with full load of fuel and fitted with its normal equipment.

#### **1.05 JOB CONDITIONS:**

- A. Environmental Requirements:
1. Do not place bituminous pavement on wet surfaces.
  2. Place bituminous pavement only when temperature of air and base exceed 40F and when by U.S. Weather Bureau forecast, the temperature is expected to remain above 40F during the course of the work.

### **PART 2 - PRODUCTS**

#### **2.01 MATERIALS:**

- A. Asphalt Cement: AASHTO M20, Penetration Grade 85-100.
- B. Cut-Back Asphalt for Prime Coat: AASHTO M82, Grade MC-30 or MC-70 as conditions warrant.

- C. Emulsified Asphalt for Tack Coat: As conditions warrant, use either of the following:
1. AASHTO M81, Cut-Back Asphalt (Rapid-Curing Type), Grade RC-70.
  2. AASHTO M140, Emulsified Asphalt, Grade SS-1 or SS-1h, diluted with water in the volumetric ratio of three parts emulsion to one part water.
- D. Aggregate: Coarse and fine aggregate free from substantial portions of serpentine or talc materials or carbonate aggregates containing less than 25 percent by weight insoluble residue retained between Size 10 and Size 200 sieves as determined by leaching samples with 6N hydrochloric acid.
1. Coarse aggregate: Crushed stone, AASHTO M79 and AASHTO M76 except for grading. Weight loss not to exceed 15 percent by weight when subjected to five alternations of magnesium sulfate soundness test.
  2. Fine aggregate for hot asphaltic concrete: Consisting of one or a combination of the following materials:
    - a. Material conforming to AASHTO M6 with the following additional requirements:
      - 1) When the material is subjected to five alternations of the magnesium sulfate soundness test, weighted loss not exceeding 12 percent by weight; amount of deleterious substances not exceeding following maximum permissible percent limits by weight:
        - a) Clay lumps: 0.5.
        - b) Coal and lignite: 0.25.
        - c) Material passing size 200 sieve: 3.0.
        - d) Other deleterious substances, such as shale, alkali, mica, coated grains, soft and flaky particles: 2.0.
    - b. Material conforming to specified requirements for No. 10 coarse aggregate in accordance with AASHTO M43.
  3. Fine aggregate for sheet asphalt binder: AASHTO M45, with the following additional requirements:

Sieve Designation	Percentage By Weight Passing Square Mesh Sieves
8	100
50	15 - 40
100	0 - 10
200	0 - 5

**THIS SPACE NOT USED.**

4. Fine aggregate for sheet asphalt surface: AASHTO M29, with the following additional requirements:

Sieve Designation	Percentage By Weight Passing Square Mesh Sieves
4	100
10	95 - 100
40	55 - 80
80	15 - 40
200	0 - 5

5. Mineral filler: Limestone dust, hydrated lime, or portland cement, AASHTO M17; uniformly graded, non-plastic, free from lumps, balls or foreign materials, and having a maximum moisture content of 0.5 percent when incorporated into the bituminous mix.

6.

**2.02 MIXES:**

- A. Provide mixes in accordance with ASTM D3515 and as specified.
- B. Proportion constituents of job mixes within limits specified in Table 02740-1.
- C. Submit mixes as directed for evaluation of job-mix formula, with bulk specific gravity determined in accordance with AASHTO T165.

**2.03 TEMPERATURE OF MIXES:**

- A. Maintain temperature of mixes within plus-or-minus 25F of that given in job-mix formula. Temperature ranges as specified in Table 02740-2.

**PART 3 - EXECUTION**

**3.01 EQUIPMENT:**

- A. General:
  - 1. The requirements specified for equipment are pursuant to the equipment provisions of the General Provisions.
  - 2. The requirements specified for equipment are not intended to be complete; rather, the intent is that the characteristic equipment be used to produce certain of the required results.
  - 3. Suitability of the equipment is a determination made by the Engineer that the equipment will produce the required results.
- B. Batch-Type Bituminous Mixing Plants: Of sufficient capacity to adequately handle the proposed construction; maintained in good mechanical condition; equipped with the necessary scales and measures to ensure proper proportioning of ingredients; and designed, coordinated and operated so as to produce a mixture within the job-mix tolerances. Ensure that defects which would adversely affect the proper functioning of the plants or the quality of the mixture are replaced or repaired immediately upon instruction from the Engineer.
  - 1. Tanks for storage of bituminous material: Capable of heating the material, always under effective and positive control, to specified temperature requirements.

- a. Heating: Accomplished by steam coils, electricity or other means so that no flame can come in contact with the heating tank, and so that uniform heating of the entire contents is provided.
  - b. Circulating system for the bituminous material: Of adequate size to ensure the proper and continuous circulation during the entire operating period.
  - c. Pipelines and fittings: Steam-jacketed or otherwise properly insulated to prevent heat loss.
  - d. Provide separate tanks and delivery lines for each grade of asphalt cement or liquid asphaltic material for mixtures to be produced in the same mixer unit.
2. Feeder for drier: Accurate mechanical means for uniformly feeding the aggregate into the drier so that a uniform production and a uniform temperature may be secured.
    - a. Have each aggregate, except for mineral filler added cold, fed to a central elevator, conveyor or feeder by accurate mechanical means with adjustable gates that will deliver each aggregate in the desired proportion. When more than one cold elevator is used, feed each by a separate feeder unit with the individual controls integrated with a master total control.
    - b. Set and lock the total and proportional controls when so directed by the Engineer.
  3. Driers: Capable of drying and heating the aggregates as specified for any item, and of sufficient capacity to supply the mixing unit at its operating capacity. Drier is to continuously agitate the aggregates during the heating and drying process so that the temperature can be positively regulated.
  4. Screening system for grading the aggregate: Shaker or vibrating type capable of screening the aggregates to specified sizes and proportions, producing a quantity of aggregate sufficient to keep the mixer operating at the rated plant capacity.
    - a. Have screening system equipped with a chute or pipe for removal of oversized aggregate having the discharge end located so as not to create a hazard or nuisance.
    - b. Revolving double-jacketed screens may be accepted if they give satisfactory performance of a maximum plant production.
  5. Storage bins: Of sufficient capacity to supply the mixer when it is operating at full capacity; divided into at least three compartments arranged to ensure separate and adequate storage of appropriate proportions of aggregates; each compartment provided with an adequate overflow opening located so as to prevent backing up of material into other bins.
    - a. Each compartment provided with its individual outlet gate, so designed and constructed that when closed there will be no leakage; gates cutting off quickly and completely.
    - b. Have discharge points of overflow located so that they will not create a hazard or nuisance.
    - c. Bins equipped with adequate tell-tale devices to indicate the position of the aggregate in the bins at the lower quarter points.
    - d. Provide separate dry storage for the mineral filler.
  6. Bituminous control unit: Satisfactory means, either by weighing, metering or volumetric measurements, to obtain the proper amount of bituminous material in the mix within the tolerance specified for the job-mix; with suitable means, either by steam-jacketing or other insulation, for maintaining the specified temperature of the bituminous material in the pipelines, meters, weigh buckets, spray bars, and other containers or flow lines.
  7. Bitumen bucket (if a bucket is used for weighing the bituminous material): Capacity sufficient to hold not less than 20 percent of the weight of aggregate required for one batch; steam-jacketed or equipped with properly insulated electric heating units; and suspended on dial scales or beam scales so that the tare weight of bucket will be shown for each weighing.

- a. Bucket equipped with tell-tale device to accurately control the net weight of bituminous material added to the mix to within two percent above or below the actual weight in pounds required.
  - b. Bucket arranged so that it will deliver molten bitumen in a thin uniform sheet or in multiple streams the full width of the mixer, except in the case of a rotary mixer where bitumen is sprayed.
8. Thermometric equipment: Have plant equipped with the following as approved:
- a. Armored thermometer reading from 200F to 400F, fixed at a suitable location so that the temperature of the bitumen at the bucket or spray bar can be determined.
  - b. Dial-scale, mercury-activated thermometer, electric pyrometer or other approved thermometric instrument, so placed at the discharge chute of the drier as to register automatically or indicate the temperature of the heated aggregate; of such accuracy that the temperature of the aggregate can be maintained within the limits specified; and so located so that its dial is in plain view of the drier fireman or feeder.
9. Mixing time: Positive means to govern the time of mixing and to maintain it constant unless changed by order of the Engineer.
10. Timing devices: Accurate timelock to control the operation of a complete mixing cycle by locking the weight box gate after the charging of the mixer, until the closing of the mixer gate at the completion of the cycle. Timeclock is to lock the bitumen bucket throughout the dry-mixing period and lock the mixer gate throughout the dry-mixing and wet-mixing periods.
- a. Control of the timing is to be flexible and capable of being set at intervals of not more than five seconds throughout cycles up to three minutes.
  - b. A mechanical batch or box counter is to be designed so as to register only upon the actuation of the bucket release and to preclude the register of dry batches or the register of material through the operation of pulling bins.
11. Plant scales: Either the beam or springless-dial type; of a standard make designed as an integral part of the plant; accurate to within one-half percent of the true weight of the load being weighed; having significant graduations that can be easily read to that degree of accuracy; and with dials and indicators in plain view of the operator when on the weighing platform.
- a. Beam-type scales: Balanced on knife edges and fulcrums that are kept clean and constructed so that they will not easily be thrown out of alignment and adjustment; each beam having a locking device which will permit the beam either to be suspended or thrown into action; a separate beam for each size aggregate and a tare beam for balancing the hopper; each aggregate beam equipped with an auxiliary dial or tell-tale that will indicate that the required load to the weighing hopper is being approached and will continue to indicate further movement of the beam after that.
    - 1) For weighing bituminous material, use beam-type scales that are provided with a tare beam and a full-capacity beam.
    - 2) Graduations: Two pounds or smaller.
  - b. Dial scales: Springless and so constructed, installed, and maintained, to be free from vibration; of such size that the numerals on the dial can be easily read from a distance of 25 feet; dials of the compounding type having full complements of index pointers.
    - 1) For weighing asphalt cement, capacity equal to or less than two times the maximum weight of the material to be weighed.
    - 2) Graduations: Such that they can be easily read to the nearest two pounds.
  - c. Weigh box or hopper: Provide means for accurately weighing each bin size of aggregate in a weigh box or hopper suspended on scales and of sufficient size to hold a full batch without hand raking or running over; with gates on both bins and hopper constructed so as to prevent leakage when they are

- closed. Have container supported on knife edges or fulcrums constructed so that it will not easily be thrown out of alignment or adjustment; with edges, ends and sides free from contact with supporting parts that could possibly affect proper weighing; and with adequate clearance of the parts to prevent accumulation of foreign materials. In plants where the weigh box is enclosed for the purpose of minimizing dust nuisance, have some provision made to permit sampling the materials by the Engineer as discharge is made from the storage bins.
- d. Provide ten 50-pound standard test weights at each plant for testing weighing equipment.
12. Mixer unit: Batch mixer of an approved twin-pugmill type or rotary-drum type, with a batch capacity of not less than 2,000 pounds, and capable of producing a uniform mixture within the job-mix tolerances specified; constructed as to prevent leakage of contents until the batch is to be discharged.
    - a. If mixer is the pugmill type, have the clearance of the blades from fixed and moving parts not to exceed 3/4 inch, unless the maximum aggregate particle exceeds 1-1/2 inches.
    - b. If not enclosed, equip the mixer box with a dust hood to prevent loss of dust. When so enclosed, make provision to permit visual inspection of mixing operation by the Engineer.
  13. Dust collectors: When plant is located where dust may be objectionable or become a nuisance or where dust interferes with the efficiency of the operation of the plant, provide proper housing, mixing covers, or dust collecting systems. Make provision to dispose of the material so collected or to return it uniformly to the mixture, as the Engineer may direct.
  14. Safety Requirements:
    - a. Provide a mixer platform sufficiently rigid and of ample size to provide for safe and convenient access to the mixer and pertinent equipment.
    - b. Place adequate and safe stairways to the mixer platform and guarded ladders to other plant units at points where accessibility is necessary during plant operations.
    - c. Thoroughly guard gears, pulleys, chains, sprockets and other dangerous moving parts.
    - d. Always maintain a clear, ample and unobstructed passage in and around the truck loading space. Keep this space free from drippings from the mixing platform.
- C. Continuous-Type Bituminous Mixing Plants: Meet the requirements for batch-type bituminous mixing plants, except for the requirements as to scales and weighing equipment and the requirements for the mixer unit which do not apply. The following are required in continuous mixing plant:
1. Gradation control unit: Means for accurately proportioning aggregate from each bin either by weighing or by volumetric measurement. When gradation control is by volume, have the unit include a feeder mounted under the bin compartments. Equip each bin with an accurately controlled individual gate to form an orifice for volumetrically measuring the material drawn from each bin compartment. Make the orifice of adequate dimensions to provide a positive feed without bridging and with one dimension adjustable by positive mechanical means provided with a lock. Provide indicators graduated from sufficient subdivisions of inches to provide accuracy of measurements, on each gate to show the size of gate opening. If mineral filler is required, proportion it separately, and add it to the mix in such a manner as to ensure uniform distribution.
  2. Weight Calibration of Aggregate Feed: Have plant include a means for calibration of gate openings with weight test samples. Allow materials fed out of the bins through individual orifices to be bypassed to a suitable test box or boxes, the material from each compartment being confined separately. Equip the plant to

handle conveniently test samples of size adequate to provide an accurate gate calibration commensurate with the aggregate size, the gate opening, and the plant capacity setup. Provide an accurate platform scale with a minimum capacity of 500 pounds.

3. Synchronization of Aggregate Feed and Bitumen Feed: Provide satisfactory means to afford positive interlocking control between the flow of aggregate from the bins and the flow of bituminous material from the meter or other proportioning source. Accomplish this control by interlocking mechanical means or by another positive method under the control of the Engineer.
4. Mixer Unit for Continuous Method: Continuous mixer of an approved twin-pugmill type, steam-jacketed and capable of producing a uniform mixture within the job-mix tolerances. Use paddles that are adjustable for angular position on the shafts and reversible to retard the flow of the mix. Have the mixer carry a manufacturer's plate stating the net volumetric contents of the mixer at the several heights inscribed on a permanent gauge. Provide charts showing the rate of feed of aggregate per minute required, controlled by weight method under the following formula. The weights will be determined by tests made by the Engineer.

$$\text{Mixing time in seconds} = \frac{\text{Pugmill dead capacity in lbs.}}{\text{Pugmill output in lbs./sec.}}$$

- D. Trucks for Transporting Bituminous Mixtures: Solid metal, dump-type bed, clean and smooth; with a tight-fitting rear gate to prevent loss of materials while in transit.
  1. Spray the inside surface of the bed with a minimum amount of approved thin oil or a mixture of lime and water proportioned at a rate of 100 pounds of lime to 50 gallons of water, prior to loading, to prevent adhesion of the mixture to the bed. Kerosene and gasoline will not be approved nor will the use of excessive quantities of approved oil be permitted.
  2. Equip each truck with a canvas or other covering of sufficient size to cover the material and protect it from weather. To prevent excessive temperature loss while in transit, equip the trucks with insulating units composed of wood or other approved material between October 15 and March 15, when so directed by the Engineer.
  3. Do not use trucks with appreciable oil leakage that may cause damage to the new bituminous construction.
- E. Bituminous Spreading and Finishing Machines: Use spreading and finishing machine that operates without side forms and of a self-propelled type approved by the Engineer and equipped with the following features:
  1. An efficient steering device of both forward and reverse traveling speeds.
  2. Adjustments, of the manufacturer's standard design, that permit the bituminous material to be placed to a maximum width of not less than 12 feet and to a minimum width of 8 feet; the adjustments made in increments of one foot or less.
  3. Devices to adjust the thickness of material being placed, with suitable hopper for receiving the material, and with distributing screws, rake bars, or similar for evenly placing the mixture in front of the screed.
  4. The screed is a strike-off device operated by cutting, crowding or other practicable action that is effective on the bituminous mixture being placed, that is equipped with a heater, that produces a finished surface of uniform texture, and that is adjustable to the shape of the cross section of the finished surface.
  5. Joint-leveling or joint-blending devices for smoothing and adjusting longitudinal joints between adjacent layers of the same thickness.
  6. Ability to spread the bituminous mixture without tearing the surface and to strike a finish that is smooth, true to cross section, uniform in density and texture, and free from hollows, corrugations and other irregularities.
- F. Tools for Finishing Asphalt Surfaces:

1. Asphalt lute: Wood, with a blade six feet in length, six inches in width, and one-half inch in thickness; edged on the contact surface; with the handle 16 feet in length, to one end of which the blade is firmly affixed with adequate bracing.
  2. Rakes: Metal, not be less than 14 inches wide; with tines of sufficient depth to penetrate and rake the material for its full depth.
  3. Smoothing irons: Metal, weighing not less than 40 pounds; with bearing surface not be less than 80 square inches.
  4. Hand tampers for compaction of bituminous material in locations inaccessible to rollers: Metal, weighing not less than 25 pounds, with tamping face of not less than 48 square inches.
- G. Rollers: Use rollers that are in first-class mechanical condition, complying with the requirements for the individual items as to classifications, weights and service requirements. Use tandem and three-wheel rollers that are power-driven, always capable of being reversed smoothly, and free from backlash, loose-link motion, faulty steering mechanism, and worn king bolts and bearings. A roller of these types that has been improperly weighted or that has in any way been thrown out of its original balance by the application of attachments not approved or not the manufacturer's original standard design will not be permitted on the project; nor will any roller that does not have displayed thereon in permanent legible characters the manufacturer's guaranteed net operating weight as distributed on each axle be permitted on the project. The net operating weight is the actual net weight plus one-half of the total maximum weight of fuel and water. Ensure that rolls have closely fitting spring scrapers, adjustable for forward and reverse motion.
1. Two-Axle Tandem Rollers: Of rigid construction with the following features:
    - a. Having a low center of gravity and balanced on the longitudinal axis, smooth operating friction clutches of the reversing type, smooth operating brakes, both hand-operated and power-operated steering devices.
    - b. The type of driving mechanism is to be such as to give the lowest side clearance possible.
    - c. Equipped with a water sprinkling system having a tank capacity as indicated in the table below, with the water piped to the spray pipes on each roll, the spray pipe extending the full width of the roll and installed so as to be readily cleanable, the water distributed from the spray pipes through cocoa-fiber mats securely suspended against the rolling surface, and having separate valves to control the flow of water to each roll and if enough pressure is not secured by force of gravity, some satisfactory pressure device installed.
    - d. Minimum compression per inch of width of drive roll may include only the net operating weight of the roller, with the distribution of weight such that not more than 68 percent of the total gross weight is placed upon the drive roll.

**THIS SPACE NOT USED**

Manufacturer's rating, tons	5 - 6	10 - 12	15
Minimum diameter, drive roll, inches	42	60	70
Minimum diameter, guide roll, inches	36	48	50
Minimum rolling width, inches	20	20	20
Minimum compression, per inch width of drive roll, pounds	130	220	300
Minimum water sprinkling tank capacity, gallons	70	100	125

2. Three-Axle Tandem Rollers: Of rigid construction with the following features:
- a. Having a low center of gravity and balanced on the longitudinal axis, smooth operating friction clutches of the reversing type, smooth operating brakes of ample capacity, and power-operated steering devices, with both guide rolls steerable and the ratio of steering synchronized.
  - b. The type of driving mechanism is to be such as to give the lowest side clearance possible.
  - c. Equipped with a water sprinkling system having a tank capacity as indicated in the table below, with the water piped to the spray pipes on each roll, the spray pipe extending the full width of the roll and installed so as to be readily cleanable, the water distributed from the spray pipes through cocoa-fiber mats securely suspended against the rolling surface, and having separate valves to control the flow of water to each roll and if enough pressure is not secured by force of gravity, some satisfactory pressure device installed.
  - d. Minimum compression per inch of width of drive roll may include only the net operating weight of the roller, with the distribution of weight such that not more than 68 percent of the total gross weight is placed upon the drive roll.

**THIS SPACE NOT USED**

Manufacturer's rating, tons	12 - 20
Minimum diameter, drive roll, inches	60
Minimum diameter, guide roll, inches	48
Minimum rolling width, inches	54
Minimum compression, per inch width of drive roll, pounds, all three rollers in same plane	210
Minimum water sprinkling tank capacity, gallons	200

3. Pneumatic-Tire Rollers: Provide the following features:
  - a. Multiple-axle, multiple-wheel type with smooth-tread pneumatic tires of equal size staggered on the axles at such spacing and overlaps as will provide uniform compactive pressure for the full compacting width of the roller when operating. In operating pneumatic-tire rollers, have the tires inflated to the same air pressure, within a tolerance of five pounds, and to the pressure required or designated for use.
  - b. If provided, have oscillation of the wheels in a vertical plane only.
  - c. Capable of being ballasted sufficiently to bring its loaded weight to at least 2-1/2 times its own weight and of exerting compactive ground contact pressures of at least 80 psi. Have the roller ballasted to the extent required or designated; and within limits prescribed above, so that the roller provides the compactive ground pressure per square inch that is most efficient under the conditions and for the purpose of its use, and as directed.
  - d. Furnish to the Engineer charts or tabulations showing the contact areas and contact pressures for the full range of tire inflation pressures and for the full range of tire loadings for each type and size compactor tire furnished.
4. Trench Rollers: Provide the following features:
  - a. Constructed so that the guide roll or wheel either operates in tandem with the compression roll on the area to be compacted or in tandem with the auxiliary wheel or roll.
  - b. An auxiliary wheel or roll that operates outside the area to be compacted, mounted upon an axle having height adjustability so that the contact surface of the auxiliary wheel or roll is capable of being adjusted at least 10 inches above and two inches below the rolling plane of the compression roll or the amount necessary to compact the soils base to the plan elevation. If the guide roll or wheel operates in tandem with the auxiliary roll or wheel, it may or may not be adjustable as to height. Have the auxiliary wheel or roll operate upon the surface of the pavement adjacent to the area to be compacted, and at such a distance from the pavement edge as to cause no change thereto. Keep the auxiliary wheel or roll in such adjustment as to

height that the compression roll will develop a smooth compacted surface true to crown.

- c. Smooth operating friction clutches of the reversing type, smooth operating brake of ample capacity, and either hand-operated or power-operated steering devices.
- d. Compression roll may be of hollow-type construction and the minimum weight secured by liquid ballast; minimum 300 pounds compression per inch of width of compression roll; and minimum width of compaction at least 15 inches.
- e. Maximum rolling speed 1-1/2 miles per hour.
- f. Equipped with sprinkling system having a tank or tanks with total capacity of not less than 50 gallons, with the water piped to the spray pipes on each roll, the spray pipes extending the full width of rolls and installed so as to be readily cleanable, the water distributed from the spray pipes through cocoa-fiber mats securely suspended against the rims of the rolls, and having separate to control the flow of water to each roll and if enough pressure is not secured by force of gravity, some satisfactory pressure device installed.

### **3.02 BASE PREPARATION:**

- A. Prior to placing bituminous mixture, check line, grade and cross section of underlying course. Repair defective areas.
- B. Have base approved, before beginning installation work.
- C. Aggregate and Soil Aggregate Bases:
  - 1. Apply primer using equipment designed for that purpose.
  - 2. When base is dry, uniformly apply primer at rate of application directed, approximately 0.15 gallons per square yard.
  - 3. Allow primer to cure satisfactorily before placing mix.
- D. Portland Cement Concrete, Bituminous and Brick Pavement Bases:
  - 1. Apply tack coat using equipment designed for that purpose.
  - 2. Prior applying tack coat, satisfactorily clean the base and verify that base is dry at time of application.
  - 3. Apply tack coat uniformly to clean dry base at rate as directed by the Engineer, 0.02 to 0.05 gallons per square yard.
  - 4. The Engineer has the right to direct omission of tack coat over new bituminous courses, or to order the tack coat to be "run in" by the use of trucks or other rubber-tire equipment.
  - 5. Ensure that surface has cured and is satisfactorily tacky before placing mix.
- E. Immediately prior to placing mix, apply thin coat of hot asphalt cement to contact surfaces of curbs, gutters, manholes and similar structures.

### **3.03 PLACING MIX:**

- A. Place mix by two or more machines operating in echelon in such manner that joints between lanes are hot. Keep machines clean and free from accumulations of asphaltic materials by acceptable means.
- B. If equipment being used produces tracks, pulling, indented areas or other permanent blemishes in material being spread, remove such equipment from site and substitute other approved spreading and finishing equipment.

- C. Do not permit direction of movement of paving equipment to be changed by turning on newly completed base, binder or surface courses.
- D. Adjacent to headers, gutters, manholes and similar structures, place surface course so that finished surface is 1/4-inch above edge of structure.
- E. When the Engineer considers it impractical to place mix with two machines, one machine will be permitted. Treat joints created by such operation as cold joints.

#### **3.04 COMPACTION:**

- A. Compact as soon as the condition of the mix permits. Have rollers start longitudinally at the extreme sides and proceed toward the center of pavement, overlapping on each successive trip by one-half the width of the rear roll. Diagonally roll surface courses in two directions, the second diagonal crossing the lines of the first. Have rolling proceed in one continuous operation until roller marks are eliminated and until courses required density, specified below under Tolerances.
- B. Perform breakdown rolling with a three-wheel steel-wheel roller designed for the purpose; the weight as required for job conditions.
- C. Perform initial finish rolling and final rolling with at least one 10-ton tandem steel-wheel roller and one three-axle tandem steel-wheel roller designed for the purpose.
- D. When temperature is below 50F, the Engineer may direct the use of a 5-ton tandem roller to seal the surface.
- E. Perform intermediate rolling of sheet asphalt with tandem steel-wheel rollers or with self-propelled pneumatic-tire rollers designed for the purpose, as conditions warrant.
- F. Perform intermediate rolling of hot asphaltic concrete with self-propelled pneumatic-tire rollers designed for the purpose.
- G. For binder courses adjacent to structures where use of rollers is impractical, use hand tampers designed for the purpose.
- H. Use trench rollers designed for the purpose where necessary.

#### **3.05 COLD JOINTS:**

- A. Avoid cold joints; permitted only when necessary in the opinion of the Engineer.
- B. Where mix is to be placed against cold asphaltic material, cut back the cold asphaltic material with a power masonry saw a minimum of three inches so that a vertical face of compacted full-thickness material is exposed. Treat this cut face as a contact surface.

#### **3.06 BULKHEADS:**

- A. Where placement of mix is to be discontinued for such period of time that material will fall below specified street temperature, place suitable bulkhead.
- B. Construct cold joint as specified when work is resumed.

#### **3.07 HANDWORK:**

- A. When approved, perform bituminous paving work by hand in areas inaccessible to machines.
- B. Undertake handwork using equipment designed and approved for purpose.
- C. Perform handwork so that resulting paving meets specified requirements.

**3.08 FIELD QUALITY CONTROL:**

- A. Allowable Tolerances:
  - 1. Thickness: Place bituminous pavement to within tolerance of plus-or-minus 1/8 inch of thickness shown.
  - 2. Surfaces: Construct surfaces to the following tolerances:
    - a. Binder courses to within plus-or-minus 3/8 inch of elevation shown.
    - b. Surface courses to within plus-or-minus 3/16 inch of elevation shown.
    - c. Surfaces to deviate no more than 1/8 inch in the length of 10-foot steel straightedge, not cumulative.
    - d. During compacting, screed surface using straightedge as specified in Section 02750. Adjust rolling procedures so that tolerances are met.
  - 3. Densities required:
    - a. Binder courses: 94 percent of Marshall density.
    - b. Surface courses: 96 percent of Marshall density.
- B. Testing:
  - 1. Mixes:
    - a. During course of the work submit mixes as directed for testing of gradation and bitumen content in accordance with AASHTO T30 and AASHTO T164 on random samples selected in accordance with AASHTO T168.
  - 2. Cores: Test base and surface courses for density by taking test cores at designated locations for testing by the Engineer, number of cores not exceeding one core per 500 square yards of bituminous pavements or two cores per shift, whichever is greater.
    - a. Wherever deficient pavement is discovered take such additional cores as directed.
    - b. Repair core holes promptly using the same mix that was cored; where cores are taken through both binder course and surface course simultaneously, use surface course mix for repair work.

**3.09 PROTECTION OF BITUMINOUS PAVEMENT:**

- A. Obtain approval for use of pavement by public and construction traffic.
- B. Do not permit traffic to cross uncompleted longitudinal joints.

**3.10 DEFICIENT PAVEMENT:**

- A. Where directed, replace with new material or repair bituminous pavement that does not meet specified requirements..

**THIS SPACE NOT USED**

<b>TABLE 02740-1 CONSTITUENT PROPORTIONS</b>					
<b>GRADING OF TOTAL AGGREGATE (COARSE, FINE, MINERAL FILLER: AS NECESSARY) AMOUNTS FINER THAN LABORATORY SIEVE (SQUARE OPENING) WEIGHT PERCENT</b>					
SIEVE	SHEET ASPHALT		HOT ASPHALTIC CONCRETE		* JOB-MIX FORMULA TOLERANCE: ALL MIXES
	BINDER	SURFACE	BINDER	SURFACE	
1 inch	--	--	100	--	+7
3/4 inch	--	--	90 - 100	--	+7
1/2 inch	100	--	--	100	+7
3/8 inch	85 - 100	--	60 - 85	85 - 100	+7
No. 4	35 - 55	100	45 - 65	55 - 80	+7
No. 10	20 - 35	95 - 100	30 - 50	40 - 65	+6
No. 40	--	55 - 92	10 - 25	10 - 30	+6
No. 80	--	20 - 60	3 - 15	3 - 15	+4
No. 200	0 - 5	9 - 20	2 - 8	2 - 8	+3
<b>ASPHALTIC CEMENT, WEIGHT PERCENT OF TOTAL MIXTURE</b>					
	4.0 - 7.0	8.5 - 11.5	5.0 - 8.0	5.0 - 8.0	+0.5
* Notwithstanding tolerances, supply mixes within specified grading limits.					

<b>TABLE 02740-2 MIX TEMPERATURE RANGES</b>				
MIX	TEMPERATURES, DEGREES F			
	PLANT			STREET
	AGGREGATE	ASPHALT CEMENT	TOTAL MIX	
Sheet Asphalt Binder	250 - 325	250 - 325	250 - 325	250 - 325
Sheet Asphalt Surface	300 - 375	250 - 350	300 - 375	275 - 350
Hot Asphaltic Concrete	250 - 325	250 - 325	250 - 325	250 - 325

**SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.**

**ENDNOTES:**

- \*1. Use second version of SECTION 02740 BITUMINOUS PAVEMENT for contracts where bituminous pavement work is performed within the jurisdiction of the District of Columbia except as noted. (Use first version for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia.)

**END OF SECTION**

**SECTION 02750**  
**(Version 1)<sup>\*1</sup>**

**CONCRETE PAVEMENT**

**PART 1 - GENERAL**

**1.01 DESCRIPTION:**

- A. This section specifies providing portland cement concrete pavement, plain or reinforced or both, in conformance with the sections, lines and grades shown.
- B. Related Work Specified Elsewhere:
  - 1. Base for pavements: Section 02725.
  - 2. Concrete reinforcement: Section 03200.
  - 3. Cast-in-place structural concrete: Section 03300.

**1.02 SUBMITTALS:**

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Shop Drawings:
  - 1. Joint devices.
- B. Certification: As specified in Section 03300, including design mixes.

**1.03 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. AASHTO: M33, M74, M81, M148, M153, M171, M182, M194, M220, M227, T51, T148.
  - 3. FS: TT-P-86, TT-S-00227.
  - 4. ASTM: A185, A370, A615, C33, C294, C920, D3405.
- B. Concrete: Conform to quality assurance requirements as specified in Section 03300 and this section.
- C. Testing: Subject concrete for pavements to test procedures specified in Section 03300.

**1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Aggregates and Cement: As specified in Section 03300.

**1.05 JOB CONDITIONS:**

- A. Environmental Requirements:
  - 1. Do not place concrete on frozen soil base.
  - 2. Apply joint sealer when the air temperature is 50F or higher.
- B. Refrain from placing concrete while the temperature is lower than 40F or when by the National Weather Service forecast it may be expected to reach 40F or lower during the 24-hour period following placement of concrete.

## PART 2 - PRODUCTS

### 2.01 MATERIALS:

- A. Subgrade Paper: AASHTO M74.
- B. Polyethylene sheet and tape: AASHTO M171, white opaque for curing.
- C. Wire Fabric: Welded steel-wire fabric, ASTM A185.
- D. Bituminous Paint: AASHTO M81, Grade RC-250.
- E. Joint Devices:
  - 1. Tie bars: ASTM A615, Grade 60.
  - 2. Tie rod assemblies: Tensile requirements of AASHTO M227, Grade 80 based on measured cross-sectional area of unthreaded portion of bar when tested in assembled condition in accordance with ASTM A370.
  - 3. Dowels:
    - a. Plain round bars, AASHTO M227, Grade 80 coated with paint, FS TT-P-86, Type I.
    - b. Dowel sleeves in accordance with the following:
      - 1) Snug fit with dowel bar.
      - 2) Closed end.
      - 3) Limit stop for dowel approximately one inch from closed end.
      - 4) Sufficient rigidity to prevent entry of fresh concrete and collapse during construction.
  - 4. Hook bolt:
    - a. Material: As specified for dowels.
    - b. Fabrication: As shown.
- F. Grease for Dowels: Approved water-resistant grease.
- G. Expansion Joint Materials:
  - 1. Preformed expansion joint fillers:
    - a. Bituminous: AASHTO M33.
    - b. Cork: AASHTO M153, Type II.
    - c. Preformed joint seals: AASHTO M220.
  - 2. Expansion joint sealing compounds:
    - a. Hot-poured: ASTM D3405 and when tested in accordance with AASHTO T51 having ductility not less than 40 centimeter and flow at 140F not greater than one centimeter. Use of ground rubber scrap is prohibited.
    - b. Cold-applied: Single-component type, ASTM C920.
    - c. Elastomeric: FS TT-S-00227, Type 1, Class A.
- H. Burlap: AASHTO M182, Class 3 or 4.
- I. Waterproof paper: AASHTO M171.
- J. White burlap-polyethylene sheet shall conform to AASHTO Designation M171.
- K. Liquid Membrane Forming Curing Compounds: AASHTO M148, Type 1, resin base, wax-free.
- L. Concrete: Section 03300, Class 3500, air-entrained, with the following additional requirements:

1. Portland cement: Type I.
  2. Minimum cement content: Six bags per cubic yard of concrete.
  3. Maximum water content: Water/Cement ratio of 0.45 by weight.
  4. Air content: 6-1/2 percent plus-or-minus 1-1/2 percent by volume.
  5. Slump: 2-1/2 inches plus-or-minus 1/2 inch.
  6. Water reducing admixture: AASHTO M194, Type A or D as directed.
  7. Coarse aggregate:
  8. Size: ASTM C33 and as follows: 57; 67; 57 and 67; 57 and 4; 67 and 4; or 57, 67 and 4.
  9. Deleterious materials: Maximum amount of soft fragments, 2.0 percent by weight; maximum amount of coal and lignite 0.25 percent by weight; and material passing Size 200 sieve 0.5 percent by weight.
    - a. Maximum abrasion loss: 40 percent by weight.
  10. Fine aggregate:
    - a. Deleterious material: Maximum amount of friable particles, 0.5 percent by weight; maximum amount of coal and lignite 0.25 percent by weight; material passing Size 200 sieve three percent maximum by weight.
  11. For bridge decks and bridge sidewalks: Use only crushed trap rock aggregate, trap rock to be diabase rock, ASTM C294.
- M. High-Early-Strength Concrete: As specified for concrete and modified to produce high-early-strength concrete by one or a combination of the following methods.
1. Substitution of Type III or Type I cement in approved mix.
  2. Addition of Type I cement to the approved mix, but so that the total cement does not exceed eight bags per cubic yard of concrete.
  3. Addition of an approved accelerating admixture to approved mix as specified in Section 03300.

## **PART 3 - EXECUTION**

### **3.01 EQUIPMENT:**

- A. Provide appropriate equipment in sufficient quantity and sizes to perform work as specified and shown.
- B. Maintain machinery and equipment on site in first class working condition. Provide necessary tools and supplies for maintenance.
- C. Straightedges and Templates:
  1. Use metal straightedges, 10 feet long, rigidly constructed so as to prevent vertical deflection exceeding 1/32 inch and fitted with handles for ease of use.
  2. Use templates, constructed so as to extend from form to form and to ride on form, having adjustable tines spaced at six-inch intervals and rigidly constructed so as to prevent vertical deflection exceeding 1/32 inch.

### **3.02 BASE:**

- A. Check previously placed base for grade and crown with templates and straightedges for compliance with tolerances specified in Section 02725.
- B. Correct deficiencies in grade, contour and compaction.
- C. Obtain approval of base prior to placing forms and impervious material.

### **3.03 SETTING FORMS:**

- A. Unless concrete is placed against abutting structures, use steel forms to maintain concrete within required tolerance and to support paving equipment.
- B. Use flexible steel forms for curve radii less than 250 feet. For small radius curves and non-standard closures, use approved wood forms. Provide properly drilled forms to accommodate tie rod assemblies.
- C. Set forms accurately and firmly to line and grade throughout entire length of approved base.
- D. Set forms sufficiently ahead of other work to avoid conflict during operations.
- E. Concurrent with setting of forms, cover base with layer of impervious material of either subgrade paper or polyethylene sheet.
  - 1. Subgrade paper: Overlap adjacent strips at least four inches and ends not less than 12 inches.
  - 2. Polyethylene sheet: Overlap sides at least 12 inches.
  - 3. Maintain cover intact until concrete is placed.
- F. Apply one coat of bituminous paint to contact areas of abutting structures and previously placed slabs.

### **3.04 FIELD QUALITY CONTROL:**

- A. Allowable Tolerances:
  - 1. Joints and joint devices: Maximum deviation of 1/4 inch from position shown and 1/8 inch from ten-foot steel straightedge.
  - 2. Dowels: Aligned to tolerance of not more than 1/8 inch in 12 inches.
  - 3. Fabric reinforcement:
    - a. Clearance from vertical surfaces and joints: Minus 1/4 inch or plus 1/2 inch.
    - b. Clearance from top and bottom surfaces: Plus-or-minus 1/4 inch.
    - c. Clearance from top surface of additional reinforcing at penetrating structures: Plus-or-minus 1/8 inch.
  - 4. Top surface of concrete: Maximum deviation of 1/8 inch from ten-foot steel straightedge and within plus-or-minus 1/8 inch of the required elevation.
  - 5. Grooves for joints: Within minus 1/16 inch or plus zero inch of dimensions shown.
  - 6. Thickness of concrete pavement: Within minus 1/8 inch of the thickness shown, in accordance with AASHTO T148.
- B. Testing of Concrete:
  - 1. Conform to requirements specified in Section 03300.

### **3.05 JOINT DEVICES:**

- A. General:
  - 1. Place and secure joint devices to ensure that deviation does not exceed specified tolerances. Finish joints to such tolerances.
  - 2. Provide acceptable means of splicing.
  - 3. Provide satisfactory gages for checking position of joint devices.
  - 4. Where joints are to be completed after placing concrete, mark location of joint devices so as to permit installation of joint to tolerances specified.
  - 5. Where options for construction are permitted, use approved method.
  - 6. Do not disturb joint devices. Do not permit workers to step on joint devices. Realign devices immediately if displaced.
  - 7. Hold initial installation of devices firmly in place by tap bolts installed in holes drilled in forms. If holes in forms have been formed by method other than drilling, use steel washers in addition to tap bolts. After removal of forms replace tap bolts until

adjoining subgrade is ready for concrete placement. Remove tap bolts and install remainder of tie devices prior to placing adjoining slab. Apply heavy coating of bituminous paint prior to placing concrete for adjacent slab.

- B. Construction Joints:
  1. Make transverse construction joints at locations shown; use joint device applicable to particular type of joint.
  2. Install dowels at transverse construction joints, spaced as shown but clearing pavement edges and longitudinal joints by a minimum of six inches. Align dowels both vertically and horizontally to tolerance specified.
  
- C. Contraction Joints:
  1. Provide longitudinal contraction joints between previously placed slabs and new slabs and between slabs and abutting curbs and gutters.
  2. Tie longitudinal contraction joints together by installation of 1/2-inch tie rods or tie-rod assemblies 30 inches long placed across longitudinal contraction joint and spaced as shown. Do not install tie rods or tie-rod assemblies closer than 18 inches to transverse joints.
  3. Make groove for contraction joints by formwork or using an approved joint tooling device. When latter method is used saw joint to one third depth of slab within 24 hours of concrete placement.
  
- D. Expansion Joints and Joint Filler: Make grooves for expansion joints by forming. Where grooves are made by device, use approved device of such design that work can be properly performed.
  1. Prepare preformed expansion joint filler in greatest length possible and no less than ten feet.
  2. Cut filler for joints transverse to the slab in a single piece of the required shape.
  3. Cut pieces for curb and gutter as directed to exact size, from larger pieces.
  4. When splicing joint filler, butt tightly to prevent penetration of concrete between adjacent strips of joint filler.
  5. For longitudinal joints, except at curb and gutter sections, use preformed tongue and groove filler as shown.
  6. Where dowels or other approved load-transfer devices have to penetrate joint filler, properly locate and drill holes of correct size or diameter through filler at required intervals to receive bars and to achieve tight fit.
  7. Make groove for cement pavement for surface course by forming, sawing or leaving preformed joint in place.
  8. Protect preformed joint filler during placing of concrete.

**3.06 PLACING REINFORCEMENT:**

- A. Install welded steel wire fabric in flat sheets where shown in accordance with Section 03200.
- B. Unless otherwise noted, use wire fabric as follows:

Depth of Slab/Inches	Pounds Per 100 Square Feet
6	30
8	50
10	61

- C. Place wire fabric to clear vertical surfaces and joints by two inches and within tolerances specified. Lap sheets distance equal to spacing of wires and tie securely.
- D. Place two layers of wire fabric in concrete pavements over trench cuts, each layer to be of weight and type as specified for thickness of concrete. Position each layer two inches clear of top and bottom surfaces of slab and within tolerance specified. Extend each layer nine inches beyond sides of trench.
- E. Where other structures, such as manholes, penetrate concrete pavements, place wire fabric on one inch centers in each direction so that there is a minimum of two feet of fabric extending horizontally around perimeter of structure. Install layer of fabric one inch clear of top surface of slab and within tolerance specified.
- F. In surface courses, place wire fabric two inches clear of top surface of slab and within tolerance specified.
- G. Install layer of wire fabric to serve as top layer over trenches. Install additional fabric around penetrations.
- H. Except for pavements over trench cuts and around penetrations, do not place wire fabric in base course.

### **3.07 PLACING CONCRETE:**

- A. Supply and place portland cement concrete as specified in Section 03300, with the following additional requirements:
  1. Place concrete only during daylight unless otherwise approved. If placement is authorized during darkness provide adequate lighting system.
  2. Prior to placing concrete around poles, manholes or other structures projecting through pavement, coat such structures heavily with bituminous paint.
  3. Place concrete to the full thickness, deposited in successive batches for full width of slab by means of discharging device which does not cause segregation of materials.
  4. Compact concrete thoroughly during placement.
  5. When spreading by hand, employ sufficient work force for leveling, spading and spreading concrete in front of screed. Do not use rakes for handling concrete.
  6. Deposit concrete as near as practicable to joints but not touching expansion and contraction joint devices. Shovel concrete to height approximately two inches more than depth of the joint. As soon as forms are removed, clean ends of expansion joints of concrete and expose full width of preformed joint filler for full depth of slab. Place concrete against previously constructed slabs only after ends of preformed joint filler have been so cleaned and ends of performed joint filler in slab being poured have been neatly and firmly butted.
  7. Where wire fabric is required, place concrete in layers so that wire fabric may be properly placed. Requirements for machine placing and for vibration apply for each layer. Place layers and wire fabric, large wires running in longitudinal direction in such rapid sequence that monolithic slab will result.
  8. Compact concrete both by internal and surface vibration. Vibrators may be combined with spreading and finishing machines. Compact concrete adjacent to forms, joints, existing concrete or other structures by use of spud vibrator. Insert vibrator in concrete and work along entire length. Avoid contact with joint devices or underlying base. Evidence of honeycomb or lack of compaction constitute basis for rejection of concrete pavement as deficient.
  9. Construction Joints:

- a. Form construction joints where it is necessary and approved to stop concreting for 30 minutes or longer, by staking in a bulkhead and finishing the concrete to the bulkhead.
- b. If, due to an emergency, concreting must be stopped within less than ten feet of a previously formed joint of any type, remove the concrete to the joint prior to resuming the placing of the slab.

### **3.08 INITIAL FINISHING, FLOATING AND FINAL FINISHING:**

- A. Give concrete initial finish by use of finishing machines operated so as to minimize formation of laitance and to give required uniformity of surface and compaction. Remove laitance in approved manner.
- B. Avoid prolonged operation over a given area. Operate the machine over each area of pavement as directed and only as many times and at such intervals as required to give the proper compaction and uniformity of surface.
- C. Keep tops of forms clean to permit true and accurate movement of machine.
- D. On completion of screeding, bring surface to smooth finish by use of floats, eight inches wide and a minimum of four feet long, with handles at least four feet longer than width of slab and not less than 16 feet long.
- E. Operate float transversely with combined longitudinal and transverse motion for sufficient number of passes to smooth ridges and fill depressions.
- F. On completion of floating operations, screed top surface of concrete with deviation not exceeding 1/8 inch from straightedge and within tolerance specified for required elevation. Correct deficiencies by handwork if approved.
- G. After floating and verifying that surface is within specified tolerances, drag surface in longitudinal direction with longitudinal and crosswise motions using burlap so to prevent edges digging into surface of concrete or working crown out of pavement.
- H. Brooming:
  1. Upon completion of burlap dragging, broom finish top surface of pavement. Use street brooms made for the purpose with split bamboo bristles or metal bristles
    - a. Broom width: 14 inches.
    - b. Broom handle: At least one-half slab width.
  2. In general make brooming perpendicular to centerline of paving unless otherwise shown. Prior to brooming, obtain the Engineer's approval of the direction of brooming for each area.
  3. Pull broom gently over surface of pavement from edge to edge walking back and forth on bridge over pavement, holding handle almost vertical and allowing broom to drag lightly over surface without interruption, leaving slight ridges in concrete perpendicular to centerline of pavement.
  4. Overlap ridging. Ridging not more than 1/8 inch in depth with corrugations of uniform character and width.
  5. Complete brooming before rounding edges of pavement and joints.
- I. Round joints and edges to radius shown.
- J. To form flow line for gutters, trowel smooth 12-inch width of pavement adjacent to curbs unless otherwise shown.

- K. Joint Work and Edging: Where there is an option of method for doing joint work, secure approval for the method elected and use only that method.
1. Perform joint work and edging when condition of concrete permits.
  2. Ensure that joints are within tolerances specified and that there is no perceptible lip or depression other than rounding.
  3. Prepare clean grooves rounded to 1/4-inch radius with smooth even walls.
  4. Make grooves for expansion joints by forming. See requirements above for expansion joints.
  5. For joints to be sealed with poured sealer, prepare grooves with dimensions as shown and within tolerance specified. For joints to be sealed with preformed elastomeric seals, leave grooves of dimensions and within tolerances shown. Provide suitable gauges for checking dimensions.
  6. Where joints in surface course are sealed with cold-poured joint sealer, break bottom bond by placing polyethylene tape full width of groove, laid flat along top of preformed joint filler prior to joint sealing.
  7. When using hot-poured or cold-applied joint sealer, use only equipment designed for purpose. Hand-pouring pots are prohibited. Maintain material within temperature range recommended by manufacturer. Apply sealer when air temperature is as specified. Construct so that resulting stripe is straight, neat, of uniform width and joint is filled to 1/4 inch from top surface of pavement.
  8. When placing elastomeric joint seals, use equipment and methods recommended by manufacturer.

### **3.09 CURING:**

- A. Allow finished concrete to cure by one of the following methods for seven days or until concrete has developed flexural strength of 500 psi:
1. Wet burlap: Cover pavement with double thickness of thoroughly wet burlap, overlapping adjacent sheets by at least six inches. Maintain burlap in saturated state by sprinkling until it is removed. Use only clean material free from holes.
  2. Waterproof paper, polyethylene sheet or white burlap-polyethylene sheet: Place material so that adjacent sheets overlap by at least 12 inches. Secure material along side and ends so as to maintain reasonably airtight seal.
  3. Use approved liquid-membrane curing compounds as recommended by manufacturer, using equipment designed for purpose.

### **3.10 REMOVAL OF FORMS:**

- A. Remove forms as soon as condition of concrete permits, but in no case sooner than 12 hours after placement.
- B. When the temperature is below 40F, leave forms in place for at least 48 hours or as directed.

### **3.11 COLD WEATHER CONSTRUCTION:**

- A. Whenever, by the National Weather Service forecast for the locality, the temperature may be expected to reach 50F or lower during the 24-hour period following placement concrete mix, include an approved accelerating admixture in the concrete mix as specified in Section 03300.
- B. Place concrete when temperature conditions are as specified, unless otherwise directed. If placing of concrete is so directed, in addition to adding an accelerating admixture heat aggregates, water or both, so that mix when placed is not less than 55F nor more than 90F. Do not exceed 140F for mixing water and 150F for aggregates.

- C. As soon as concrete has hardened sufficiently to prevent marring, cover pavement surface and edges with dry burlap, building paper or other approved material and subsequent layer of at least six inches of dry hay, straw or other approved material. Maintain such protection for at least three days or until field tests indicate that concrete has attained required strength.
- D. During low temperatures, install truck-mixed concrete immediately upon delivery.
- E. When temperature by National Weather Service forecast will be 40F or lower during the 72-hour period following placement of concrete, do not use membrane curing compound.

**3.12 HOT WEATHER CONSTRUCTION:**

- A. When by National Weather Service forecast, temperature will be 90F or higher during the 24-hour period following placement of concrete, cover pavement by wet-burlap method for first 24 hours, after which curing may be completed by one of the specified methods.

**3.13 PROTECTION OF CONCRETE PAVEMENT:**

- A. Obtain approval prior to permitting use of completed pavement by public and construction traffic.

**3.14 DEFICIENT PAVEMENT:**

- A. Where directed, remove and replace with new materials or correct concrete pavement that does not meet requirements.

**SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.**

\*1. Use first version of SECTION 02750 CONCRETE PAVEMENT for contracts where concrete pavement work is performed outside the jurisdiction of the District of Columbia. (Use second version for contracts where concrete pavement work is performed within the jurisdiction of the District of Columbia.)

**END OF SECTION**

**SECTION 02750**  
**(Version 2)<sup>1</sup>**

**CONCRETE PAVEMENT**

**PART 1 - GENERAL**

**1.01 DESCRIPTION:**

- A. This section specifies providing portland cement concrete pavements complete in place as shown.
- B. Related Work Specified Elsewhere:
  - 1. Base for pavements: Section 02725.
  - 2. Concrete reinforcement: Section 03200.
  - 3. Cast-in-place structural concrete: Section 03300.

**1.02 SUBMITTALS:**

Submit the following for approval in accordance with the General Requirements with the additional requirements as specified for each:

- A. Shop Drawings:
  - 1. Joint devices.
- B. Certification: As specified in Section 03300, including design mixes.

**1.03 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. AASHTO: M33, M74, M81, M148, M153, M171, M182, M194, M220, M227, T51 T148.
  - 3. FS: SS-S-164, SS-S-195, TT-P-86, TT-S-00227.
  - 4. ASTM: A185, A370, A615, C33, C294, C920.
- B. Concrete: Conform to quality assurance requirements as specified in Section 03300 and this section.
- C. Testing: Subject concrete for pavements to test procedures specified in Section 03300.

**1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Aggregates and Cement: As specified in Section 03300.

**1.05 JOB CONDITIONS:**

- A. Environmental Requirements:
  - 1. Do not place concrete on frozen soil base.
  - 2. Apply joint sealer when the air temperature is 50F or higher.
- B. Refrain from placing concrete while the temperature is lower than 40F or when by the National Weather Service forecast it may be expected to reach 40F or lower during the 24-hour period following placement of concrete.

## PART 2 - PRODUCTS

### 2.01 MATERIALS:

- A. Subgrade Paper: AASHTO M74.
- B. Polyethylene sheet and tape: AASHTO M171, white opaque for curing.
- C. Welded Wire Fabric: Welded steel-wire fabric, ASTM A185.
- D. Bituminous Paint: AASHTO M81, Grade RC-250.
- E. Joint Devices: Use joint devices which are so designed that, when under the load of fresh concrete, the parts will deviate no more than 1/4 inch from the position shown and not more than 1/8 inch from the specified tolerances, and that the finish joints can be constructed to these same tolerances. Provide joint devices complete with accessories, approved supporting devices, and installing devices and equipment.
  - 1. Tie bars: ASTM A615, Grade 60.
  - 2. Tie rod assemblies: Tensile requirements of AASHTO M227, Grade 80 based on measured cross-sectional area of unthreaded portion of bar when tested in assembled condition in accordance with ASTM A370.
  - 3. Dowels:
    - a. Plain round bars, AASHTO M227, Grade 80 coated with paint, FS TT-P-86, Type I.
    - b. Dowel sleeves in accordance with the following:
      - 1) Snug fit with dowel bar.
      - 2) Closed end.
      - 3) Limit stop for dowel approximately one inch from closed end.
      - 4) Sufficient rigidity to prevent entry of fresh concrete and collapse during construction.
  - 4. Grease for Dowels: Approved water-resistant graphite grease.
  - 5. Preformed joint fillers: AASHTO M153, Type II.
  - 6. Preformed Plank: Rigid plank of asphalt hardboard or similar material approved by the Engineer.
- F. Joint Sealer Materials:
  - 1. Joint sealing compound: Materials so proportioned that joints will be satisfactorily sealed from moisture and other foreign matter. Add appropriate tinting during manufacture, if necessary, to produce a black color.
    - a. Hot-poured joint sealing compound for joints in concrete pavement: FS SS-S-164 except the use of ground rubber scrap is prohibited. Ductility of not less than 40 centimeter in accordance with AASHTO T51; flow at 140F not greater than 1.0 centimeter.
    - b. Cold-applied joint sealing compound for joints in concrete pavement: FS SS-S-195.
    - c. Joint sealing compound for joints between concrete pavement and other structures: FS TT-S-00227.
- G. Preformed joint seals: AASHTO M220.
- H. Burlap: AASHTO M182, Class 3.
- I. Waterproof paper: AASHTO M171.
- J. White burlap-polyethylene sheet shall conform to AASHTO Designation M171.

- K. Liquid Membrane Forming Curing Compounds: AASHTO M148, Type 1, resin base, wax-free.
- L. Concrete: Section 03300, Class 3500, air-entrained, amended as follows:
1. Portland cement: Type I.
  2. Minimum cement content: Six bags per cubic yard of concrete.
  3. Maximum water content: 0.45 maximum water cement ratio.
  4. Air content: 6-1/2 percent plus-or-minus 1-1/2 percent by volume.
  5. Slump: 2-1/2 inches plus-or-minus 1/2 inch.
  6. Water reducing admixture: AASHTO M194, Type A or D as directed.
  7. Coarse aggregate:
    - a. Size: ASTM C33 Size No. 67 or a combination of Size No. 4 and Size No. 67.
    - b. Deleterious materials: Maximum amount of soft fragments, 2.0 percent by weight; maximum amount of coal and lignite 0.25 percent by weight; and material passing Size 200 sieve 0.5 percent by weight.
    - c. Maximum abrasion loss: 40 percent by weight.
  8. Fine aggregate:
    - a. Deleterious material: Maximum amount of friable particles, 0.5 percent by weight; maximum amount of coal and lignite 0.25 percent by weight; material passing Size 200 sieve three percent maximum by weight.
  9. For bridge decks and bridge sidewalks: Use only crushed trap rock aggregate, trap rock to be diabase rock, ASTM C294.
- M. High-Early-Strength Concrete: As specified for concrete and modified to produce high-early-strength concrete by one or a combination of the following methods.
1. Substitution of Type III or Type I cement in approved mix.
  2. Addition of Type I cement to the approved mix, but so that the total cement does not exceed eight bags per cubic yard of concrete.
  3. Addition of an approved accelerating admixture to approved mix as specified in Section 03300.

## **PART 3 - EXECUTION**

### **3.01 EQUIPMENT:**

- A. General: See General Provision's Article on equipment.
1. Provide suitable equipment in sufficient quantity and sizes to perform work as specified and shown.
  2. Maintain machinery and equipment on site in first class working condition. Provide necessary tools and supplies for maintenance.
  3. The term EQUIPMENT includes such specialized devices and tools that are customarily used in the construction of concrete pavements. The requirements for equipment given are not intended to be complete; rather, the intent is that characteristic equipment be used to produce certain of the required results. The suitability of the equipment is a determination made by the Engineer that the equipment will produce the required results.
- A. Concrete Spreading Machines: Power driven spreaders capable of spreading concrete to the full width and depth specified as it is delivered and as follows:
1. Standard-width machines with adjustments up to five feet.
  2. Controls conveniently grouped in easy reach of the operator.
  3. Multiple speeds in both reverse and forward gear.

4. Capable of spreading concrete to both the depth specified for reinforcement and the full thickness of the slab, without segregation and without interfering with the joints or reinforcement.
  5. Not disturbing the forms due to lateral pressure of the spreading operation; the weight of the machines of such amount and so distributed as not to cause settlement of the forms.
  6. Equipped with dismountable rims to be used when operating on concrete.
  7. Provided with suitable means to keep material off the wheel and the top of the forms or slab.
  8. Spreading accomplished by either a screw, blade, or other suitable device of the reversing type, followed by a strike-off screed; the strike-off screed adjustable to the specified crown and section.
- B. Internal Vibrators Operated Independently of Spreading or Finishing Machines: Use approved type of internal vibrators such as the spud-type, for compacting pavement concrete at joints and edges, operating at a frequency capable of producing at least 5,000 pulsations per minute, and with sufficient cable to permit being moved to any location directed by the Engineer. Do not use vibrators of such weight as to be unwieldy in application.
- C. Concrete Finishing Machines:
1. Power-driven and of the transverse-screed type.
  2. Equipped with traction wheel or wheels with dismountable rims to be used when operating on concrete.
  3. Equipped with two screeds, maintained in the best possible condition and adjustment throughout their use: Front screed used for striking off excess concrete to exact grade and crown; the rear screed used for finishing and smoothing operation.
  4. Screeds constructed of steel, be capable of being adjusted to the specified cross section, and be of such rigidity as to produce the specified crown and cross section.
  5. Each screed of the floating or suspended type, at least 1-1/2 feet longer than the width between the forms, and easily and quickly adjustable to the width required.
  6. Both machine and screeds are to have variable speeds and independently controlled.
  7. The weight of the machines of such amount and so distributed as not to cause settlement of the forms upon which operated.
  8. Provided with suitable means to keep material off the wheel and the top of the forms or slab.
- D. Straightedges: Ten feet long, made of metal with handles suitable for ease of use, and rigidly constructed so that there will be no deflection exceeding 1/32 inch.
- E. Templates: Constructed to extend from form to form and to ride on the form, equipped with adjustable tines spaced at six-inch intervals, and rigidly constructed that there will be no deflection exceeding 1/32 inch.

### **3.02 BASE:**

- A. Base Preparation: In accordance with Section 02725.
- B. Check previously placed base for grade and crown with templates and straightedges for compliance with tolerances specified in Section 02725.
- C. Correct deficiencies in grade, contour and compaction.
- D. Obtain approval of base prior to placing forms and impervious material.

### **3.03 SETTING FORMS:**

- A. Unless concrete is placed against abutting structures, use steel forms to maintain concrete within required tolerance and to support paving equipment.
- B. Use flexible steel forms for curve radii less than 250 feet. For small radius curves and non-standard closures, use approved wood forms. Provide properly drilled forms to accommodate tie rod assemblies.
- C. Set forms accurately and firmly to line and grade throughout entire length of approved base.
- D. Set forms sufficiently ahead of other work to avoid conflict during operations.
- E. Concurrent with setting of forms, cover base with layer of impervious material of either subgrade paper or polyethylene sheet.
  - 1. Subgrade paper: Overlap adjacent strips at least four inches and ends not less than 12 inches.
  - 2. Polyethylene sheet: Overlap sides at least 12 inches.
  - 3. Maintain cover intact until concrete is placed.
- F. Apply one coat of bituminous paint to contact areas of abutting structures and previously placed slabs.

### **3.04 FIELD QUALITY CONTROL:**

- A. Allowable Tolerances:
  - 1. Joints and joint devices: Maximum deviation of 1/4 inch from position shown and 1/8 inch from ten-foot steel straightedge.
  - 2. Dowels: Aligned to tolerance of not more than 1/8 inch in 12 inches.
  - 3. Fabric reinforcement:
    - a. Clearance from vertical surfaces and joints: Minus 1/4 inch or plus 1/2 inch.
    - b. Clearance from top and bottom surfaces: Plus-or-minus 1/4 inch.
    - c. Clearance from top surface of additional reinforcing at penetrating structures: Plus-or-minus 1/8 inch.
  - 4. Top surface of concrete: Maximum deviation of 1/8 inch from ten-foot steel straightedge and within plus-or-minus 1/8 inch of the required elevation.
  - 5. Grooves for joints: Within minus 1/16 inch or plus zero inch of dimensions shown.
  - 6. Thickness of concrete pavement: Within minus 1/8 inch of the thickness shown, in accordance with AASHTO T148.
- B. Testing of Concrete:
  - 1. Conform to requirements specified in Section 03300.

### **3.05 JOINT DEVICES:**

- A. General:
  - 1. Place and secure joint devices to ensure that deviation does not exceed specified tolerances. Finish joints to such tolerances.
  - 2. Provide acceptable means of splicing.
  - 3. Provide satisfactory gages for checking position of joint devices.
  - 4. Where joints are to be completed after placing concrete, mark location of joint devices so as to permit installation of joint to tolerances specified.
  - 5. Where options for construction are permitted, use approved method.
  - 6. Do not disturb joint devices. Do not permit workers to step on joint devices. Realign devices immediately if displaced.
  - 7. Hold initial installation of devices firmly in place by tap bolts installed in holes drilled in forms. If holes in forms have been formed by method other than drilling, use steel washers in addition to tap bolts. After removal of forms replace tap bolts until

adjoining subgrade is ready for concrete placement. Remove tap bolts and install remainder of tie devices prior to placing adjoining slab. Apply heavy coating of bituminous paint prior to placing concrete for adjacent slab.

- B. Construction.
  - 1. Longitudinal: The longitudinal joint at a previously placed slab and the joint between a slab and abutting curb and gutter are longitudinal construction joints.
    - a. For these joints, with the exception of the ones at the curb and gutter sections, use a tongue-and-groove joint of an isosceles trapezoidal section one inch in height with the bases two inches and 2-1/2 inches, respectively; with the groove located as shown
    - b. Tie the separately constructed slab sections together by the installation of longitudinal tie devices.
    - c. The groove for concrete pavement for surface course may be made by forming or sawing as specified below, or by preformed plank left in place.
    - d. Coat edges of the slab first constructed with heavy coat of bituminous paint prior to placing concrete for the adjacent slab.
  - 2. Transverse joints: Make transverse construction joints only at a planned transverse expansion or contraction joint. Accordingly, have transverse construction joint devices conform to the requirements for the particular type of joint.
- C. Contraction Joints:
  - 1. Provide longitudinal contraction joints between previously placed slabs and new slabs and between slabs and abutting curbs and gutters.
    - a. Tie longitudinal contraction joints together by installation of 1/2-inch tie rods or tie-rod assemblies 30 inches long placed across longitudinal contraction joint and spaced as shown. Do not install tie rods or tie-rod assemblies closer than 18 inches to transverse joints.
    - b. Make groove for contraction joints by formwork, sawing or leaving filler in place.
- D. Expansion Joints and Joint Filler:
  - 1. Make grooves for expansion joints by forming. Where grooves are made by device, use approved device of such design that work can be properly performed.
    - a. Prepare preformed expansion joint filler in greatest length possible and no less than ten feet.
    - b. Cut filler for joints transverse to the slab in a single piece of the required shape.
    - c. Cut pieces for curb and gutter as directed to exact size, from larger pieces.
    - d. When splicing joint filler, butt tightly to prevent penetration of concrete between adjacent strips of joint filler.
    - e. For longitudinal joints, except at curb and gutter sections, use preformed tongue and groove filler as shown.
    - f. Where dowels or other approved load-transfer devices have to penetrate joint filler, properly locate and drill holes of correct size or diameter through filler at required intervals to receive bars and to achieve tight fit.
    - g. Make groove for cement pavement for surface course by forming, sawing or leaving preformed joint in place.
    - h. Protect preformed joint filler during placing of concrete.

### **3.06 PLACING REINFORCEMENT:**

- A. Install welded steel wire fabric in flat sheets where shown in accordance with Section 03200.
- B. Unless otherwise noted, use wire fabric as follows:

Slab Thickness (Inches)	Roadway Width	
	Equal to or less than 24'-0"	Greater than 24'-0"
	Pounds/100 Square Feet	Pounds/100 Square Feet
6	44	46
8	51	54
10	61	69

- C. Place wire fabric to clear vertical surfaces and joints by two inches and within tolerances specified. Lap sheets distance equal to spacing of wires and tie securely.
- D. Place two layers of wire fabric in concrete pavements over trench cuts, each layer to be of weight and type as specified for thickness of concrete. Position each layer two inches clear of top and bottom surfaces of slab and within tolerance specified. Extend each layer nine inches beyond sides of trench.
- E. Where other structures, such as manholes, penetrate concrete pavements, place wire fabric on one inch centers in each direction so that there is a minimum of two feet of fabric extending horizontally around perimeter of structure. Install layer of fabric one inch clear of top surface of slab and within tolerance specified.
- F. In surface courses, place wire fabric two inches clear of top surface of slab and within tolerance specified.
- G. Install layer of wire fabric to serve as top layer over trenches. Install additional fabric around penetrations.
- H. Except for pavements over trench cuts and around penetrations, do not place wire fabric in base course.

**3.07 PLACING CONCRETE:**

- A. Supply and place portland cement concrete as specified in Section 03300, with the following additional requirements:
  1. Place concrete only during daylight unless otherwise approved. If placement is authorized during darkness provide adequate lighting system.
  2. Do not place concrete at temperatures below 40F unless otherwise approved; nor place concrete on a frozen base.
  3. Prior to placing concrete around poles, manholes or other structures projecting through pavement, coat such structures heavily with bituminous paint.
  4. Place concrete to the full thickness, deposited in successive batches for full width of slab by means of discharging device which does not cause segregation of materials.
  5. Compact concrete thoroughly during placement.
  6. Place concrete mechanical spreaders except where hand methods for spreading are approved. When spreading by hand, employ sufficient work force for leveling, spading and spreading concrete in front of screed. Do not use rakes for handling concrete.
  7. Deposit concrete as near as practicable to joints but not touching expansion and contraction joint devices. Shovel concrete to height approximately two inches more than depth of the joint. As soon as forms are removed, clean ends of expansion joints of concrete and expose full width of preformed joint filler for full depth of slab.

Place concrete against previously constructed slabs only after ends of preformed joint filler have been so cleaned and ends of performed joint filler in slab being poured have been neatly and firmly butted.

8. Where wire fabric is required, place concrete in layers so that wire fabric may be properly placed. Requirements for machine placing and for vibration apply for each layer. Place layers and wire fabric, large wires running in longitudinal direction in such rapid sequence that monolithic slab will result.
9. Compact concrete both by internal and surface vibration. Vibrators may be combined with spreading and finishing machines. Compact concrete adjacent to forms, joints, existing concrete or other structures by use of spud vibrator. Insert vibrator in concrete and work along entire length. Avoid contact with joint devices or underlying base. Evidence of honeycomb or lack of compaction constitute basis for rejection of concrete pavement as deficient.
10. Construction Joints:
  - a. Form construction joints where it is necessary and approved to stop concreting for 30 minutes or longer, by staking in a bulkhead and finishing the concrete to the bulkhead.
  - b. If, due to an emergency, concreting must be stopped within less than ten feet of a previously formed joint of any type, remove the concrete to the joint prior to resuming the placing of the slab.

### **3.08 INITIAL FINISHING, FLOATING AND FINAL FINISHING:**

- A. Give concrete initial finish by use of finishing machines operated so as to minimize formation of laitance and to give required uniformity of surface and compaction. Remove laitance in approved manner.
- B. Avoid prolonged operation over a given area. Operate the machine over each area of pavement as directed and only as many times and at such intervals as required to give the proper compaction and uniformity of surface.
- C. Keep tops of forms clean to permit true and accurate movement of machine.
- D. On completion of screeding, bring surface to smooth finish by use of floats, eight inches wide and a minimum of four feet long, with handles at least four feet longer than width of slab and not less than 16 feet long.
- E. Operate float transversely with combined longitudinal and transverse motion for sufficient number of passes to smooth ridges and fill depressions.
- F. On completion of floating operations, screed top surface of concrete with deviation not exceeding 1/8 inch from straightedge and within tolerance specified for required elevation. Correct deficiencies by handwork if approved.
- G. After floating and verifying that surface is within specified tolerances, drag surface in longitudinal direction with longitudinal and crosswise motions using burlap so to prevent edges digging into surface of concrete or working crown out of pavement.
- H. Brooming:
  1. Upon completion of burlap dragging, broom finish top surface of pavement. Use street brooms made for the purpose with split bamboo bristles or metal bristles.
    - a. Broom width: 14 inches.
    - b. Broom handle: At least one-half slab width.
  2. In general make brooming perpendicular to centerline of paving unless otherwise shown. Prior to brooming, obtain the Engineer's approval of the direction of brooming for each area.

3. Pull broom gently over surface of pavement from edge to edge walking back and forth on bridge over pavement, holding handle almost vertical and allowing broom to drag lightly over surface without interruption, leaving slight ridges in concrete perpendicular to centerline of pavement.
  4. Overlap ridging. Ridging not more than 1/8 inch in depth with corrugations of uniform character and width.
  5. Complete brooming before rounding edges of pavement and joints.
- I. Round joints and edges to radius shown.
  - J. To form flow line for gutters, trowel smooth 12-inch width of pavement adjacent to curbs unless otherwise shown.
  - K. Joint Work and Edging: Where there is an option of method for doing joint work, secure approval for the method elected and use only that method.
    1. Perform joint work and edging when condition of concrete permits.
    2. Ensure that joints are within tolerances specified and that there is no perceptible lip or depression other than rounding.
    3. Prepare clean grooves rounded to 1/4-inch radius with smooth even walls.
    4. Make grooves for expansion joints by forming. See requirements above for expansion joints.
    5. For joints to be sealed with poured sealer, prepare grooves with dimensions as shown and within tolerance specified. For joints to be sealed with preformed elastomeric seals, leave grooves of dimensions and within tolerances shown. Provide suitable gauges for checking dimensions.
    6. Where joints in surface course are sealed with cold-poured joint sealer, break bottom bond by placing polyethylene tape full width of groove, laid flat along top of preformed joint filler prior to joint sealing.
    7. When using hot-poured or cold-applied joint sealer, use only equipment designed for purpose. Hand-pouring pots are prohibited. Maintain material within temperature range recommended by manufacturer. Apply sealer when air temperature is as specified. Construct so that resulting stripe is straight, neat, of uniform width and joint is filled to 1/4 inch from top surface of pavement.
    8. When placing elastomeric joint seals, use equipment and methods recommended by manufacturer.

### **3.09 CURING:**

- A. Allow finished concrete to cure by one of the following methods for seven days or until concrete has developed flexural strength of 500 psi:
  1. Wet burlap: Cover pavement with double thickness of thoroughly wet burlap, overlapping adjacent sheets by at least six inches. Maintain burlap in saturated state by sprinkling until it is removed. Use only clean material free from holes.
  2. Waterproof paper, polyethylene sheet or white burlap-polyethylene sheet: Place material so that adjacent sheets overlap by at least 12 inches. Secure material along side and ends so as to maintain reasonably airtight seal.
  3. Use approved liquid-membrane curing compounds as recommended by manufacturer, using equipment designed for purpose.
- B. Obtain approval of the Engineer for the curing method elected and use only that method.

### **3.10 REMOVAL OF FORMS:**

- A. Remove forms as soon as condition of concrete permits, but in no case sooner than 12 hours after placement.

- B. When the temperature is below 40F, leave forms in place for at least 48 hours or as directed.

**3.11 COLD WEATHER CONSTRUCTION:**

- A. Whenever, by the National Weather Service forecast for the locality, the temperature may be expected to reach 50F or lower during the 24-hour period following placement concrete mix, include a Type C accelerating admixture in the concrete mix as specified in Section 03300. The accelerating admixture shall comply with AASHTO M 194, Type C, except that it shall contain not more than 500 parts per million chloride ion.
- B. Place concrete when temperature conditions are as specified, unless otherwise directed. If placing of concrete is so directed, in addition to adding an accelerator heat aggregates, water or both, so that mix when laid is not less than 55F nor more than 90F. Do not exceed 140F for mixing water and 150F for aggregates.
- C. As soon as concrete has hardened sufficiently to prevent marring, cover pavement surface and edges with dry burlap, building paper or other approved material and subsequent layer of at least six inches of dry hay, straw or other approved material. Maintain such protection for at least three days or until field tests indicate that concrete has attained required strength.
- D. During low temperatures, install truck-mixed concrete immediately upon delivery.
- E. When temperature by National Weather Service forecast will be 40F or lower during the 72-hour period following placement of concrete, do not use membrane curing compound.

**3.12 HOT WEATHER CONSTRUCTION:**

- A. When by National Weather Service forecast, temperature will be 90F or higher during the 24-hour period following placement of concrete, cover pavement by wet-burlap method for first 24 hours, after which curing may be completed by one of the specified methods.

**3.13 PROTECTION OF CONCRETE PAVEMENT:**

- A. Obtain approval prior to permitting use of completed pavement by public and construction traffic.

**3.14 DEFICIENT PAVEMENT:**

- A. Where directed, remove and replace with new materials or correct concrete pavement that does not meet requirements.

**SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.**

- \*1. Use second version of SECTION 02750 CONCRETE PAVEMENT for contracts where concrete pavement work is performed within the jurisdiction of the District of Columbia. (Use first version for contracts where concrete pavement work is performed outside the jurisdiction of the District of Columbia.)

**END OF SECTION**

## SECTION 02765

### PAVEMENT MARKINGS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing pavement markings and striping.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Samples:
    - a. Paint: One quart of each color.
    - b. Spheres: Two pounds.
    - c. Thermoplastic compound: Ten pounds of each color.
    - d. Preformed plastic markings: Five each of plain and reflective, each three inches wide by one-foot long.
  - 2. Certification.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. AASHTO: M249-79.
  - 3. USDOT/FHWA: Manual on Uniform Traffic Control Devices for Streets and Highways.
  - 4. Federal Test Method Standard 141.
  - 5. FED STD: 595.
  - 6. FS: TT-P-85, TT-B-1325.
  - 7. ASTM: D638.

##### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver materials in factory-sealed containers plainly marked as follows:
  - 1. Manufacturer's name and address.
  - 2. Location of plant.
  - 3. Material.
  - 4. Color of material.
  - 5. Amount of contents.
  - 6. Date of manufacturer and lot number.

##### 1.05 JOB CONDITIONS:

- A. Environmental Requirements:
  - 1. Traffic zone paint:
    - a. Apply only when ambient air temperature is above 40F and temperature of surface to be painted is above 45F.
    - b. If pavement is wet, allow surface to dry for eight hours minimum after surface appears dry.
    - c. Do not apply glass spheres in strong windy conditions.
  - 2. Extruded thermoplastic compound:

- a. Apply by extrusion at 400F minimum, 440F maximum, when air temperature is more than 35F and pavement temperature is above 50F.
  - b. If pavement is wet, delay application until the pavement has been exposed to at least two hours of direct sunlight after surface appears dry.
3. Preformed plastic traffic markings:
- a. Apply on dry pavement when ambient temperature and temperature of pavement surface is above 60F.
  - b. When temperature of pavement surface is less than 60F and when approved, apply surface heating to degree necessary for application of plastic marking.

B. Protection:

- 1. Provide traffic protective devices and methods of protection to comply with requirements of the jurisdictional authorities.
- 2. Provide and maintain traffic cones, barricades, lights and other protective devices necessary to protect traffic, workmen and completed pavement marking and striping. Remove such devices when marking and striping, including painted sections of curbing and raised traffic bars, have sufficiently cured for intended use.

**PART 2 - PRODUCTS**

**2.01 MATERIALS:**

A. Traffic Zone Paint:

- 1. Primer: If recommended by paint manufacturer or required by jurisdictional authorities, type as recommended by paint manufacturer.
- 2. Paint: Traffic, FS TT-P-85, white and yellow.

B. Glass Beads: Retroreflective glass spheres, FS TT-B-1325, with the following additional gradation requirements:

US Sieve Size	Percentage Passing
40	100
50	80 - 100
80	35 - 80
100	20 - 50
200	0 - 15

C. Extruded Thermoplastic Compound: Hot-applied alkyd thermoplastic per AASHTO M249-79 and as follows:

- 1. Thermoplastic compound:
  - a. Mixture of thermoplastic resins and other substances compounded for use in traffic markings which, when extruded hot in place and cooled to ambient temperature, will produce stark white or yellow reflective marking stripe.
  - b. Permanently white or yellow, without blemish or discoloration, with straight, clean cut, sharply defined, parallel edges and of uniform cross section.
  - c. Shaped to minimize tire impact and adhere permanently to road.
  - d. Set to solid, non-tacky, non-slippery line of sufficient elasticity to resist cracking and chipping caused by weather and temperature changes, traffic action, as well as pavement crawl and lift in freezing weather.
  - e. After curing, does not react with nor deteriorate in contact with snow

- f. removal chemicals, oil and other substances common to roadway surfaces. Chemically stable and emitting no dangerous fumes.
- g. Especially compounded for traffic markings, with no change in color and brightness characteristics after prolonged exposure to sunlight.
- h. No breakdown or deterioration when held at plastic temperature for extended periods of time nor when repeatedly reheated to plastic temperature.
- i. No change in temperature versus viscosity characteristics through repeated reheatings and from batch to batch.

2. White thermoplastic compound:

- a. Pure white, free from dirt or tint after drying.
- b. Maximum allowable compound deviations from magnesium oxide standard when tested by standard color difference meter, Gardner Color Difference Meter, Gardner Laboratories, Inc. Bethesda, Maryland or equal, with the following minimum requirements:

Scale	Definition	Magnesium Oxide Standardized	Sample
Rd	Reflectance	100	70 minimum
a	Redness - Greenness	0	Minus five to plus five
b	Yellowness - Blueness	0	Minus 10 to plus 10

- c. The white compound pigment containing not less than six-percent titanium dioxide (TiO<sub>2</sub>).

3. Yellow thermoplastic compound:

- a. After drying, yellow, FED STD 595, Color 33538, tested in accordance with Federal Test Method Standard 141, Method 4252.
- b. Pigmented binder well dispersed and free from skins, dirt, foreign objects or ingredients that will cause bleeding, staining or discoloration and consisting of mixture of non-drying synthetic resins at least one of which is solid at room temperature.
- c. Total binder content of thermoplastic compound: 15-percent minimum, 35-percent maximum by weight.
- d. Filler incorporated with resins or binder: White calcium carbonate with compressive strength of 5,000 psi.

D. Preformed Plastic Traffic Markings:

- 1. Composed of preformed plastic, smooth on top surface, undersurfaces factory-coated with pressure-sensitive adhesive coating overlaid with protective paper, polyethylene or other suitable material which remains in place until plastic is ready for application to pavement.
- 2. Plain or reflectorized.
- 3. White or yellow.
- 4. Composition:
  - a. Nonreflectorized plastic material: Consisting of basic plastic and plasticizers, 50-percent minimum by weight.
  - b. Reflectorized plastic material: Consisting of 40-percent minimum by weight of basic plastic and plasticizer and 30-percent minimum by weight of clear, reflective glass spheres, thoroughly and uniformly dispersed throughout plastic.
- 5. Pigmentation:

- a. White plastic markings: Pure white, free from tint and containing not less than six-percent titanium dioxide.
  - b. Yellow plastic markings: Yellow, FED STD 595, Color 33538, Federal Test Method 141, Method 4252.
  - c. Uniform coloring throughout cross section of plastic.
- 6. Low-temperature stress resistance: No indication of breaking, chipping or cracking when sample of specified thickness is abruptly bent to right angle after being immersed in water at 32F for 30 minutes.
  - 7. Resistance to wear: Endure not less than 2,500 cycles of a Taber Abraser, using CS-17 wheels under a load of 1,000 grams, when each 0.001-inch thickness of plastic is tested at 21C.
  - 8. Tensile strength: Nonreflectorized markings not less than 1500 psi; reflectorized markings not less than 750 psi when tested in accordance with ASTM D638.
  - 9. Bond strength: Withstand 50-pound static shear load for 15 seconds average at 21C before complete parting of bond when pair of two-inch wide strips are overlapped two inches and adhesive faces placed together.

### **PART 3 - EXECUTION**

#### **3.01 FIELD QUALITY CONTROL:**

- A. Layout of Work:
  - 1. Lay out lane widths, parking spaces and crosswalks in accordance with regulations of jurisdictional authorities and as shown.
- B. Letters and Symbols:
  - 1. Unless otherwise shown or specified, apply letters, directional arrows and other pavement markings of size and configuration in accordance with referenced USDOT/FHWA Manual on Uniform Traffic Control Devices for Street and Highways.
  - 2. Apply letters, directional arrows and other markings in color shown.
- C. Width and Color of Lines for Pavement Striping:
  - 1. Apply lines for pavement striping as follows:
    - a. Width:
      - 1) Continuous centerline striping and parking space markings: Four inches.
      - 2) Dashed lane striping: Four inches.
      - 3) Solid crosswalk lines: Six inches.
      - 4) Solid stop lines: Twelve inches.
    - b. Lines:
      - 1) Dashed lane lines: White stripes nine feet in length separated by 15 feet of unmarked surface.
    - c. Color:
      - 1) Stripes:
        - a) Solid centerline stripe: White or yellow as shown.
        - b) Lane striping, parking space marking, crosswalk and stop lines: White, unless otherwise shown.
- D. Allowable Tolerances:
  - 1. Traffic-zone paint:
    - a. Width of lines not to vary from specified width by more than 1/8 inch in each linear foot.
    - b. Lengths of skip or lane lines and unpainted surface between skip lines not to vary by more than three inches from specified length.
    - c. Coverage rate maximum: 100 square feet minimum and 110 square feet maximum of surface coverage per gallon of paint, yielding wet-film thickness

- of 0.015 inches minimum.
    - d. Coverage rate of glass spheres: Ten pounds per gallon of paint minimum.
  - 2. Extruded thermoplastic compound:
    - a. Thickness of stripe: 90 to 125 mils.
    - b. Rate of application of binder-sealer: Between 800 linear feet and 1,000 linear feet per gallon for four-inch wide lines. For lines of other widths, apply in proportion based on such rate.
  - 3. Preformed plastic traffic markings:
    - a. Thickness: 0.095 inch, minus 0.005 inch or plus 0.010 inch.
    - b. Width: Four inches, plus-or-minus 1/8-inch per 12-inch length.
  - 4. Painting of curbing and raised traffic bars:
    - a. Wet-film thickness: 0.015 inches minimum.

### 3.02 APPLICATION:

- A. Traffic Zone Paint:
  - 1. Equipment:
    - a. Use equipment suitable for mechanical application of paint and glass spheres.
    - b. Apply paint with atomizing spray machines designed for striping to apply stripes of uniform cross section, and thickness, at specified coverage with clean-cut edges permitting easy and accurate adjustment of width and rate of application as well as immediate shutoff.
    - c. Use automatic mechanical equipment designed and constructed to distribute glass spheres in uniform pattern and at prescribed coverage regardless of variation in speed of travel. Equipment may be integral part of striping machines or self-contained unit designed for attachment to striping machines, so that glass spheres will be applied immediately following application of paint. Use equipment designed and constructed to permit adjustment of coverage rate.
  - 2. Method of application:
    - a. Schedule marking and striping operations to permit paint to set and harden before roadway is opened to traffic.
    - b. Allow hot laid bituminous material to cool, prior to beginning striping operations.
    - c. Remove foreign matter from surfaces prior to painting.
    - d. Apply pigmented binder and glass spheres, mix and thin pigmented binder in accordance with manufacturer's recommendations.
    - e. Apply glass spheres uniformly, immediately following application of paint. Do not premix paint and spheres.
    - f. Apply pavement markings accurately with straight, clean-cut, sharply defined parallel edges and of uniform cross section.
    - g. Clean striping machines as often as necessary to ensure application of markings of specified quality and physical requirements.
- B. Extruded Thermoplastic Compound:
  - 1. Equipment:
    - a. Master kettle:
      - 1) Minimum capacity: 800 pounds of melted compound.
      - 2) Double oil jacket.
      - 3) Thermostatic controls.
      - 4) Approved heating device.
      - 5) Temperature gauges for oil and compound.
      - 6) Integrally mounted chopping device to chop and drop solid compound into kettle.

- b. Liner:
        - 1) Use liners with self-contained heat source, such as propane heater, capable of maintaining compound at drawing temperature of not less than 420F as well as radiant heater installed over die for same purpose.
        - 2) For installation of crosswalk lines, stop lines and solid center lines, use liner with capacity of approximately 150 pounds and automatic sphere dispenser capable of distributing reflective spheres on surface of line while still plastic.
        - 3) For centerline and lane line installation, use mobile unit equipped to automatically install dashed lines in combinations of line and skip up to 40 feet and for application of reflective spheres as specified for smaller liner.
        - 4) Provide for varying die widths in liner to produce specified line widths, including shaping die cutoff device to provide clean, square ends at beginnings and ends of lines.
    - 2. Application of binder-sealer:
      - a. Before applying binder-sealer or thermoplastic compound, prepare roadway surface by buffing and cleaning or other appropriate method.
      - b. Where thermoplastic stripe is to be installed, spray surfaces with binder sealer consisting of two parts epoxy and one-part hardener-catalyst immediately prior to installation of compound.
      - c. Mix binder-sealer fresh each day. Do not premix.
    - 3. Application of thermoplastic compound:
      - a. Apply compound in colors shown and at locations shown.
      - b. Do not use pans and aprons to control width of lines.
      - c. Use equipment including extrusion dies capable of maintaining compound at specified extrusion temperature and density and capable of producing stripe of specified width.
    - 4. Application of glass spheres:
      - a. Perform reflectorizing of thermoplastic compound by immediate application of glass spheres to specified density.
      - b. Perform reflectorizing so that completed line registers not less than 55 on Hunter Nite Visibility Meter.
- C. Preformed Plastic Traffic Markings:
- 1. Prepare roadway surface by removing dirt, dust, oily substances and other foreign matter before installing plastic markings.
  - 2. Do not install plastic marking on wet or damp pavement.
  - 3. Make installations in neat, workmanlike manner with ends and edges of successive strips of material even.
  - 4. Position center and lane markings using chalk as guides.
  - 5. Installation on sheet-asphalt surfaces:
    - a. When plastic markings are to be installed on new sheet-asphalt surfaces, install while asphalt is still hot and immediately before final rolling is performed.
    - b. As part of final rolling operation, position and embed plastic marking into surface.
    - c. To install plastic markings on existing sheet asphalt, accurately locate and press marking into place and obtain final bond by at least two longitudinal passes of ten-ton roller.
  - 6. Installation on asphaltic-concrete surfaces:
    - a. Install as specified for sheet-asphalt surfaces except apply prime coat recommended by manufacturer of plastic markings to pavement surface prior to installation of markings.
  - 7. Installation on portland-cement concrete pavement:

- a. Seal surface of concrete pavement with quick-setting primer to reduce capillary action and improve bond between marking and pavement surface.
  - b. Otherwise install as specified for sheet-asphalt pavement.
- D. Painting of Curbing and Raised Traffic Bars:
- 1. Paint curbing and raised traffic bars with traffic-zone paint.
  - 2. Clean surfaces to be painted of dirt, dust, laitance, oil or other foreign substances.
  - 3. Allow 14 days minimum after installation of portland-cement concrete before painting.
  - 4. Curbing:
    - a. Paint top and front of curbing in locations shown with one coat of nonreflectorized traffic-zone paint as specified.
  - 5. Raised traffic bars:
    - a. Paint surfaces, except bottom of raised traffic bars with one coat of white traffic-zone paint and apply glass spheres before paint has hardened.
    - b. Apply paint and glass spheres as specified.

**END OF SECTION**

## SECTION 02772

### CURBS, GUTTERS AND WALKS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing curbs, gutters, curb and gutters and walks. \*1
- B. This section specifies providing walks, curbs, gutters, curb and gutters, coping curbs and integral curbs. \*2
- C. Related Work Specified Elsewhere:
  - 1. Grading, excavating and backfilling: Section 02320.
  - 2. Base course for pavements: Section 02725.
  - 3. Concrete pavement: Section 02750.
  - 4. Concrete reinforcement: Section 03200.
  - 5. Cast-in-place structural concrete: Section 03300.
  - 6. Granite: Section 04415.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Documentation:
    - a. Where stone curb is provided by street or highway jurisdiction, submit bill of stone curb materials prior to picking up materials at designated storage facility and transporting to site.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ASTM: C979.

##### 1.04 PRODUCT DELIVERY AND HANDLING:

- A. Handle stone so as to maintain curb intact with exposed faces unmarred.

#### PART 2 - PRODUCTS

##### 2.01 MATERIALS:

- A. Concrete: Section 02750 and as specified in this section.
- B. Carbon Black:
  - 1. Emulsified: At least 25 percent by weight standard carbon-gas black colloiddally dispersed in liquid medium so that when one part of product is stirred into ten parts of water, resulting liquid, after standing undisturbed for 72 hours, is uniformly colored and contains no fillers nor other material that would adversely affect quality or appearance of concrete.
  - 2. Powder:
    - a. Concrete grade carbon black, meeting the requirements of ASTM C979.

- b. Carbon black powder to disperse in water without floating and to be capable of uniform dispersion in plastic concrete.
- C. Joint Devices:
  - 1. In accordance with Section 02750, with the following additional requirements:
    - a. Dowels: 14 inches long, 3/4-inch diameter for curb and gutter and 1/2-inch diameter for sidewalk.
    - b. Plates for construction joints and planes of weakness: 14-gauge galvanized sheet metal cut to section as necessary.
- D. Expansion Joint Materials:
  - 1. In accordance with Section 02750, with the following additional requirements:
    - a. Preformed joint filler for stone curb, 1/4-inch thick; otherwise, 1/2-inch thick, subject to specified construction requirements.
- E. Granite Curb: Section 04415 and as specified in this section.
- F. Polyethylene Tape: Section 02750.

## **2.02 MIXES:**

- A. Mix exposed aggregate surface course concrete comprising by volume, one part portland cement to three parts granite aggregate or gravel, crushed gravel or crushed stone aggregate as shown, with sand added to form workable mix.
- B. Where concrete walks are shown to be darkened, add 1/2 pound of emulsified carbon black or 1/3 pound of carbon powder per bag of portland cement.

## **2.03 FABRICATION AND MANUFACTURING:**

- A. Fabrication of Granite Curbing:
  - 1. Drill holes are prohibited, unless otherwise specified.
  - 2. Straight granite curbstone:
    - a. Width: Eight inches plus-or-minus 1/8 inch at top surface.
    - b. Front face: Between 12 inches and 14 inches deep.
    - c. Batter: One-inch per foot to depth equal to reveal plus two inches.
    - d. Length: Random, three feet minimum.
  - 3. Radius curb up to and including 100 feet: Radius to have same cross section dimensions as straight curb and cut true to radius ordered. Radius curb to be not less than three feet in length measured on arc.
  - 4. Radius curb greater than 100 feet through 200 feet: Radius to consist of straight sections not exceeding five feet in length with the ends cut to form radial joints.
  - 5. The top surface of curbstone to be finished with four-cut or 550-shot finish, but not both, to approximately true plane, with no projection or depression greater than 1/8 inch.
  - 6. Front face finished same as top surface for depth of reveal plus two inches, except that sawn finish will be acceptable alternate, with no projection or depression greater than 1/8 inch. Remaining depth of front face may be rough cut with depressions or projections not exceeding 1-1/2 inches.
  - 7. Arris line between top and face to have 1/4-inch bullnose.
  - 8. Bottom surfaces to have no projection or depression greater than 1-1/2 inches.

9. Back surfaces to be sawn or split approximately at right angles to plane of top surface. No projection or depression greater than 1/4 inch will be allowed for a distance of four inches from top. Remaining distance to have no projection or depression greater than 1-1/2 inches. Drill holes will be permitted in back surface if they do not show in top arris line.

### **PART 3 - EXECUTION**

#### **3.01 FIELD QUALITY CONTROL:**

- A. Allowable Dimensional Tolerances:
  1. Concrete surfaces constructed in accordance with the following:
    - a. Plus-or-minus 3/16 inch of elevation shown.
    - b. Deviation: 1/8-inch maximum from steel straightedge as specified in Section 02750.

#### **3.02 BASE:**

- A. Ensure that previously placed base is satisfactorily compacted and free from loose material.
- B. Have base approved prior to placing forms and base covering.
- C. Correct deficiencies in grade, contour and compaction.

#### **3.03 FORMS:**

- A. Place forms as specified in Section 02750.

#### **3.04 JOINT DEVICES AND CONTRACTION JOINTS:**

- A. General Requirements:
  1. Place joint devices and contraction joints as specified in Section 02750.
  2. Where work abuts concrete pavement, adjust spacing of joints so that joints of same type coincide with transverse joints of concrete pavement.
  3. Width of preformed expansion joint filler: Same as thickness of concrete pavement minus 3/4 inch.
  4. Concrete curb, gutter and curb and gutter:
    - a. Place two dowels in each joint between eight and twelve inches apart; for curb and gutter place one of the dowels four inches from back of curb. For curb and gutter abutting concrete pavements, complete partial tie rod assemblies in slab. Place preformed expansion joint filler in single piece depressed 1/2-inch below finished surface.
    - b. For curves of 100 feet radius or less, space expansion joints equally at intervals of approximately 15 feet; for radii greater than 100 feet space expansion joints at intervals of 45 feet, with contraction joints at intervals of 15 feet. Form contraction joints, with plates left in place, depressed 1/2-inch below finished surface.
    - c. Where placed in curves of 100 feet radius or less, stop reinforcing steel two inches clear of expansion joints.
  5. Sidewalk:
    - a. Place 1/2-inch preformed expansion joint material between sidewalks and curb where sidewalks are constructed between permanent structure and curb.
    - b. Place transverse expansion joints at intervals of 45 feet. <sup>\*3</sup>

- c. Place transverse expansion joints at intervals of 45 feet, unless otherwise shown. \*4
  - d. Provide dowels in expansion joint spaced at two-foot intervals, clearing edges of sidewalk by one foot. Where sidewalks intersect, place expansion joints in each sidewalk for full width along extension of back edges.
6. Uniform Joint Spacing: For the entire length of each straight or curved run of sidewalk or curb to be placed, lay out the work and adjust joint spacing to provide intervals of equal dimension between joints, including grooves, unless otherwise shown.

### **3.05 CONCRETE AND WIRE FABRIC:**

- A. Place concrete and wire fabric in accordance with applicable requirements of Section 02750 except that top layer of fabric over trench-cuts to clear top surface by 1-1/2 inches, plus-or-minus 1/4-inch tolerance.
- B. Place pipe for weep holes through curbs for rain leaders from building downspouts where shown.

### **3.06 STONE CURB:**

- A. Excavating and backfilling in accordance with Section 02320.
- B. Place no-slump concrete as setting bed.
- C. Ram stone curb into proper position in setting bed and set to line and grade.
- D. Where stone curb ties into existing curb, align exposed abutting surfaces.
- E. Place preformed expansion joint filler at each joint.

### **3.07 FINISHING CONCRETE CURB, GUTTER AND CURB AND GUTTER:**

- A. Remove curb and face forms as soon as condition of concrete permits and perform finishing work on exposed surfaces.
- B. Finish face edge of curb to one-inch radius. Finish other edges to 1/4-inch radius.
- C. Provide steel troweled finish followed by brushing with fine-hair brush.
- D. Remove other forms when condition of concrete permits, but no sooner than 12 hours after placing. Rub surfaces with carborundum stone where necessary.

### **3.08 FINISHING SIDEWALK:**

- A. Work on Authority Property:
  - 1. Strike off and screed top surfaces so that resulting surface is smooth and within specified tolerances.
  - 2. As soon as condition of work permits, perform joint work, edging and marking.
  - 3. Finish edges to 1/4-inch radius.
  - 4. Scoring pattern: Unless otherwise shown, as follows:
    - a. Expansion joints: Install on 45-foot centers. For the entire length of each straight or curved run of sidewalk to be placed, layout the work and adjust joint spacing to provide intervals of equal dimension between joints, including grooves, unless otherwise shown.

- b. Contraction joints: Make transverse grooves 1/3 depth of the concrete at approximately nine-foot equal intervals between expansion joints perpendicular to longitudinal grooves.
  - c. Control joints: Make transverse grooves 1/2-inch deep at approximately three foot equal intervals between contraction joints perpendicular to longitudinal grooves.
  - d. Make longitudinal grooves 1/2-inch deep at approximately three foot equal intervals between and parallel to sides of sidewalk.
  - 5. Finish surface with final light broom finish with fine-hair broom.
  - 6. Construct wheel chair ramps at locations shown.
  - 7. Remove forms when condition of concrete permit, but no sooner than 12 hours after placement. Rub surfaces with carborundum stone where necessary.
- B. Non-Authority Work:
- 1. In accordance with codes and regulations of the jurisdictional authorities.

**3.09 CURING:**

- A. In accordance with Section 02750, except that liquid membrane curing compounds not to be used on curb of curb and gutter when temperatures tend to go lower than 40F within 24 hours after application.
- B. Do not use liquid membrane curing compounds on exposed aggregate concrete or darkened concrete surfaces.

**3.10 SEALING JOINTS:**

- A. Immediately prior to sealing joints, place polyethylene tape width of groove flat on preformed expansion joint filler.
- B. Seal expansion joints in concrete curb, gutter and curb and gutter with poured joint sealer in conformance with Section 02750. Do not seal expansion joints in sidewalk and stone curb.

**3.11 HIGH EARLY STRENGTH CONCRETE:**

- A. Use high-early-strength concrete in accordance with Section 02750 when approved.

**3.12 CORES:**

- A. Where directed, provide test cores in accordance with Section 02750.

**3.13 PROTECTION OF THE WORK:**

- A. Protect new work in accordance with Section 02750.

**3.14 DEFICIENT WORK:**

- A. Remove and replace with new materials or correct as directed work which does not meet specified requirements.

**3.15 INTEGRAL CURBS: \*5**

- A. Pour integral curbs with the pavement slab.

**SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.**

\*1. Use first version of 1.01 A. for contracts where curb, gutter and walk work is performed outside the jurisdiction of Alexandria, Virginia.

\*2. Use second version of 1.01 B. modification for contracts where curb, gutter and walk work is performed within the jurisdiction of Alexandria, Virginia.

\*3. Use first version of 3.04 A.5.b. for contracts where curb, gutter and walk work is performed outside the jurisdiction of Alexandria, Virginia.

\*4. Use second version of 3.04 A.5.c. modification for contracts where curb, gutter and walk work is performed within the jurisdiction of Alexandria, Virginia.

\*5. Add Article 3.15 including A. for contracts where curb, gutter and walk work is performed within the jurisdiction of Alexandria, Virginia.

**END OF SECTION**

## SECTION 02820

### FENCING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing chain-link fencing, gates and fan guards.
- B. Related Work Specified Elsewhere:
  - 1. Cast-in-place Structural Concrete: Section 03300.
  - 2. Grounding: Section 16060.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Manufacturer's product data and installation instructions for fence, posts, fabric, gates, hardware and accessories.
    - b. Site plan with fence showing locations of bracing, fan guards, gates, ground rods, depression closures and other special fence construction.
    - c. Details of gates, depression closures and other special construction showing fabrication and installation.
    - d. Details for installation of accessories.
  - 2. Samples:
    - a. Chain link fabric: One of each width and type, each 24 inches long.
    - b. Posts, railing, braces, gate frames: One of each size and type, each 24 inches long.
    - c. Truss rod and turnbuckle: One each.
    - d. Tension wire: One, 24 inches long.
    - e. Barbed wire: One, 24 inches long.
    - f. Tension bar: One, 24 inches long.
    - g. Gate corner assembly: One.
    - h. Fabric ties: Four each.
    - i. Rail and brace ends and post caps: Two each.
    - j. Barbed wire extension arms: One each.
    - k. Other materials and accessories: One each.
  - 3. Certification.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. AWS: D1.1.
  - 3. MS: MIL-P-21035.
  - 4. FS: FF-T-791, RR-F-191/2D, RR-F-191/3D, RR-F-191/4D.
  - 5. ASTM: A121, A392, A413/A413M-01, C1107/C1107M-07a, F668.

#### 1.04 JOB CONDITIONS:

- A. Right of Access to Adjacent Private Property: As shown.

#### PART 2 - PRODUCTS

##### 2.01 MATERIALS:

- A. Fabric:
  - 1. Steel, hot-dip galvanized after weaving, ASTM A392; Class 2 coating, two-inch mesh, No. 9 gauge wire, height shown, both top and bottom selvage twisted and barbed unless otherwise indicated on Contract Drawings. <sup>\*1</sup>
  - 2. PVC-coated steel: ASTM F668 Class 2b; two-inch mesh, 0.148-inch diameter zinc-coated steel core wire, height as shown, black color PVC; top and bottom selvages twisted and barbed, unless otherwise shown on Contract Drawings.
- B. Posts, Top Rails and Braces:
  - 1. FS RR-F-191/3D, with the following additional requirements:
    - a. Posts: Class 1, Grade. Size in accordance with Table I unless otherwise shown.
    - b. Top rails: Class 1, Grade A; Size SP1.
    - c. Bracing: Class 1, Grade A; Size SP1.
    - d. Color coating: Where PVC-coated fabric is specified, provide matching PVC color ASTM F668 Class 2b coating.
- C. Accessories:
  - 1. FS RR-F-191/4D, with the following additional requirements:
    - a. Hot-dip galvanized, unless otherwise specified.
    - b. Wire ties:
      - 1) Fabric: No. 9-gauge steel.
      - 2) Tension wire: No. 11-gauge steel.
    - c. Tension wire: No 7-gauge Steel. <sup>\*1</sup>
    - d. Color coating: Where PVC-coated fabric is specified, provide matching PVC color ASTM F668 Class 2b coating.
- D. Barbed Wire:
  - 1. ASTM A121, Chain Link Fence Grade, 12-1/2 gauge steel wire with 14-gauge, four-point round barbs, five inches on center.
- E. Turnbuckle:
  - 1. FS FF-T-791, Type 1, Form 1, Class 8, Size 3/8 by six, hexagonal heads, UNC threads, hot-dip galvanized. Where PVC-coated fabric is required, provide matching PVC color coating thermally fused to the galvanized steel substrate.
- F. Latch:
  - 1. Plunger bar full height of gate, to engage stop at double gates.
- G. Security Chain:
  - 1. ASTM A413, Grade 43 High Test Chain, case-hardened carbon-steel, 3/8-inch diameter; hot-dipped galvanized at exterior locations.

- H. Padlock:
  - 1. **WMATA Station areas - Corbin Russwin, Catalog No. PL5090 IC high security or equal. All keys are to be turned over to the Engineer or WMATA Representative.**
    - a. Removable interchangeable core; with two keys, keyed and master-keyed as directed.
    - b. Body: Solid extruded brass.
    - c. Six-pin tumblers.
    - d. Shackle: Hardened steel, zinc-plated, 2-5/8 inch shackle length, ball bearing locking heel and toe.
  - 2. **WMATA Track & Line chain-link fence gates areas - Master Lock #5KA, Key A389 with two keys. All keys are to be turned over to the Engineer or WMATA Representative.**
- I. Concrete: Section 03300, Class 3500, air-entrained
- J. Grout: Non-shrink, in accordance with ASTM C1107.
- K. High Zinc-Dust Content Paint: MS MIL-P-21035.

## **2.02 SWING-TYPE GATES:**

- A. Provide swing-type gates, size as indicated on the Contract Drawings, complete with latches, stops (if required by the manufacturer), keepers, hinges and three strands of above the fabric (if shown on the Contract Drawings).
- B. Conform to Federal Specifications RR-F-191/2D, Single Swing Type I, Double Swing Type II, and as follows:
  - 1. Hot-dipped galvanized.
  - 2. Fabrication:
    - a. Fabricate gate perimeter frame from Class 1, Size SP2 pipe per Federal Standard RR-F-191/3D.
    - b. Fabric: Same fabric as used on the fence. Attach fabric securely to the gate frame at intervals not exceeding 15 inches.
    - c. Barbed wire: As specified in 2.1. D above.
    - d. Fan Guard: Materials and fabrication as specified for fencing.
  - 3. Hardware:
    - a. Hinges: Two or more galvanized steel or malleable iron, to suit the gate size: non-lift type, offset to permit 180 degrees opening.
    - b. Latch: Galvanized steel or malleable iron, combination type with provision for padlock.
    - c. Gate stops and center rest: Manufacturers' standard.

## **2.03 CANTILEVERED SLIDE GATE:**

- A. Conform to Federal Specification RR-F-192/2D, Type III.
- B. Barbed Wire: As specified in 2.01 D. above.

## PART 3 - EXECUTION

### 3.01 FENCE INSTALLATION:

- A. Perform necessary clearing, grubbing, excavation and filling to provide clear line-of-fence runs.
- B. Set posts in concrete footings, sized as shown. **All end, corner, pull and intermediate posts are to be embedded a minimum of 3 foot below final grade. Footing depth shall be a minimum of 3 feet 6 inches.**
- C. Extend concrete to two inches above ground line at posts and slope to drain away from posts. Form top 12 inches of footing, with remainder poured against excavated hole.
- D. Space posts at 10 feet maximum and eight feet minimum on centers. Place additional posts at each abrupt change in grade.
- E. Where rock is encountered, drill holes two inches deeper than depth shown and two inches greater than outside diameter of post. After post is placed as shown and specified, and supported, fill remaining void with one-to-three grout mixture of cement and sand.
- F. Where fence is located on concrete structure, weld post to base plate, thickness and size as shown on Contract Drawings. Erect fence post truly vertical, where necessary using shims of approved alloy. Secure to structure with anchor bolts; number, diameter and length as shown on Contract Drawings. Fill void under base plate with non-shrink grout. Bolts, base plate and weld to be hot-dipped galvanized.
- G. Space pull posts at approximately 500-foot intervals for straight runs and at each vertical angle point. Install corner posts at each horizontal angle point. Provide corner, end and pull posts with horizontal braces and tie rods on each side of posts extending to and connecting to adjacent line posts.
- H. After posts are installed and grout has set, install top rail or tension wire and securely anchor at ends and to line posts before hanging fabric.
- I. Secure ends of fabric by tension bars threaded through loops in fabric and secured to posts by bands with bolts and nuts or other approved devices.
- J. Attach fabric outside framing system, away from Authority property. Stretch fabric by securing one end and applying sufficient tension by mechanical fence stretchers. Fasten fabric to line posts, tension wire and top railing with tie wires at spacing shown.
- K. Hold bottom of fabric as uniformly as possible to, but in no case to exceed, two inches above finished grade.
- L. Provide barbed wire where shown. Install support arms at 45 degrees upward and outward from Authority property; extend corner, gate and end posts as shown. Stretch barbed wire to remove kinks and sags and secure to bracket arms, using tension bands for attachment to posts.

- M. Install gates, gate stops and fan guards as shown.
- N. Set gate stops in concrete accurately so that plunger can be fully engaged.
- O. Furnish one chain with one padlock for each gate.
- P. Grounding: Section 16060.

### **3.02 GATE INSTALLATION**

- A. Install gates plumb, level and secure for full opening without interference. Install ground-set items in concrete for anchorage, as detailed on the Contract Drawings. Adjust the hardware for smooth operation and lubricate where necessary.
- B. Attach barbed wire as shown on the Contract Drawings.

### **3.03 DEFECTIVE WORK:**

- A. Remove and replace fencing which is improperly located and is not true to line and grade, and posts which are not plumb.
- B. Repair damaged galvanizing by thoroughly wire brushing damaged area to remove loose and cracked zinc coating, and paint with two coats of high zinc-dust content paint. Allow first coat to dry thoroughly before applying second coat.

## **PART 4 -MEASUREMENT AND PAYMENT**

### **4.01 MEASUREMENT**

- A. Measurement of work specified in this Section will be made in the following manner:
  - 1. No separate measurement.

### **4.02 PAYMENT**

- A. Compensation for work specified in this Section will be made in the following manner:
  - 1. Included in the price of the work of which it is a part.

**SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.**

### **ENDNOTES**

**\*1.** Please verify that Standard Drawings conform to the revised Specifications for Section 02820; particularly that Utility Standard Drawing ST-U-34 contains Note 8 stating that fabric on Type A & A-1 fences less than 72 inches high have both top & bottom selvages knuckled, and that Note 8 is referenced on applicable section of CHART; and contains notes to Details 2 & 3 indicating maximum height of bottom tension wire above grade is 6 inches.

**END OF SECTION**



## SECTION 02845

### TRAFFIC CONTROL DEVICES

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing vehicular traffic barriers and raised concrete traffic bars.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Certification:
    - a. Certificates from guardrail element manufacturer and pressure preservative-treatment plant stating that materials furnished meet specified requirements.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. AWWA: C1, P8.
  - 3. AASHTO: T68.
  - 4. ASTM: A36, A123, A153, A307.
  - 5. FS: TT-P-641.
- B. Allowable Dimensional Tolerances:
  - 1. Steel guardrail elements fabricated to width and depth tolerance of minus 1/8 inch.
  - 2. Dimensions of concrete posts and raised concrete traffic bars: Plus-or-minus 1/8 inch of dimensions shown.
  - 3. Dimensions of timber posts and bracket blocks: Plus-or-minus 1/2 inch of dimensions shown.

#### PART 2 - PRODUCTS

##### 2.01 MATERIALS:

- A. Guardrail:
  - 1. Steel posts and brackets:
    - a. Structural steel: ASTM A36.
  - 2. Wood posts and bracket blocks:
    - a. Number 1 Dense SR southern pine, minimum stress-grade 1400f.
    - b. Well-seasoned, sound and free from splits, cracks and other defects.
    - c. Pressure treated in accordance with AWWA Standard C1 using pentachlorophenol preservative in light petroleum solvent conforming to AWWA Standard P8.
  - 3. Concrete posts:
    - a. Concrete reinforcement: Section 03200.
    - b. Concrete: Section 03300 and 03400.
  - 4. Rail elements and terminal sections:
    - a. Rail elements and terminal sections fabricated from open-hearth or electric-furnace steel of thickness shown. Sheet shaped into beam with longitudinal corrugations forming section 12 inches minimum width and three inches minimum depth.

- b. Fabrication:
    - 1) Edges of rail element straight and smooth.
    - 2) Steel sheet subject to standard mill tolerances for gauge.
  - c. For steel-beam type guardrail installed on curves having radius of more than 20 feet and less than 150 feet: Rail elements convex or concave as shown.
  - d. Elongation of two-inch specimen of sheet steel used for rail elements: 12-percent minimum when tested in tension in accordance with AASHTO T68.
  - e. Comply with the following:
    - 1) Tensile strength of specimen of full size of rail element, including a splice at center of specimen: 70,000-psi minimum.
    - 2) Post connections to withstand 5,000-pound side pull in both directions.
    - 3) Section of rail with traffic face up, freely supported at both ends of 12-foot span, to support concentrated load of 2,000 pounds at center of span with maximum deflection of two inches.
  - f. Rail elements and terminal pieces hot-dip galvanized after fabrication.
5. Hardware:
- a. Bolts and nuts: Steel, ASTM A307, Grade A.
  - b. Post and splice bolts machined, button-head, shoulder bolts with roll threads, Class 2A fit before galvanizing. Shoulder or neck to have an oval shape as shown. Hexagon nuts for rail connections to be machined American Standard heavy-type with recess to accommodate shoulder on bolts.
  - c. Bolts and nuts for offset steel brackets: American Standard heavy-type.
  - d. Plate washers fabricated from steel conforming to requirements specified for rail elements and terminal connections.
  - e. Hot-dip galvanized after fabrication.
6. Galvanizing:
- a. Steel posts, post anchors, brackets, rail elements and terminal sections hot-dip galvanized after fabrication in accordance with ASTM A123.
  - b. Hardware hot-dip galvanized after fabrication in accordance with ASTM A153. Zinc coating: Two ounces per square foot minimum.
  - c. Replace components on which galvanizing is damaged with new material having properly galvanized surfaces.
7. Primer coating: FS TT-P-641.
8. Non-shrink grout: Section 03300, shrinkage compensating.
9. Welding: Section 05120.

**B. Raised Traffic Bars:**

- 1. Formwork: Section 03100 or 03400.
- 2. Reinforcing steel: Section 03200.
- 3. Concrete: Section 03300, Class 3000, air-entrained.
- 4. Portland-cement grout: Section 03300.
- 5. Adhesive for attaching traffic bars to pavement: Polyvinyl acetate or asphaltic emulsion. If asphaltic emulsion is used, do not use clay or similar substances as emulsifying agents. Consistency of adhesive suitable for heavy trowel application at prevailing ambient temperature.
- 6. Anchor pins: Section 03200, concrete reinforcing rods.

**2.02 FABRICATION AND MANUFACTURE:**

**A. Steel Posts, Brackets and Post Anchors:**

- 1. Cut ends square. Punch or drill posts and brackets as shown.
- 2. After being cut to length and punched or drilled, hot-dip galvanize posts and brackets separately before bolting.
- 3. On end steel posts and adjacent posts weld steel channel anchor, 15.3 pounds per linear foot and one-foot three-inches long minimum.

- a. Weld anchors to posts and hot-dip galvanize.
    - b. Welding: Section 05120.
  - 4. Replace components on which galvanizing is damaged with new material having properly galvanized surfaces.
- B. Wood Posts and Bracket Blocks:
  - 1. Cut ends square. Drill posts and bracket blocks as shown.
  - 2. After cutting to length and drilling, saturate cut ends and holes with same preservative as that used for pressure treatment.
- C. Concrete Posts:
  - 1. Precast concrete, Class 5000, in accordance with Section 03300, eight inches square by five feet-nine inches.
  - 2. Reinforcement as shown and in accordance with Section 03200.
  - 3. Cure in accordance with Sections 03300 and 03400.
- D. Traffic Bars:
  - 1. Apply shop mark on each raised traffic bar with water-resistant paint showing the following:
    - a. Date of manufacture.
    - b. Identifying mark of manufacturer.

### **PART 3 - EXECUTION**

#### **3.01 EQUIPMENT:**

- A. Where posts are to be set in drilled holes, use mobile auger.
- B. Where steel posts are to be driven in place, use mobile drop hammer equipped with leads and mounted on track or on crawler treads. Protect heads of posts with driving cap designed to fit section of post being driven.

#### **3.02 POSTS IN DRILLED HOLES:**

- A. Drill holes plumb, accurately positioned and of diameter and depth shown.
- B. Position posts in hole to alignment shown; brace in position until remainder of hole has been backfilled with excavated material or concrete as shown.
- C. Place backfill in layers six inches maximum and compact in accordance with Section 02320.
- D. Dispose of surplus excavated material in accordance with Section 02320.
- E. In unpaved areas, carry backfill to height of two inches above surface of ground and slope to drain away from post.
- F. When holes in paved areas are shown to be backfilled with excavated material, place and compact backfill to bottom of pavement. Where pavement is portland-cement concrete pavement, fill remainder of hole with concrete to surface of pavement. Where pavement surface is asphaltic concrete, stop concrete fill two inches below final grade and fill remainder of hole with asphaltic concrete of same type as existing surface. Tamp asphaltic concrete well and slope to drain away from post.
- G. Where shown to be encased in concrete, compact concrete well and carry it to height of two inches above natural ground and slope to drain. Trowel finish surface.

### **3.03 POST DRIVEN IN PLACE:**

- A. Ensure that posts are plumb and located as shown. Remove and redrive posts which are not in compliance.
- B. Drive steel posts before offset bracket is attached.
- C. After driving, top of posts to have substantially same cross-sectional dimensions as body of posts and be free of bends and damage to galvanizing coat. Remove posts not in compliance and drive new replacement post.
- D. Drive posts carefully to prevent damage to utility facilities; if such facilities are encountered, relocate posts. Repair facilities damaged by construction operations.

### **3.04 POST SET ON CONCRETE PAVEMENTS AND DECK SLABS:**

- A. Where steel-beam guardrail is installed on existing portland-cement concrete pavement or deck slabs, fabricate steel post assembly as shown. Anchor assembly to pavement or deck slab with through-bolts or four-unit expansion anchors as shown.
- B. Clean pavement or deck surface area where base plate is to be installed. Set post with base plate over bolts; plumb and shim posts to proper grade and alignment with metal shims.
- C. Work nonshrink grout under plate to ensure full contact of bearing area. Remove shims as soon as concrete has hardened sufficiently to support weight of post. Finish edges true and smooth.

### **3.05 INSTALLATION OF STEEL-BEAM GUARDRAIL:**

- A. Install brackets and blocks on roadway side of posts. Tighten bolts after rail elements have been attached and entire assembly adjusted to line and grade.
- B. Erection of Rail Elements and Terminals Sections:
  - 1. Erect rail elements and terminal sections on posts and post brackets previously set to produce smooth continuous rail to line and grade shown. Install rail with double-corrugation face toward traffic.
  - 2. Bolt edges and center corrugation fully.
  - 3. Make vertical adjustment at posts by use of oversize bolt holes in posts and brackets as shown. If oversize holes do not permit sufficient adjustment, reset post until guardrail is properly aligned.
  - 4. After rail has been correctly aligned, tighten bolts. Check or burr threads projecting beyond nut to prevent removal.
  - 5. Where steel beam-type guardrail is shown anchored to bridge piers or terminating at concrete parapet walls, punch slotted bolt holes in rail elements terminating at such locations and make connections as shown. Flame-cutting is prohibited.
- C. Where approved, repair damaged zinc coating by wire brushing damaged area to remove loose or cracked zinc coating and applying two coats of primer.
- D. Punching, drilling, reaming, cutting or welding rail elements or terminal pieces in the field is prohibited except as approved.

### **3.06 INSTALLATION OF RAISED TRAFFIC BARS**

- A. Install raised traffic bars at locations shown.
- B. Before adhesive is applied, remove dirt, dust, grease, oil and other foreign matter that would adversely affect bond of adhesive.
- C. Apply adhesive to surfaces in such quantity that firm even bearing is obtained throughout entire contact area. Remove excess adhesive.
- D. Where use of steel pins is shown, drill holes through pavement, before adhesive is applied.
- E. After adhesive has been applied and bars properly positioned, drive steel pins in place with top of pin two inches below top of bar. Firmly press bar into adhesive, fill pin holes with portland-cement grout flush with top of bar.
- F. Where traffic bars extend across pavement joints, cut bars and make open joint of same width as joint in pavement.
- G. Painting: In accordance with Section 02765.
- H. Installation of traffic bars which are chipped, cracked or otherwise defective is prohibited.
- I. Protect completed installation until final acceptance.

**3.07 FIELD QUALITY CONTROL:**

- A. Top of post: Plus-or-minus 1/4 inch of elevation shown.
- B. Location of post: Plus-or-minus 1/4 inch of location shown.

**END OF SECTION**

## SECTION 02871

### BICYCLE RACKS AND STORAGE LOCKERS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies furnishing and installing bicycle racks and storage lockers.

##### 1.02 QUALITY ASSURANCE:

- A. Conform to the following codes, regulations, reference standards and specifications:
- B. Codes and regulations of jurisdictional authorities.
- C. FS: FF-S-325C.
- D. ASTM: F593.
- E. UL 94-V2.

##### 1.03 SUBMITTALS:

Submit for approval in accordance with the Special Conditions and with the additional requirements as specified for each:

- A. Shop Drawings: Provide manufacturer's literature showing details bicycle racks and storage locker construction, size, anchors, locks and installation instructions.
- B. Samples: Submit one each of the following. Usable approved samples will be returned by the Engineer for use in the work:
  - C. Anchor bolt.
  - D. Lock.
- E. Certifications:
  - 1. Submit certification from the manufacturers that the bicycle rack, storage locker and lock products to be supplied are compatible with specified substrate materials and will perform satisfactorily for not less than seven years.
- F. Documentation:
  - 1. Bike rack and storage locker installation procedures.
  - 2. Submit a packaging plan for the bike rack and locker units to the Engineer for approval.

##### 1.04 PACKAGING, DELIVERY, STORAGE AND HANDLING:

- A. Protect, package and deliver all bike rack and locker units complete. Deliver products to site in original unopened moisture-proof containers clearly labeled indicating manufacturer's name, type, grade and color.

- B. Store all products in approved dry area and protect from contact with soil and from exposure to the elements and contamination. Store on pallets so as to prevent damage and moisture penetration. Protect materials from rust-causing conditions and protect all materials from freezing or excessive heat.
- C. Handle assembled bike locker units in such a manner as to prevent damages to surfaces. Handle all products so as to prevent breakage of containers and damage to materials.

## **PART 2 - PRODUCTS**

### **2.01 BICYCLE RACKS**

- A. Manufacturer: High Security Bicycle Racks Co., Rack III or approved equal.
- B. Frame: All welded galvanized steel construction.
  - 1. Posts and Arms: Tubing members; 1-1/2 inch x 1-1/2-inch, 1/8-inch thick.
  - 2. Base: channel member; 4-inch x 1 5/8 inch, 3/16-inch thick.
  - 3. Locking Bars: Solid round bar, 1-inch diameter.
- C. Style: Traditional, double-unit.
- D. Security: Three-point locking system for wheel and frame. Shielded padlock receptacle to accept chain, cable and U-shaped bike locks.
- E. Size: 23 1/2-inches high, 28-inches wide, 48-inch length.
- F. Anchors: Three (3) 1/2-inch x 4 1/2-inch stainless steel expansion anchor bolts as indicated.
- G. Steel Finish: Manufacturer's standard powder coat finish.
- H. Color: As selected by the Engineer from Manufacturer's standard colors.

### **2.02 BICYCLE LOCKERS**

- A. Manufacturer: ProPark Bicycle Security Locker as manufactured by Cycle-Safe, Inc., or approved equal.
- B. Construction: Compression-molded thermoset compound, glass-fiber reinforced conforming to UL 94-V2. Formed doors and roof with frames of interlocking flanges.
- C. Model: [M/10DFR, M/12DFR, M/20DFR, and M/24DFR.]
- D. Hardware:
  - 1. Lock: Contract restricted as manufactured by Medco High Security Lock Co., or approved equal, individually keyed with five duplicate keys conforming to WMATA master key systems; R17D, R34H and d93D with 0951 cylinder.
  - 2. Latch: Stainless steel with recessed 18 ga. stainless steel plate.
  - 3. Hinges: stainless steel.

- E. Anchorage: 3/8-inch x 1-1/2-inch stainless-steel expansion type anchor bolts, four per unit as indicated.
- F. Leveling Brackets: Concealed adjustable, 3-inch vertical adjustment.
- G. Interior Partitions: Exterior grade OSB panels, sealed.
- H. Finish: Manufacturer's standard Acrylic Urethane, textured semi-gloss finish.
- I. Color: Manufacturer's standard.

**2.02 FASTENERS.**

- A. Provide fasteners as recommended by the manufacturer: Anchor bolts: FS FF-S-325, Group II, Type 3, Class 3, fabricated from stainless steel, Type 303/304. One-piece steel expander-type with bottom grooves, integral threaded stud per ASTM 593. Anchor bolts with pull-out force not less than 1,500 pounds.

**PART 3 - EXECUTION**

**3.01 INSPECTION AND COORDINATION:**

- A. Inspect the site, substrates and conditions under which the bicycle lockers will be installed. Report to the Engineer conditions that may adversely affect the work or that differ substantially from conditions shown. Follow Engineer's direction regarding such conditions.

**3.02 INSTALLATION:**

- A. As bicycle lockers are being transported and installed, prevent flexing and stressing of the lockers or other possibility of damage. Take precautions as work is being performed.
- B. Install bicycle racks and storage lockers in locations and configurations shown following manufacturer's installation instructions: Drill holes to accommodate installation of anchor bolts, adjust footing and leveling brackets and set anchor bolts. Install anchors as recommended by manufacturer to develop their rated pull-out strength. Fasten work in place so that items will not be distorted, finish will not be impaired, nor the fasteners overstressed from expansion and contraction. Set slab-mounted lockers in locations shown, install plumb, level and in true alignment with adjoining work.

**3.02 CLEANUP:**

- A. Remove all construction debris from the site.

**END OF SECTION**

## SECTION 02872

### STATION MEZZANINE ENCLOSURES AND PLATFORM SHELTERS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing mezzanine enclosures and station platform shelters.
- B. Related Work Specified Elsewhere:
  - 1. Premolded expansion joint filler: Section 03100.
  - 2. Cement grout and nonshrink grout: Section 03300.
  - 3. Sealant: Section 07900.
  - 4. Chain and padlock: Section 08710.
  - 5. Tempered glass and safety plastic: Section 08800.
  - 6. Field painting: Section 09920.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. AWS: D1.1.
  - 3. AWI: Architectural Woodwork Quality Standards.
  - 4. SDI: 100.
  - 5. FS: FF-S-325.
  - 6. ASTM: A36, A53, A123, A153, A181, A193, A307, A366, A384, A500, A501, A570, A780, B455, C307, C413, C509, C579, C580, D2559.
- B. Qualifications of Welding Personnel: Employ welders whose qualification is certified in accordance with AWS Standard D1.1. Such certification is to remain in force for the duration of the welding operations under this Contract.
- C. Job Mock-Ups:
  - 1. Complete full-size mock-up of typical bay of mezzanine-area enclosure.
  - 2. Complete full-size mock-up of station platform shelter.
- D. Lock Functions and Keying: Require hardware supplier to provide padlock and chain and meet with Engineer to finalize cremone bolt lock-functions and keying requirements.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Include details of construction, connections, anchors, interfacing with the work of other trades, schedules and setting diagrams.
    - b. Minor variations in detail for the purpose of improving fabrication and installation procedures, but not affecting general design or structural stability, will be given consideration.
    - c. Note extent of shop-applied finishes and field-painted finishes.
    - d. Use field measurements for critical dimensions and indicate them as such.

2. Samples:
  - a. Three of each type of the following products used in the work:
    - 1) Steel frame section: 12 inches long, with bolting flange.
    - 2) Steel face sheet: 12 inches square.
    - 3) Gasket material: 12 inches long.
    - 4) Wood: 2-1/2 inches by 5-1/2 inches by 12 inches.
    - 5) Fasteners, attachments devices to substrates and other accessories.
  - b. One sample of each of the following:
    - 1) Cremone bolt, trim, and escutcheon.
    - 2) Three 12-inch long assemblies of enclosure frame and stops for panels, with means of attachment to enclosure framework.
3. Certification.
  - a. Certified test reports: Certified test reports verifying that epoxy grout conforms to specified requirements.
  - b. Certification that welding personnel are currently qualified in accordance with AWS D1.1.

#### **1.04 PRODUCT, DELIVERY, STORAGE AND HANDLING:**

- A. Deliver products to the jobsite in original unopened containers or wrappings clearly labeled with manufacturer's name and brand designation, referenced specification number, type and class as applicable.
- B. Store products in an approved dry area, protect from contact with soil and from exposure to the elements. Keep products dry.
- C. Handle products to prevent breakage of containers and damage to products.

### **PART 2 - PRODUCTS**

#### **2.01 MATERIALS:**

- A. Steel Tubing: ASTM A500, ASTM A501.
- B. Steel Bars, Plates and Shapes: ASTM A36.
- C. Hot-rolled carbon steel sheets and strips: ASTM A570.
- D. Cold-rolled steel sheets and strip for forming processes: ASTM A366.
- E. Sleeves: Steel pipe, Schedule 40, ASTM A53, with welded steel-plate bottom.
- F. Bolts:
  1. Carbon steel: ASTM A307, with mated nuts, washers, and anchors, hot-dip galvanized.
  2. Stainless steel: ASTM A193, Class 1A.
  3. Expansion shields: FS FF-S-325; Group, Type and Class best suited to each purpose as approved.
- G. Screws: Corrosion-resistant, either hot-dip galvanized or stainless steel, oval, tamper-resistant design as approved. Where exposed, finish to match material being fastened.
- H. Glazing Materials:
  1. Glass: 1/4-inch tempered glass specified in Section 08800.

2. Plastic: Clear safety plastic, 1/4-inch thick minimum specified in Section 08800.
  3. Gaskets: Neoprene, ASTM C509. Shore A Durometer, scale of hardness 50-60.
  4. Butyl tape: Preshimmed, Tremco Polyshim II or equal.
- I. Wood: Natural-finished white oak, select-grade or better, dried to moisture content of 12-percent maximum. Formed from one piece of solid edge-grain lumber or glue-laminated boards matched for color and grain and with nonstaining adhesive complying with ASTM D2559.
- J. Core material: Continuous phenolic-resin-impregnated honeycombed paper.
- K. Paint: Shop finish (primer):
1. Manufacturer standard primer, providing it complies with primer requirements of Section 09920 and is compatible with undercoat and finish coat. Finish paint: Section 09920.
  2. Zinc-rich paint: MS MIL-P-21035.
- L. Cremona Bolt:
1. Handle: Bronze, ASTM B455 Alloy C38500.
  2. Pins, washers, nuts and bolts: Stainless steel, ASTM A193, Alloy C30400.
  3. Padlock and chain: Section 08710.
- M. Flanges: ASTM A181.
- N. Cement Grout and Nonshrink Grout: Section 03300.
- O. Epoxy Grout:
1. Nonshrink, nonstaining, 100-percent solids, two-component or three-component epoxy-resin system, that has been in successful use for an equivalent application for a minimum of five years.
  2. On horizontal applications: Self-leveling type.
  3. On vertical and overhead surface application: Non-sag type.
  4. Physical properties:

Property	Requirement	ASTM Test Method
Tensile strength	1,800-psi minimum in seven days	C307
Compressive strength	13,500-psi minimum in 28 days	C579
Modulus of rupture	13,500 psi	C580
Water absorption	One-percent maximum, two hours at 212F	C413

- P. Sealant: Section 07900.
- Q. Premolded Expansion-joint Filler: Section 03100.
- R. Filler Panels:
1. Structural steel, ASTM A36.

- S. Galvanizing Repair Compound:
  - 1. Stick form, melting point 600F to 650F,
  - 2. GALVABAR or equal.

## 2.02 FABRICATION:

- A. Fabricated as shown on approved shop drawings.
- B. Hollow-metal panels. Fabricate in accordance with SDI 100, Grade III, model 2A, one of the following styles:
  - 1. Seamless hollow-steel construction.
  - 2. Seamless composite construction.
- C. Cremona bolt: Fabricate and assemble as shown.
- D. Fabricate and fasten metalwork to prevent distortion and overstressing from expansion and contraction of metal. Conceal fastenings wherever practicable.
- E. Perform welding in accordance with AWS D1.1. Grind exposed welds smooth. Finish flush and grind smooth welds exposed after installation.
- F. Align members to provide true planes and square openings for installation of glass panels. Fabricate horizontal and vertical members square, level, plumb with respect to other members and true within a tolerance of plus-or-minus 1/8 inch. Cap mullions.
- G. Fabricate woodwork to AWI Architectural Woodwork Quality Standards, Premium-Grade.
- H. Pre-Assembly and final Installation: Insofar as practicable, preassemble and fit work of this section in shop to ensure proper field assembly. To the extent that work cannot be shop-assembled with permanent connections; pre-assemble, mark and disassemble before shipment.
- I. Galvanizing: For installations exposed to weather and elsewhere where indicated, hot-dip galvanize enclosures and gates after fabrication and prior to finishing. Galvanize in largest assembled units possible.
  - 1. Use hot-dip galvanizing process in accordance with ASTM A123, ASTM A153 and ASTM A384 as applicable.
  - 2. Clean and phosphatize surface as needed for priming.
  - 3. Prior to priming, treat welds and cut edges with a galvanizing repair compound at a rate of two ounces per square foot, and prepare for priming.
- J. Swing Gates
  - 1. Fabricate to operate smoothly with minimum applied pressure.
  - 2. Detail and construct assemblies to permit replacement of components that wear without disassembling entire gate.
- K. Miscellaneous Components:
  - 1. Fabricate metal items indicated on the drawings from materials shown or, if not otherwise described, from galvanized steel wherever exposed to the weather or in contact with concrete or masonry.
  - 2. Make miscellaneous items to the size and configuration indicated, welded or bolted at joints to develop full strength equal to a continuous member, and in every way complete for the intended purpose and finished in appearance.

### **2.03 SHOP PAINTING:**

- A. Shop paint (prime) before shipment. Work primer well into joints. Do not prime surfaces to be field-welded.
- B. Ensure that galvanized surfaces are phosphatized before priming.
- C. Thoroughly clean bare steel as recommended by primer manufacturer and in accordance with SSPC SP11 and apply one shop primer coat; work well into joints. Do not prime surfaces to be field-welded.
- D. On surfaces not accessible for field painting after erection, apply two coats of primer in shop.
- E. Finish Paint: Silicone-alkyd, two coats over primer; color to be determined. See Section 09920.

## **PART 3 - EXECUTION**

### **3.01 PREPARATION:**

- A. Verify dimensions before proceeding. Measure structure to ensure accurate fit to other construction, including wall-to-wall dimensions, floor-to-ceiling dimensions and those controlled by other trades.
- B. Remove foreign substances from surfaces to receive work described in this section.
- C. Protect surrounding surfaces from damage while performing the work of this section.

### **3.02 INSTALLATION:**

- A. General:
  - 1. Coordinate work of this section with work of other trades.
  - 2. Fit work to adjoining construction as shown on Contract Drawings and approved shop drawings.
  - 3. Install work plumb and true, properly align, and securely fasten as shown on Contract Drawings and approved shop drawings.
  - 4. Firmly anchor mullion of each station-platform shelter to withstand inward or outward wind pressure of 25 psf.
  - 5. Touch-up prime coat to cover field welds and damaged areas.
  - 6. Install glass and glazing material per specifications in Section 08800.
  - 7. Install cremone bolt and adjust operation as approved.
- B. Coat field welds and repair damage to zinc-coated surfaces in accordance with ASTM A780 and as follows:
  - 1. Wire-brush areas to be coated to bright metal.
  - 2. Apply galvanizing repair compound at rate of two ounces per square foot and prepare for priming.
- C. Epoxy Grouting:
  - 1. Remove contaminants from surfaces receiving and coming into contact with the grout. Remove surface contaminants such as curing compounds from holes that receive grout. Ensure that surfaces to receive grout are dry at the time of grouting.
  - 2. Prime surfaces in accordance with grout manufacturer's recommendations unless manufacturer recommends against priming.

3. Mix and place epoxy grout for locations shown or specified as recommended by grout manufacturer. Level exposed surfaces of grout joints with adjacent surfaces. Grind rough or raised projections smooth and flush with adjacent surfaces.
- D. Painting and Repairing Coated Surfaces:
1. Before enclosing construction, paint items that will be concealed in finished work.
  2. Where shop primer coat is abraded or burned by welding, clean, apply galvanizing repair compound and touch-up. Touch-up primed surfaces with same material as original coating.
  3. See Section 09920 for field painting.

**3.03 CLEAN-UP:**

- A. Remove from the site rubbish and debris caused by this work.
- B. Leave areas surrounding the work in broom-clean condition.

**END OF SECTION**

**SECTION 02890**

**MARKERS**

**PART 1 - GENERAL**

**1.01 DESCRIPTION:**

- A. This section specifies providing markers.
- B. Related Work Specified Elsewhere:
  - 1. Concrete reinforcement: Section 03200.
  - 2. Cast-in-place concrete: Section 03300.
  - 3. Precast Structural Concrete: Section 03400.

**1.02 SUBMITTALS:**

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Product Data:
    - a. Manufacturer's construction details showing materials, dimensions and profiles for each individual component.
  - 2. Shop Drawings:
    - a. Plans, elevations and sections detailing fabrication and erection. Show anchors, reinforcements, accessories, layout, installation details, colors and finish treatments.
    - b. Message list including wording and lettering layout. Include full-size details of special graphics.
    - c. Setting drawings, templates and directions for installation of anchors to be installed as work in other sections.

**1.03 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications.
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. FS: QQ-B-654, WW-T-791.
  - 3. ASTM: B36, B135
- B. Survey Certification:
  - 1. All Right-Of-Way markers shall be set by a surveyor registered in the area where the work is to be performed.
  - 2. The following certification statement or a similar statement is required and shall be placed on all approved Mylar sepia as-built Right-of-Way drawings:

"I hereby certify to the best of my knowledge that the Right-Of-Way markers shown on this as-built drawing have been set in accordance with the coordinate information provided by WMATA as shown on the Contract Documents."

\_\_\_\_\_ (seal)  
**Registered Surveyor in the State of Maryland** \*\*

\_\_\_\_\_ (seal)  
**Registered Surveyor in the Commonwealth of Virginia** \*\*

\_\_\_\_\_ (seal)  
**Registered Surveyor in the District of Columbia** \*\*

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS:**

- A. Precast Concrete: Section 03400.
- B. Concrete: Section 03300, Class 3500, air-entrained.
- C. Concrete Reinforcement: Section 03200.
- D. Bronze Discs:
  - 1. 3 ½ inch diameter domed survey marker forged from sold unleaded bronze in accordance with ASTM B98-98 with a classic 3 inch long and 5/8 inch diameter split-style tapered stem designed for use in concrete or rock (the Corp of Engineers Type 1 disc). Like or equivalent to the Berstsen C-1 Bronze 3 ½ inch domed marker #C35DB.
  - 2. Refer to Standard Drawings ST-C-3 and ST-C-19 for additional details on bronze discs and installation.
- E. Epoxy Hilti

### **2.02 FABRICATION AND MANUFACTURE:**

- A. Markers and Monuments:
  - 1. Legend:
    - a. Apply legend shown for various markers and monuments using characters of size and type shown. Clearly indicate use.
  - 2. Bronze disc markers:
    - a. Bronze discs as specified with imprinted or stamped legend.
  - 3. Precast-concrete markers and monuments:
    - a. Four inches square by length shown, with 1/2-inch chamfered edges.
    - b. Precast concrete.
    - c. One 29-inch long, No. 4 steel-reinforcing bar centered in casting.
    - d. With lettering, when shown, incised v-shaped, 1/4-inch wide and 3/16-inch in depth.

## **PART 3 - EXECUTION**

### **3.01 BRONZE DISCS FOR MARKERS AND MONUMENTS:**

- A. Except as shown, form discs into convex shape 3/16 inch in depth with edges free from burrs and blemishes.
- B. Press legend into the upper surface of disc so that surface is not raised. Ensure that legend conforms to that shown for markers and monuments.
- C. Do not place letters closer than 1/8 inch to outer rim of marker. Letters in outer ring of legend, 1/2-inch high; medium-sized letters, 7/32-inch high. Place letters along radius of disc. Imprint legend symmetrically about center of disc.
- D. When bronze-disc markers are set in concrete pavements and roadways, set stem in drilled hole and secure with approved epoxy cement, like or equivalent to Hilti HIT Hy 150.
- E. At other locations, set bronze-disc markers into tops of markers and monuments as specified; set markers and monuments in ground at locations shown.

**3.02 PRECAST-CONCRETE MARKERS AND MONUMENTS:**

- A. Install precast-concrete markers and monuments at locations and to elevations shown or as directed.
- B. Set markers and monuments as shown. Compact bottom of excavation to prevent settlement.

**END OF SECTION**

**SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.**

**ENDNOTES:**

- \*1. Enter jurisdictions as applicable for the project locations.

## SECTION 02920

### TOPSOIL, SEEDING AND SODDING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing and maintaining seeding and sodding, including grass, crownvetch and lespedeza.
- B. Related Work Specified Elsewhere.
  - 1. Site grading: Section 02320.
  - 2. Removal and restoration of existing landscaping: Section 02205.
  - 3. Landscaping: Section 02930.
- C. Definitions:
  - 1. UMPC: University of Maryland, College Park
  - 2. Numerical fertilizer analysis: Three-digit number indicates nitrogen, phosphoric acid and potash percentages by weight. Thus, 3-25-25 means three-percent nitrogen, 25-percent phosphoric acid and 25-percent potash by weight.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications: Keep always available at the work site a copy of each of the cited references.
  - 1. Codes and regulations of the jurisdictional authorities.
  - 2. USDA-SCS.
  - 3. UMPC: Current publication of Agronomy Mimeo #77 (Turfgrass Cultivar Recommendations for Maryland).
  - 4. ASTM: C51.
- B. Personnel Qualifications:
  - 1. Superintendent: Use a Superintendent with previous knowledge and verifiable experience in supervising seeding and sodding work of similar size and scope. Have the Superintendent present whenever work is being performed and have the Superintendent responsible for controlling the quality of work and inspecting completed work to ensure that Contract requirements are met. The Superintendent is the primary contact person with the Engineer regarding seeding and sodding work.
  - 2. Workers: Have the work performed only by experienced workers, who through related training and verifiable previous on-the-job experience, are familiar with the technical aspects of seeding and sodding, and with the materials and equipment used for each operation. Have each worker abide by the code of ethics or professional conduct established by the Landscape Contractors Association MD-DC-VA.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Samples and Certification:
    - a. Submit in accordance with Table 02920-1 and as follows:
      - 1) Seed: Each seed bag bearing the following upon delivery:
        - a) Analysis tag.

- b) Certification tag.
    - c) Maryland or Virginia State tags where applicable.
  - 2) Inoculant: Sample packet of inoculant, viable bacteria, true to legume strain required and listing source.
  - 3) Sod: Maryland or Virginia State-Certified, each delivery bearing a Maryland or Virginia certification tag and label as required by law.
  - 4) Topsoil: Submit supplier's name and address and source of topsoil. Submit certified report of soil laboratory test results listing textures, pH, P and K nutrients, soluble salt, organic matter and mechanical analysis as to percentage of sand, silt and clay. Do not deliver topsoil to site until approved. Approval does not constitute final acceptance.
  - 5) Fertilizer: Labeled with manufacturer's name and address, guaranteed analysis, including nutrient and its derived source and listing of potential acidity.
  - 6) Limestone and acidifying agent: Labeled with manufacturer's name and address, chemical analysis, oxide content and size gradation of each used.
  - 7) Mulch and mulch binder: Labeled with manufacturer's name and address, material components, trademark, chemical analysis, species, size, age and source.
  - 8) Herbicide: Labeled with manufacturer's name and address and chemical analysis. Include in submittal the Material Safety Data Sheet, with copies to the Engineer and Contractor's Safety Officer.
- b. Usable samples will be returned.
- 2. Documentation:
  - a. Personnel qualifications: A list of the qualifications and experience of the workers, and qualifications and experience of the Superintendent, as attested by knowledge and experience in supervising contracts of similar size and scope in the past.
  - b. Soil tests for crownvetch and lespedeza areas: Submit certified report of soil tests *made by a* local state agricultural experiment station or agricultural laboratory recommended by U.S. Department of Agriculture. Test for pH, P and K nutrients, soluble salt, organic matter and mechanical analysis as to percentage of sand, silt and clay; and include recommended quantities of soil amendments to be added to produce the target pH value and to produce optimal growing conditions for the target crop.
  - c. Furnish one test for each 500 square feet of each crownvetch and lespedeza planting area, and not less than one test for each area.
  - d. Equipment list: A list of the equipment anticipated for use, including the make and model, year manufactured.

#### **1.04 PRODUCT INSPECTION, DELIVERY, STORAGE AND HANDLING:**

- A. General: Materials and supplies are subject to inspection and sampling for testing. Allow no seed, sod, fertilizer, straw or other agronomic materials or supplies on site other than those for the project
- B. Seed: Deliver with labels and tags.
- C. Inoculants: Store inoculant containers below 70F until used. Keep containers sealed until contents are used in their entirety. Use inoculants before expiration date shown on packet. Using inoculants exposed to temperatures of 70F or greater is prohibited.

- D. Sod: Deliver sod with labels and tags.
  - 1. Deliver sod to job within 24 hours after being cut; place sod within 36 hours after being cut.
  - 2. Prior to and after delivery during wet weather, allow sod to dry to the extent that will prevent tearing during handling and laying. During dry weather, water sod to ensure its vitality and prevent dropping of the soil in handling.
- E. Topsoil: During hauling operations, keep walkway and roadway surfaces clean. Promptly remove fallen material.

#### **1.05 JOB CONDITIONS:**

- A. Conduct seeding and sodding only under favorable seasonal conditions throughout the period of the Contract as determined by the Engineer. Install no work during adverse weather or during periods when soil conditions are unfavorable as determined by the Engineer. Do not plant or lay sod during freezing weather, when planting area is muddy or frozen, nor when sod is frozen.
- B. Protection: During progress of operations, protect walls, walks, curbs, benches, established lawn areas, plant material, and other site improvements by adequate means acceptable to the Engineer.
  - 1. Weight Restrictions: Do not overload entrance paving, sidewalks and curbs.
  - 2. Pollution: Take necessary and adequate measures to prevent soil erosion, air pollution and water pollution by the materials and equipment used during construction.
  - 3. Repairs: If damage by the Contractor should occur, it is the Contractor's responsibility to repair or replace per the Engineer's direction, as acceptable to concerned parties, and at no additional cost to the Authority. Perform work so that damaged areas make smooth, satisfactory, and imperceptible transitions to existing adjacent work. Use materials and methods conforming to current standards for the area damaged, matching adjacent materials in appearance, and meeting approval of jurisdictional authorities and the Engineer.
- C. If, at any time, the Engineer determines that work is unsatisfactory or being conducted in an unsafe manner, immediately cease such work activities upon notification.

### **PART 2 - PRODUCTS**

#### **2.01 MATERIALS:**

- A. Seed: Free of quack grass, timothy, bentgrass, clover, dock, annual bluegrass, cheat, chess, chickweed, crabgrass, plantain, black medic and, except where specified in Table 02920-2, Canada Bluegrass. Kentucky Bluegrass and red fescue free of tall fescue.
  - 1. Grass Seed: Dated material from last available crop, with date of test not more than nine months before date of sowing; listed as Proven Cultivars in the latest Agronomy Mimeo #77 (Turfgrass Cultivar Recommendations for Maryland), *published by UMPC*; and as specified in Table 02920-2 below.
  - 2. Crownvetch Seed: Dated material from last available crop, with date of test not more than nine months before date of sowing. Germination portion consisting of minimum 35-percent normal sprouts, maximum 35-percent hard seed and as specified in Table 02920-4.
  - 3. Appalow Sericea Lespedeza Seed: Germination portion consisting of minimum 35-percent normal sprouts, maximum 35-percent hard seed and as specified in Table 02920-5.

B. Inoculant: Adaptable culture of live nitrogen-fixing bacteria true to legume strain used.

C. Sod:

1. Well-rooted Maryland or Virginia State-Certified sod, at least 18 months old. Varieties, identical to one of the following, or as approved:
  - a. Seed mixture specified in Table 02920-3.
  - b. Proven Cultivars in the latest Agronomy Mimeo #77, published by UMPC, certified 90-percent Turf-type Tall Fescue and 10-percent Kentucky Bluegrass.
2. Sod and attached soil free from noxious weeds such as Bermuda grass, quack grass, garlic, Johnson grass, Canada thistle and other turf weeds.
3. Mowed in production field to height of not more than 2-1/2 inches within five days prior to lifting.
4. Machine cut in sections not less than 2-1/2 feet in length nor less than 12 inches in width and to a depth equal to growth of fibrous roots, uniform soil thickness of 3/4 inch, plus-or-minus 1/4 inch. Measurement for thickness to exclude top growth and thatch.
5. Cut in sections or strips strong enough to support its own weight and retain size and shape when suspended vertically from firm grasp on upper 10 percent of section. Small, irregular or broken pieces of sod are prohibited. Sod on Beck Roll is permitted.

D. Topsoil: Weathered surface soils or natural friable loam obtained from approved sources, free of subsoil, hard fragments and stones larger than one-inch across greatest dimension, objectionable salts, noxious weeds and plants, debris and other materials inferior to surface soils or that would be toxic or harmful to growth; containing not less than 1.5-percent organic matter as determined by Walkley-Black Method; capable of sustaining normal, healthy growth and development of seed and sod scheduled and specified. Seed shall not be placed in topsoil which has been treated with soil sterilants until sufficient time has elapsed to allow for the dissipation of toxic materials.

1. Grading analysis:

Sieve	Minimum Percent Passing
2 inches	100
1/2 inch	90
1/4 inch	80
No. 10	70

2. Test and analysis of proposed topsoil material: Performed by local state agricultural experiment station or agricultural laboratory recommended by the U.S. Department of Agriculture, including recommendations for fertilizer and pH adjustment for target crop, and meeting the following requirements.
  - a. Acidity range: pH 5.5 to pH 7.5, inclusive. When topsoil pH is not within pH 5.5 - pH 7.5, modifications to correct topsoil pH shall be made according to the recommendations of the soil test lab, or the applicable State Cooperative Agricultural Extension Service.
  - b. Salinity by electrical-conductivity measurement: 500-ppm soluble salt maximum.
  - c. Fertility: Rated high in natural nutrients in pounds per acre based on the standard soil test in laboratory.
  - d. Texture: Classification consisting of 5-percent to 25-percent clay, 20-percent to 60-percent sand and 15-percent to 45-percent silt as determined by hydrometer or pipette method. Sand, silt and clay as defined by USDA-SCS.

- E. Fertilizer:
1. For grass seeded and sodded areas: Commercial fertilizer of standard quality, recommended by approved soil test report; 10-22-22.
  2. For crownvetch seeded areas: Use both of the following:
    - a. Commercial fertilizer of standard quality; 0-20-20 or 3-25-25.
    - b. Blue Chip Nitroform, slow-release nitrogen, granular form, of standard quality; 38-0-0.
  3. For appalow-sericea-lespedeza seeded areas: Commercial fertilizer of standard quality, recommended by approved soil test report; 10-22-22.
- F. Limestone: ASTM C51, Dolomitic, Agricultural Grade.
1. Capable of neutralizing soil acidity and containing not less than 85 percent calcium and magnesium carbonates
  2. Sieve analysis: 95-percent passing No. Eight sieve and 40-percent passing a No. 100 sieve. For hydroseeding, use pulverized limestone.
  3. Containers labeled to show chemicals.
- G. Acidifying Agent: As approved per soil analysis recommendations and seeding method.
- H. Mulch:
1. Wood-cellulose fiber: Containing no growth or germination-inhibiting factors and dyed green.
    - a. Properties:
      - 1) Fiber length: Approximately 3/8 inch.
      - 2) Diameter: Approximately 1/32 inch.
      - 3) Acidity range: pH 4.0 to 8.5, inclusive.
      - 4) Ash content: 1.6-percent maximum.
      - 5) Water-holding capacity: 90-percent minimum.
    - b. Packaging: Furnish fibers air-dry in packages not exceeding 50 pounds gross, with net weight shown on package.
    - c. Source: Conwed Hydro Mulch by Conwed Corp., St. Paul, MN 55101 or equal.
  2. Straw: Wheat, barley, oat or rye straw, threshed, air-dried and free from Canada thistle, dock, Johnson grass and other foreign matter.
  3. Mulch blanket: Knitted construction of biodegradable yarn with uniform openings, Gulf States Paper Corporation, Tuscaloosa, AL 35401 or equal.
    - a. 150-foot lengths or greater.
    - b. U-shaped staples: As standard with mulch-blanket manufacturer.
- I. Mulch Binders: Non-asphaltic only.
1. Synthetic binder for use with the following:
    - a. Wood-cellulose fiber: Terra Tack 1 by Grass Growers, Plainfield, NJ 07061; Soil-Gard by Alco Chemical Company, Philadelphia, PA 1913, or equal.
    - b. Straw: Terra Tack 1 by Grass Growers, Plainfield, NJ 07061 or equal.
  2. Biodegradable netting for use with straw: Conwed Erosion Control Netting by Conwed Corporation, St. Paul, MN 55101 or equal.
- J. Herbicides:
1. Broadleaf weed control: Trimec by P.B.I. Gordon Corporation, Kansas City, KS 66118 or equal.
  2. Pre-emergent crabgrass control: Balan by Elanco Products Company, Division of Eli Lilly Corporation, Indianapolis, IN 46206 or equal.
  3. Post-emergent crabgrass control: A.M.A., D.S.M.A., M.A.M.A. or Calcium Methyl Arsenate by W.A. Cleary Company, Somerset, NJ 08873 or equal.
  4. Perennial bunch-grass control: Round-up by Monsanto Agricultural Products Company, Wilmington, DE 19810 or equal.

- K. Stakes (for pegging sod): Wood or other biodegradable stakes suitable for the purpose, measuring 1/2-inch by one-inch by 12 inches.
- L. Water: Potable.

**2.02 SEED MIXTURES:**

- A. Grass Seed: Tables 02920-2 and 02920-3.
- B. Crownvetch Seed: Table 02920-4.
- C. Lespedeza Seed: Table 02920-5.
- D. Hydroseeding Crownvetch and Lespedeza Seed: Tables 02920-6 and 02920-7.

**2.03 EQUIPMENT:**

- A. Dry-Type Seeder: Brillion seeder, drill seeder or other approved mechanical seeder.
- B. Spraying Equipment for Hydroseeding: Use water tank equipped with liquid-level gauge calibrated in increments not larger than 50 gallons over entire range of tank capacity with gauge visible to nozzle operator. Use tank equipped with agitation system capable of maintaining solids in complete suspension until used.

**PART 3 - EXECUTION**

**3.01 PLACING TOPSOIL:**

- A. After completion of construction work in the area, prepare surface of subsoil. Finish to lines shown and parallel to proposed finished grade, as approved. Remove rocks and other foreign materials 1-1/2 inches or greater in any dimension. Immediately prior to covering with topsoil, loosen prepared subsoil surface to a minimum depth of four inches. Leave no depressions.
- B. Place and spread topsoil over areas to be seeded and sodded except areas to receive crownvetch or lespedeza (unless Contract Drawings require 2:1 or greater slopes to be sodded or seeded), to depth which will produce four-inch depth after natural settlement and will conform to finish lines, grades and elevations.
- C. When placing topsoil on slopes, work topsoil into subsoil to minimum depth of four inches to eliminate slip-plane between the two materials. Leave topsoil at surface to ensure germination of seed.
- D. After spreading topsoil, rake up and remove large stiff clods, hard lumps, large rocks, roots, stumps, litter and other foreign matter.
- E. Maintain specified depth of topsoil from time placed until specified seed or sod is established.
- F. If soil or weather conditions are unsuitable, cease topsoil operations. Resume topsoil operations when proper conditions prevail.

**3.02 SEEDING GRASS:**

- A. Dry Seeding: After placing topsoil, proceed as follows:
1. Seed bed preparation:
    - a. pH adjustment: Adjust topsoil pH to raise it by applying limestone or approved acidifying agent or elemental sulfur to lower the topsoil pH at per-acre rate recommended by approved soil test report so as to obtain a 6.5 pH. Apply separately prior to fertilizing and seeding operations. Work into the top three inches of soil.
    - b. Fertilizing: After acidity adjustment and within 24 hours before seeding, apply fertilizer at per-acre rate recommended by approved soil test report. Use machine spreader and lightly drag or rake fertilizer into top 1/4 inch of soil.
  2. Seeding: Clean seeders as approved prior to applying seed. Apply seed mixture directly after fertilizing.
    - a. Sow specified grass seed mixture from March 1 to April 30 and from August 15 to October 15. Extend or reduce specified periods as approved and as required by weather and soil conditions.
    - b. Sow at minimum rate as specified in Table 02920-3.
    - c. Work seed in to depth of 1/4-inch maximum.
    - d. Finish as follows:
      - 1) Lawn areas with slopes up to 3:1: Raked surface.
      - 2) Roadside areas with slopes up to 3:1: Scarified surface.
      - 3) Slopes over 3:1: Leave surface in irregular condition with ridges running parallel to contour of slope to prevent erosion.
  3. Rolling: Directly after seeding, roll lawn areas with slopes up to 3:1 using approved lawn roller, weighing 40 to 60 pounds per foot of width, unless intervening precipitation would cause such rolling to be detrimental.
- B. Hydroseeding: After placing topsoil, proceed as follows:
1. Seed bed preparation:
    - a. Clean hydroseeders as approved prior to coming on site.
    - b. pH adjustment: Adjust soil pH by either applying limestone or approved acidifying agent or elemental sulfur at per-acre rate recommended by approved soil test report so as to obtain a 6.5 pH. Apply separately prior to fertilizing and seeding operations.
      - 1) Use only pulverized limestone to raise soil pH.
      - 2) Apply not more than 300 pounds of limestone for each 100 gallons of water.
      - 3) After applied limestone mixture has dried, work into the top three inches of soil.
    - c. Apply elemental sulfur as recommended, and incorporate into top three inches of soil.
    - d. After pH adjustment, again grade and dress seed beds for lawn areas to raked surface.
  2. Fertilizing and seeding: After seed bed preparation, apply fertilizer-seed mixture.
    - a. Apply fertilizer at per-acre rate recommended by approved soil test report.
    - b. Apply seed at same rates and times specified for dry seeding. Mix seed and fertilizer together in proportions to meet required application rates.
    - c. If mulching with wood-cellulose fiber on areas with slopes up to 3:1, add mulch to seed and fertilizer mixture.
  3. Application method:
    - a. Apply mixtures by means of high-pressure spray directed upward into air so that mixtures fall to ground in uniform spray. Do not direct nozzle of hand-held hose toward ground in manner that would produce erosion or runoff.
    - b. Make uniform applications at required rate, with two passes at 90 degrees to each other, to ensure uniformity and prevent misses.
    - c. Agitate mixtures constantly from time mixed until application to seed bed.

- d. Use mixtures within eight hours after mixing.

### 3.03 SEEDING CROWN VETCH:

- A. Seed Bed Preparation: After construction work in the area has been completed, proceed as follows:
  1. Grading: Rough grade to remove large stones and roots. Remove or break up clods greater than one-foot diameter. Chisel surface to depth of four to six inches. When preparing slopes, chisel parallel to contour of slope.
  2. pH adjustment: Adjust soil pH by applying limestone or approved acidifying agent or elemental sulfur at per-acre rate in Table 02920-6, except as recommended by approved soil test report so as to obtain a 6.5 pH. Apply separately prior to fertilizing and seeding operations.
    - a. Apply 2/3 of limestone when seed bed is prepared. Work this into the top six inches of soil.
    - b. Apply remaining 1/3 of limestone with seed mixture.
  3. Fertilizing: After acidity adjustment, apply fertilizer at per-acre rate in Table 02920-6, except as recommended by approved soil test report.
  4. Hydraulic overseeding: For overseeding existing vegetation, cut existing vegetation to height of three inches and remove resultant refuse prior to overseeding.
- B. Seed Preparation:
  1. Inoculate crownvetch seed on day it is used.
  2. Reinoculate seeds not sown within 24 hours following inoculation.
- C. Hydroseeding: Clean hydroseeders as approved prior to coming on site.
  1. From March 1 to October 15, sow specified crownvetch seed mixture (Table 02920-4) at a rate of 100 pounds per acre.
  2. From June 1 to August 15 sow specified crownvetch seed mixture (Table 02920-4) at a rate of 100 pounds per acre, except add an additional three-percent by weight of Loehmans Weeping Lovegrass.
  3. Extend or reduce specified periods as approved and as required by weather and soil conditions.
  4. Bare areas: Perform application-sequence Stages I and II, specified below.
  5. Existing vegetation areas (hydraulic overseeding): Perform only application-sequence Stage I, specified below. Obtain the Engineer's on-site approval on whether to use nozzle or hose for hydraulic overseeding.
  6. Application method:
    - a. Apply mixtures by means of high-pressure spray directed upward into air so that mixtures fall to ground in uniform spray. Do not direct nozzle of hand-held hose toward ground in manner that would produce erosion or runoff.
    - b. Make uniform applications at required rate, with two passes at 90 degrees to each other, to ensure uniformity and prevent misses.
    - c. Agitate mixtures constantly from time mixed until application to seed bed. Use mixtures within eight hours after mixing.
    - d. Use inoculated crownvetch in slurry with fertilizers within one hour after mixing. Use fresh crownvetch seed and reinoculate seed whenever this requirement cannot be met.
  7. Application sequence:
    - a. Stage I, Table 02920-5: Load materials into water-filled tanks in proportion to tank size; agitate until smooth slurry is formed. Spray on seed bed at rates specified. Follow within two hours with Stage II.
    - b. Stage II, Table 02920-6: Mulch area within two hours after completing Stage I. Use straw mulch for slopes up to 2:1. Use mulch blanket for slopes greater than 2:1. Do not use wood-cellulose fiber.

### 3.04 SEEDING LESPEDEZA:

- A. Seed Bed Preparation: After construction work in the area has been completed, proceed as follows:
1. Grading: Rough grade to remove large stones and roots. Remove or break up clods greater than one-foot diameter. Chisel surface to depth of four to six inches. When preparing slopes, chisel parallel to contour of slope.
  2. pH adjustment: Adjust soil pH by applying limestone or approved acidifying agent, or elemental sulfur at per-acre rate in Table 02920-6, except as recommended by approved soil test report so as to obtain a 6.5 pH. Apply separately prior to fertilizing and seeding operations.
    - a. Apply 2/3 of limestone when seed bed is prepared. Work this into the top six inches of soil.
    - b. Apply remaining 1/3 of limestone with seed mixture.
  3. Fertilizing: After acidity adjustment, apply fertilizer at per-acre rate in Table 02920-6, except as recommended by approved soil test report.
  4. Hydraulic overseeding: For overseeding existing vegetation, cut existing vegetation to height of three inches and remove resultant refuse prior to overseeding.
- B. Seed Preparation:
1. Have lespedeza seed hulled, scarified and inoculated for spring sowing.
  2. Inoculate lespedeza seed on day it is used.
  3. Reinoculate seeds not sown within 24 hours following inoculation.
- C. Hydroseeding: Clean hydroseeders as approved prior to coming on site.
1. Sow specified lespedeza seed (Table 02920-5) from March 1 to April 30 and August 15 to October 31 at the rate of 90 pounds per acre.
  2. Extend or reduce specified period as approved and as required by weather and soil conditions.
  3. Bare areas: Perform application-sequence Stages I and II, specified below.
  4. Existing vegetation areas (hydraulic overseeding): Perform only application-sequence Stage I, specified below. Obtain the Engineer's on-site approval on whether to use nozzle or hose for hydraulic overseeding.
  5. Application method:
    - a. Apply mixtures by means of high-pressure spray directed upward into air so that mixtures fall to ground in uniform spray. Do not direct nozzle of hand-held hose toward ground in manner that would produce erosion or runoff.
    - b. Make uniform applications at required rate, with two passes at 90 degrees to each other, to ensure uniformity and prevent misses.
    - c. Agitate mixtures constantly from time mixed until application to seed bed. Use mixtures within eight hours after mixing.
    - d. Use inoculated lespedeza in slurry with fertilizers within one hour after mixing. Use fresh crownvetch seed and reinoculate seed whenever this requirement cannot be met.
  6. Application sequence:
    - a. Stage I, Table 02920-5: Load materials into water-filled tanks in proportion to tank size; agitate until smooth slurry is formed. Spray on seed bed at rates specified. Follow within two hours with Stage II.
    - b. Stage II, Table 02920-6: Mulch area within two hours after completing Stage I. Use straw mulch for slopes up to 2:1. Use mulch blanket for slopes greater than 2:1. Do not use wood-cellulose fiber.

### 3.05 MULCHING:

- A. General:

1. Mulch according to the following slope limitations, except as limited for crownvetch and lespedeza.
  2. Mulch within two hours after seeding as follows:
  3. Immediately replace displaced mulching.
- B. Slopes up to 3:1:
1. Wood-cellulose fiber:
    - a. Apply at a net dry weight 1,500 pounds per acre.
    - b. Apply hydraulically with seed and fertilizer at rate of 50 pounds per 100 gallons of water.
  2. Straw:
    - a. Methods of application:
      - 1) Hand spreading: 4,000 pounds per acre (100 pounds per 1,000 square feet). Cover areas uniformly to depth of not less than two inches of loose material.
      - 2) Blowing: Use of cutters is permitted in blowing equipment if at least 95-percent of mulch is six inches or more in length. For cut mulches applied by blowing method, achieve uniform distribution and loose in-place depth of not less than two inches.
      - 3) Mulch-binder application:
        - a) Synthetic binder: Apply according to manufacturer's instructions.
        - b) Biodegradable netting: Apply according to manufacturer's instructions.
- C. Slopes 2:1 to 3:1: Straw as specified above.
- D. Slopes over 2:1: Mulch blanket, applied and stapled according to manufacturer's instructions.

### 3.06 SODDING:

- A. Sod Bed Preparation: After placing topsoil, proceed as follows:
1. pH adjustment: Adjust soil pH by applying limestone or approved acidifying agent, or elemental sulfur at per-acre rate recommended by approved soil test report so as to obtain a 6.5 pH. Mix into soil to a depth of four inches minimum.
  2. Fertilizing: After pH adjustment, apply fertilizer at per-acre rate recommended by approved soil test report. Mix into soil to a depth of four inches minimum.
  3. Compact topsoil with lawn roller or tractor roller to three inches of final compacted thickness as approved.
- B. Laying Sod:
1. Lay sod between September 15 and June 1, grown from seed varieties identical to grass seed mixture in Table 02920-3, or sod which is Blue-Tag certified.
  2. Extend or reduce specified period as approved and as required by weather and soil conditions.
  3. When soil surface is hot or dry, wet soil to a depth of two inches, six to eight hours before sodding. Do not accept or lay dried sod.
  4. Place sod by hand with butted joints and no overlapping. When Beck Roll of sod is used, lay also in accordance with the supplier's instructions.
  5. Lay first row of sod in straight line. Place subsequent rows parallel to and tightly against each other. Stagger perpendicular joints to promote more uniform growth and strength. Do not stretch sod. On slopes, lay sod parallel to contour of slope.
  6. Peg sod placed on slopes 2:1 or greater. Peg each strip or section of sod with at least two stakes not more than two feet apart. Drive stakes flush with top of sod so that roots are in contact with topsoil.

7. Water sod immediately to prevent excessive drying during progress of work. Sod which dries out will be rejected.
8. Roll entire area as sodding is completed in each section so that sod is without surface irregularities, such as depressions and high spots.
9. Irrigate immediately after rolling, enough to wet underside of sod and one inch of soil immediately below.

### **3.07 MAINTENANCE AND REPLACEMENT:**

- A. Maintenance: Maintain seeding, sodding and incidental work during seeding and sodding and thereafter for a period of 120 days for work performed in the spring and for 90 days of subsequent growing weather for work performed in the fall. Perform the following and other operations of care appropriate for promotion of healthy growth, so that work is in an approved condition throughout maintenance period; uniform in color, quality and coverage; and free of weeds, insects, diseases, surface damage and other imperfections:
  1. Watering:
    - a. First week: Perform watering daily to keep soil and sod pads continuously moist, maintaining moist topsoil to a depth of at least four inches. Water prior to heat of the day as necessary to prevent wilting or as approved.
    - b. Subsequent weeks: Water seeded and sodded areas to maintain moisture in upper four inches of soil for promotion of deep root growth.
  2. Mowing: Mow only when seed or sod has firmly rooted, is securely in place and has grown to height of six inches. Mow to height of three inches at first cutting. Thereafter, do not remove more than 1/3 of grass leaf at any cutting. Maintain Kentucky Bluegrass between height of two and 2-1/2 inches and tall fescue at height of three inches, unless otherwise directed.
  3. Edging: Edge walks during alternate mowings.
  4. Rolling: Roll to maintain uniform surface.
  5. Applying herbicides: Apply in spray form. Do not apply when temperature exceeds 80F or during periods of drought. Have workers wear personal protective equipment appropriate for the submitted MSDS.
  6. Clean-up: Remove rubbish and debris caused by this work. Keep site clean during maintenance period.
- B. Replacing Seeding and Sodding: During maintenance period and until Final Acceptance, replace seeded and sodded areas that are dead, unhealthy, unsightly or badly impaired. Replace as soon as possible during the specified planting seasons. Make such replacements in the same manner as required for original seeding and sodding.

### **3.08 SUBSTANTIAL COMPLETION INSPECTION (SCI):**

- A. Substantial Completion Inspection will be held by the Engineer after completion of seeding and sodding to verify that the work was performed as defined in the Contract Documents.
- B. The Contractor will not be held responsible or liable for damage by animals, by malicious or careless human agencies over which the Contractor has no control, by fire or storm, or by vehicular accidents by others that occur after the Substantial Completion Inspection.

### **3.09 FINAL ACCEPTANCE:**

- A. Request inspection for final acceptance at least 10 days before end of maintenance period.
- B. Replace rejected seeded and sodded areas as specified so that repair or replacement plantings are rooted and established prior to final acceptance.

- C. Final acceptance of crownvetch or lespedeza areas requires a minimum of nine vigorous, healthy seedlings evenly distributed per each square yard after 12 weeks of growing weather following germination.

<b>TABLE 02920-1: MATERIALS SUBMITTAL CHART</b> This chart indicates minimum length of time required for the approval process before intended use and by which submittals must be made, as well as the minimum quantity for each sample. Useable samples will be returned.			
ITEM	TIME	QUANTITY	COMMENT
SEED	40 days	10 pounds or 5 kilograms  5 pounds or 3 kilograms	If seed is purchased as a mixture.  Per component prior to blending if Contractor blends mixture.
INOCULANT	7 days	1 packet	Keep temperature of inoculant below 70F (21C).
SOD	7 days	--	Notification of source.
FERTILIZER	14 days	50 pounds (25 kilograms)	Provide sample of each type of fertilizer used. Unopened container.
LIMESTONE	14 days	50 pounds (25 kilograms)	As specified. Unopened container.
MULCH	7 days	10 pounds (5 kilograms)  1 unbroken bale  1 square yard (1 square meter)	Wood-cellulose fiber mulch.  Straw mulch.  Mulch blanket including staples.
MULCH BINDER	14 days	1 quart (1 liter)  1 square yard (1 square meter)	Synthetic binder.  Biodegradable netting including staples.
TOPSOIL	28 days	25 pounds (15 kilograms)	--
HERBICIDE	7 days	1 quart (1 liter)	Unopened container. Include MSDS
OTHER MATERIAL	7 days	As directed and as approved	--

<b>TABLE 02920-2: GRASS SEED FOR SEED MIXTURES</b>			
<b>SPECIES</b>	<b>MINIMUM GUARANTEED PURITY</b>	<b>MAXIMUM WEED SEED AND OTHER CROP</b>	<b>MINIMUM GUARANTEED GERMINATION</b>
Certified Turf-Type Tall Fescue Festuca elatior arundinacea (Cultivars from current Agronomy Mimeo #77)	98 percent	0.2 percent	85 percent
Certified Kentucky Bluegrass Poa pratensis	95 percent	0.2 percent	85 percent

<b>TABLE 02920-3: GRASS SEED MIXTURES</b>
<b>For areas with slopes up to 2:1, unless otherwise shown.</b>
Seed Mixture:  90-percent Tall Fescue (Maryland Green-label certified cultivars from current Agronomy Mimeo #77)  10-percent Kentucky Bluegrass (Maryland Yellow-label certified cultivars from current Agronomy Mimeo #77)

<b>TABLE 02920-4: CROWNVETCH SEED MIXTURE.</b>				
<b>For areas with slopes 2:1 or greater, unless otherwise shown.</b>				
<b>SPECIES</b>	<b>PROPORTION BY WEIGHT</b>	<b>MINIMUM GUARANTEED PURITY</b>	<b>MAXIMUM WEED SEED &amp; OTHER CROP</b>	<b>MINIMUM GUARANTEED GERMINATION</b>
Certified Penngift Crownvetch Coronilla varia	40 percent	99 percent	0.25 percent	70 percent
Certified Pennfine or Manhattan or Citation Perennial Ryegrass Lolium perenne	60 percent	98 percent	0.25 percent	90 percent
Loehmans Weeping				

**TABLE 02920-5: LESPEDEZA SEED MIXTURE**

**For areas with slopes 2:1 or greater, unless otherwise shown.**

<b>SPECIES</b>	<b>PROPORTION BY WEIGHT</b>	<b>MINIMUM GUARANTEED PURITY</b>	<b>MAXIMUM WEED SEED &amp; OTHER CROP</b>	<b>MINIMUM GUARANTEED GERMINATION</b>
Certified Lespedeza Certified Appalow	44 percent	99 percent	0.25 percent	70 percent
Nurse Grass:  *Certified Tall Fescue per Maryland Green- label certified cultivars from current Agronomy Mimeo #77	56 percent	98 percent	0.20 percent	85 percent

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<b>TABLE 02920-6: MATERIALS FOR HYDROSEEDING CROWNVELTCH AND LESPEDEZA STAGE I</b>		
<b>MATERIAL</b>	<b>PER ACRE</b>	<b>PER 1,000 SQUARE FEET</b>
Limestone	**2 ton minimum	**100 pounds
3-25-25 fertilizer or 0-20-20 fertilizer or *10-22-22 fertilizer	600 pounds 800 pounds *1,075 pounds	15 pounds 20 pounds *25 pounds
Blue Chip Nitroform, granular, 38-0-0	200 pounds	4.5 pounds
Nurse Grass:  Certified Pennfine, Citation, or Manhattan Perennial Ryegrass Seed or *Certified Tall Fescue per Table 02920-5	60 pounds  *50 pounds	1.5 pounds  *1.25 pounds
Target Crop:  Blue Tag Certified Penngift Crownvetch Seed or *Certified Appalow Sericea Lespedeza	40 pounds  *40 pounds	1 pound  *1 pound
Bacterial crownvetch or lespedeza inoculant in 5-pound-size packets	Five times manufacturer's recommended rate	Five times manufacturer's recommended rate
Wood-Cellulose Fiber	435 pounds (dry weight)	10 pounds
Mulch Binder (synthetic type)	20 pounds	0.5 pounds

\* Lespedeza requirements only.

\*\*Superseded recommendation of approved soil test report

<b>TABLE 02920-7: MATERIALS FOR HYDROSEEDING CROWN VETCH AND LESPEDEZA STAGE II</b>		
<b>MATERIAL</b>	<b>PER ACRE</b>	<b>PER 1,000 SQUARE FEET</b>
Straw	4,000 pounds	100 pounds
Mulch Blanket and Staples	Use according to manufacturer's instructions	Use according to manufacturer's instructions

**END OF SECTION**

## SECTION 02930

### LANDSCAPING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing and maintaining landscape plantings, edge plantings and related accessories. It also specifies existing tree pruning and removal requirements.
- B. Related Work Specified Elsewhere:
  - 1. Site grading: Section 02320.
  - 2. Seeding and sodding: Section 02920.
  - 3. Removal and restoration of existing landscaping: Section 02205.
  - 4. Reforestation: Section 02933.
- C. Definitions:
  - 1. Landscape Plantings (Outside Reforestation areas and in Median strips): Designed planting of trees and shrubs within lawn or established areas, as shown. Landscape plantings are indicated on the Drawings with a square symbol as shown on the key in the Drawings.
  - 2. Edge Plantings: Planting of trees and shrubs along edge of reforestation areas, as shown. Edge plantings are indicated on the Drawings with a triangular symbol as shown on the key in the Drawings.
  - 3. Reforestation: Planting of trees and shrubs within designated reforestation areas. These reforestation areas are outside the limits of existing woodlands and wetlands and of landscape and mow areas, as shown. Reforestation planting areas are indicated on the Drawings with small circles as shown on the key in the Drawings.
  - 4. Plants or Plant Material: Vegetation, including trees, shrubs, ground cover, vines, and seasonal flowers.
  - 5. Size: The factor controlled by dimensions representing caliper, height or spread. For standard quality a dimension is given for caliper, height or spread, whichever is a typical characteristic of the plant. For specimen quality, all dimensions may be specified.
  - 6. Condition: The factor controlled by vitality and ability to survive and thrive and be comparable with normal plants of the same species and variety in the vicinity, at the same season of the year, free from physical damage or adverse condition that would prevent thriving, whether dormant or growing.
  - 7. Foliage line: Maximum dimension measured from ground to lowest part of body of plant.
  - 8. Quality: Structure and form as evidenced by density and number of canes and branches, compactness, symmetry and general development, without consideration of size or condition.
    - a. Standard: The least acceptable quality, good average uniform growth, absence of irregularities, typical characteristics of the species and variety, nursery-grown, well-formed, and uniformly branched, sound, healthy, vigorous and free of disease and insects, and having healthy, well-developed root systems, and having the minimum number of canes specified or conforming to minimum quality index. Plant materials below specified standard will be considered unacceptable culls and are not acceptable.

- b. Specimen: An exceptionally heavy, symmetrical, tightly knit plant, trained or favored in its development and appearance so as to be An unquestionably and outstandingly superior in form, of the designated species or cultivar number of branches, compactness and symmetry.
- 9. Spread: Single dimension that represents the minimum acceptable width. Where range is shown between two spread dimensions, the lesser is the minimum acceptable.
- 10. Root Protection Zone (Area): The root protection area is an area equal to a radius of 1.5 feet for each inch of diameter at breast height (dbh) (i.e.; a 10-inch dbh tree will require protection 15 feet from the main trunk in every direction.
- 11. Diameter at Breast Height (DBH): The DBH is the trunk diameter measured at a point 4.5 feet (Maryland State Standard) above the average ground level. If the trunk divides into several smaller trunks at a point lower than 4.5 feet (Maryland State Standard) from the ground, the tree size is the diameter measured at the highest point on the single trunk.
  - a. If a tree falls between sizes as listed in the bid schedule, the tree is placed in the next larger size. For example, a 17-1/2 inch diameter tree is placed in the 18-inch to 23-inch size.
- 12. Tracing: Careful cutting of bark along the line of sap flow to encourage wound closure and to smoothly outline the wound area.
- 13. Girdling Roots: Surface roots whose circular growth around the base of a tree trunk or around other roots applies pressure to the bark thereby restricting the sap flow.
- 14. Stumps: Stumps include the base of the trunk and visible surface roots attached to the trunk no more than three feet high, measured from the average ground level. Stump size is the diameter of the cut wood surface as measured across the narrowest portion.
- 15. B&B: Balled and burlapped.
- 16. NIC: Not in Contract.
- 17. Other Terms: The following in accordance with ANSI Z60.1:
  - a. Height.
  - b. Cane.
  - c. Caliper: Determine caliper measurement by taking the average of two trunk caliper measurements at right angles six inches above the root crown.
  - d. Height of branching.

## 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications: Keep always available at the work site a copy of each of the cited references.
  - 1. Codes and regulations of jurisdictional authorities, including but not limited to NPS, MNCPPC and MDNR.
    - a. Wherever specific reference is made to NPS, MNCPPC and MDNR, it applies to work performed on or affecting the property governed by these agencies.
  - 2. ANSI: Z60.1 (American Standard for Nursery Stock), Z133.1 (Safety Requirements for Pruning, Trimming, Repairing, Maintaining and Removing Trees and Cutting Brush).
  - 3. Bailey's Standard Cyclopedia of Horticulture.
  - 4. American Joint Committee on Horticultural Nomenclature (AJCHN): Standardized Plant Names.
  - 5. Hortus III.
  - 6. USDA-SCS.
  - 7. FS: O-F-241.
  - 8. ASTM: A36, A48, A53, A153, A307, A501, C51, D448, D2729, F593.
- B. Source Quality Control:

1. Verification of availability: Before bidding, verify sources of supply of the plants on the plant schedule, including requirements for size, species, variety and quality shown and specified.
  2. Furnish plant materials certified by state or federal Department of Agriculture to be free from disease or infestation.
  3. Obtain plants climatized to the Project area. Acclimate plants for a minimum of 3 months. Supply plants only from nurseries within U.S.D.A. Plant Hardiness Zone 6 or 7, and not more than 500 miles from the Project site.
  4. Pre-select and tag at the nursery the large plants of quality and number indicated, prior to inspection by the Engineer.
  5. Inspection of plant material:
    - a. Inspection: Have plant material inspected and trees seal-tagged by the Engineer at the nurseries prior to digging. Have representative samples of shrubs and miscellaneous plants sealed.
      - 1) To be approved, remaining plants are to be equal to sealed samples. Obtain approval of plants after delivery and before planting.
      - 2) Inspection and approval of plants at the nursery or at delivery is for quality, size and variety only and will not abolish or abrogate the right of rejection for failure to meet other requirements discovered during the progress of the work.
    - b. Travel expenses: In the bid price, include related Authority-incurred expenses for the Engineer's travel. Allow sufficient time for travel advance to be processed, minimum 2-weeks.
      - 1) Appropriate expenses include the costs associated with meals, lodging and transportation; i.e., airfare, auto rental, parking, tolls, and privately owned vehicles at the rate per mile currently in effect under Federal Travel Regulations. Daily lodging and meal expenses may not exceed the per diem limits allowed under the provisions of the Federal Travel Regulations in effect at the time the expenses are incurred. Air travel is limited to regularly scheduled airline flights, coach class, whenever possible
      - 2) In these costs allow for maximum 8-hour work days, including suitable inspection time and round-trip travel time.
      - 3) No costs are borne by the Contractor for Authority-furnished labor.
    - c. The NPS and MNCPPC, as applicable to the planting location, have the right to inspect, select and tag plants before delivery to the job site. If this inspection is made, it will be at the nursery at no additional cost to the Contractor.
  6. Inspection of topsoil.
    - a. Make arrangements with the Engineer for inspection at the source. Furnish travel expenses as specified for Inspection of Plant Material.
    - b. Obtain representative topsoil samples for submittal as specified in Section 02920.
    - c. Contractor is liable and responsible for any deleterious soil material brought on site, and subsequent pollution abatement clean-up.
- C. Personnel Qualifications:
1. Superintendent: Use a Landscaping Superintendent with previous knowledge and verifiable experience in supervising landscaping work and grounds maintenance of similar size and scope. Have the Superintendent present whenever work is being performed and have the Superintendent responsible for controlling the quality of work and inspecting completed work to ensure that Contract requirements are met. The Superintendent is the primary contact person with the Engineer regarding landscaping work.

2. Arborist: Perform tree pruning and removal work under the direction and general supervision of an Arborist certified by the International Society of Arboriculture, PO Box 908, Urbana, IL 61801, telephone 217/328-2032; or by a Maryland-licensed Tree Expert; who has verifiable experience and technical competence in tree physiology, identification, diagnosis of disorders, and current tree care and safety practices in accordance with accepted industry standards. The Arborist is responsible for controlling the quality of pruning and removal work and for inspecting such completed work.
  3. Tree Crew Supervisor: Have tree pruning and removal work performed under the full-time supervision of an experienced Tree Crew Supervisor to accompany each tree crew while work is being performed. Ensure that the Tree Crew Supervisor has verifiable work experience as a full time direct supervisor of shade tree pruning and climbing work crews.
  4. Workers: Have the work performed only by experienced workers, who through related training and verifiable previous on-the-job experience, are familiar with the technical aspects of landscape planting, grounds maintenance, with the hazards of tree pruning and removal work, and with equipment used for each of these operations as applicable. Have each worker abide by the code of ethics or professional conduct established by the Landscape Contractors Association MD-DC-VA, the National Arborist Association and the International Society of Arboriculture.
- D. Pre-Planting Conference: Hold a pre-planting conference prior to planting landscaped areas.
1. Set a time, date, and location agreeable to the Engineer and personnel of the Contractor, and jurisdictional agency, including but not limited to, NPS and MNCPPC, who are responsible for the contractual obligations of these parties. Participation of these parties at this conference is mandatory prior to beginning planting.
  2. Have discussion topics include, but not limited to, confirmation of exact plant substitutions previously accepted by the Engineer.
  3. Make notations on plans to document direction received from the jurisdictional agency, including but not limited to, NPS and MNCPPC, and send record copies to attendees.
  4. After conference, notify the Engineer 48 hours prior to beginning landscape planting work. Notify MDNR through the Engineer.

### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Location list: Within 10 calendar days after receipt of NTP, submit a complete list of locations of plant material subject to inspection. Should plant material be exhausted from these sources, the Contractor is responsible to locate elsewhere, at no additional cost to the Authority.
  2. Request for Substitutions: Submit requests for plant material substitutions, if necessary, within 10 days of NTP.
    - a. If a substitute is to be used on and jurisdictional agency, including but not limited to, NPS property, it requires approval by the Engineer and the NPS, or applicable agency.
    - b. The Engineer will approve substitutions only after thorough evaluation has been made concerning the need for such a change based upon the unavailability of plant material specified. If size changes are made, the Engineer will require equal total caliper inches for trees as bid, or if limited by space, extra numbers of plants equitable to unit cost bid price; at no additional cost to the Authority.
  3. Work routes and details: Submit plans of entire project site clearly marked to show proposed work routes of crews and equipment, turning radii, and locations of

temporary protective markers, barriers and storage areas, coordinated with details of methods to distribute concentrated loads so as not to compact soil unacceptably (above 75% maximum density). Do not route through zones designated for planting.

- B. Samples: Samples of each required type of material specified in Table 02930-1. Samples failing to meet specified requirements are unacceptable. Resubmit new samples of satisfactory material until approved.
- C. Certifications:
  - 1. Complete, certified reports attesting that proposed materials comply with specified requirements. Furnish certificates of inspection of plant materials by state or federal agency prior to delivery.
    - a. Topsoil: As specified in Section 02920.
    - b. Antidesiccant: Submit certificate from the antidesiccant manufacturer as evidence that the antidesiccant material can be safely used on both deciduous and evergreen plants. Mandatory use, if any plants installed outside the specified planting period.
  - 2. Copies of each license and certificate necessary for complying with Federal, State, and municipal laws, codes, and regulations prior to delivery.
- D. Documentation:
  - 1. Personnel qualifications: A list of the qualifications and experience of the workers, and qualifications and experience of the Landscaping Superintendent, Arborist and Tree Crew Supervisor, as attested by knowledge and experience in supervising contracts of similar size and scope in the past.
  - 2. Soil Density Tests: Submit soil proctor tests made by a qualified independent soil-testing agency, acceptable to the Engineer, stating soil density. Perform tests where directed by the Engineer. Compaction by rolling or operating heavy equipment is not permitted within planting locations. Maximum density of subgrade in planting locations is 75 percent. Disc or rototill bottom of plant beds to remove hard pan that may exist and remove rocks and debris off site, at no extra cost to the Authority.
    - a. Before beginning work: Furnish one pre-construction soil proctor test to 24-inch depth for each 100 square feet of approved work routes and storage areas.
    - b. After completing work: Furnish one post-construction soil proctor test to 24-inch depth for each 100 square feet of approved work routes and storage areas.
    - c. Perform additional soil proctor tests if correcting soil density is required.
  - 3. Topsoil pH Tests: Submit soil pH tests made by a qualified independent soil-testing agency, acceptable to the Engineer, stating soil pH. Report suitability of pH for growth of target crop in each area. State recommended quantities of soil amendments to be added to produce a satisfactory Ph.
    - a. Furnish one test for each 500 square feet of each planting area, and not less than one test for each area.
    - b. After adjusting pH, furnish one test for each 300 square feet of each pH-adjusted areas, and not less than one test for each area.
    - c. Confirming orders: Within 10 calendar days after receipt of NTP, submit confirming orders from the nursery for plant material.
  - 4. Packing slips: Certified plant materials packing slips with each delivery.
  - 5. Reports: Furnish copies of the following reports to the Engineer either on a daily or weekly basis as requested.
    - a. Daily Work Log: Maintain a daily work log recording the quantities of trees and shrubs installed, and their locations.
    - b. Maintenance Reports:
      - 1) Prepare monthly reports describing the work of the previous month and work scheduled for the following month.

- 2) At the end of maintenance period, submit maintenance schedules and instructions for future maintenance.
6. Equipment list: A list of the equipment anticipated for use, including the make and model, year manufactured, tag number if applicable, and date of last inspection. If requested by the Engineer, submit a list of the equipment to be used for each delivery order. Have the listed equipment on the job site when necessary during the execution of the delivery order.

#### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Delivery:
  1. Notify the Engineer at least 48 hours before each delivery. Describe in writing the method of shipment and include an itemized list of quantity and sizes. Do not deliver plants until the areas for planting are prepared as required, and approved by the Engineer.
  2. With each delivery, include certified packing slip for the shipment listing types and sizes of plants, types of materials, and quantities of each shipped. Inspect received materials against packing slip promptly upon arrival at the job site.
  3. Deliver materials and products to the job site in their original unopened containers or wrappings, clearly labeled with the manufacturer's name and address, material components, trademark, chemical analysis, species, age and source. Materials and supplies are subject to inspection and sampling for testing.
  4. Allow no agronomic materials or supplies on site other than those for the project.
  5. Protect plants from weather and adequately pack them to provide protection against climate and breakage during transit. When shipment is made by open vehicle, tie and cover plant materials to prevent wind-shipping and dehydration. When shipment is made by closed vehicle, carefully pack and adequately ventilate plants to prevent condensation on or overheating of plants during transit.
  6. Spray evergreen and deciduous plants in leaf with an anti-transpirant in accordance with manufacturer's instruction to protect from drying.
  7. Protect roots of bare-root plants with approved nursery packing. Keep damp during delivery and storage. If planting is delayed, heel-in plants in topsoil or wet straw and keep moist.
  8. Do not expose fertilizer to weather until used. Completely protect fertilizer before use and do not store in direct contact with the ground.
- B. Plant Identification Labels: Mark plants with identification before delivery to the site. Make labels durable and legible stating the correct botanical name and size/caliper in weather-resistant ink or embossed letters. Securely attach labels to each plant in a manner that will not restrict growth. Maintain labels until they are removed by the Contractor at final acceptance or when directed otherwise by the Engineer.
- C. Move plants marked B&B on plant list with root systems as intact solid units and with root balls of earth firmly wrapped.
- D. Exercise care during every handling operation so as to prevent damage to bark, branches, roots and stem, and to preclude cracked root balls. Use platforms under balls whenever hoisting plants. Do not use plants with cracked, broken or loosely wrapped root balls. Handle plants only by root balls. Plants handled by tops will be rejected. Protect plant roots, root balls and tops from sun or drying winds until planted.
- E. Do not stack root balls. This will mean that for a 40-foot flat bed trailer, the number of 1.75-inch to 2-inch B&B plants may not exceed 130.
- F. Do not handle soil in a frozen or muddy condition.

## 1.05 JOB CONDITIONS:

- A. Conduct planting operations only under favorable seasonal conditions throughout the period of the Contract as determined by the Engineer. Install no plants during adverse weather or during periods when soil conditions are unfavorable as determined by the Engineer. Do not plant when ground is frozen.
- B. Daily Work Log: Coordinate daily work log with work performed, recording numbers of plants planted and their locations.
  - 1. To indicate progress, attach color-coded survey tape in the planting areas, with a different color tape per month and marked with the date of installation in weather-resistant ink, keyed to the Plant Schedule shown.
  - 2. Securely attach tape to each plant in a manner that will not restrict growth. Maintain tape on plants until removal is directed by the Engineer.
- C. Protection: During progress of operations, protect walls, walks, curbs, benches, lawn areas, plant material, and other site improvements by adequate means acceptable to the Engineer.
  - 1. Existing Vegetation: Preserve and protect existing vegetation such as trees, shrubs, and grass on or adjacent to the site which do not reasonably interfere with the construction. Box and protect trees and shrubs that may be subject to construction activities within the root protection area with chain link or wood fencing as directed by the Engineer.
  - 2. Weight Restrictions: Do not overload entrance paving, sidewalks and curbs. These areas are limited to a maximum load of 1,250 pounds per square foot.
  - 3. Existing Utilities and Structures: The existence and location of underground utilities on the plans are not guaranteed. Investigate and verify locations in the field before starting work. The Contractor will be held responsible for damages to, and for maintenance and protection of existing utilities and structures.
    - a. Obtain copies of available as-built utility drawings from the Engineer for reference.
    - b. Contact the local utility companies concerned to inform them of excavation plans.
    - c. To locate utilities in the field, contact Miss Utility at 800/257-7777, 48 hours in advance of work.
    - d. Perform excavation in vicinity of existing structures and utilities with great care.
  - 4. Pollution: Take necessary and adequate measures to prevent soil erosion, air pollution and water pollution by the materials and equipment used during construction.
  - 5. Repairs: If damage by the Contractor should occur, it is the Contractor's responsibility to repair or replace per the Engineer's direction, as acceptable to concerned parties, and at no additional cost to the Authority. Perform work so that damaged areas make smooth, satisfactory, and imperceptible transitions to existing adjacent work. Use materials and methods conforming to current standards for the area damaged, matching adjacent materials in appearance, and meeting approval of jurisdictional authorities and the Engineer.
    - a. Replace damaged existing turf areas with approved sod per Section 02920.
- D. Root Protection Zone (Area): Do not permit heavy equipment or vehicles or the stockpiling of materials in the root protection area without advance permission of the Engineer. Where such activity is allowed within the root protection area, provide an ample mitigation plan to prevent the possibility of damage to the tree trunk and roots, or to increase soil compaction.
  - 1. If the Engineer approves construction activities within the root protection area, protect tree trunks and shrubs with chain link fence or wooden fencing as directed, cover the entire root protection area with landscape fabric and weed barrier as approved, and mulch with four inches of mulch prior to construction. Placing metal

- plates, tree pruning, fertilization, aeration and irrigation may also be required as directed by the Engineer.
2. If damage by the Contractor should occur, it is the Contractor's responsibility to repair or replace per the Engineer's direction, as acceptable to the applicable regional jurisdictions, including, but not limited to NPS, MNCPPC, and at no additional cost to the Authority.
  3. For pruning or removal of existing trees, obtain approval by the NPS or the MNCPPC, as applicable, through the Engineer. Tree pruning and removal, except as shown, is NIC. and at no additional cost to the Authority.
- E. If, at any time, the Engineer determines that work is unsatisfactory or being conducted in an unsafe manner, immediately cease such work activities upon notification.

#### **1.06 SCHEDULING AND COORDINATION:**

- A. General:
1. Perform planting operations according to Contractor's detailed and updated plan of the work as approved by the Engineer.
  2. Schedule and arrange work so as not to interfere with normal activities of the applicable regional jurisdictions including, but not limited to NPS and MNCPPC land and adjacent properties. Advance notice will be given to the Contractor if a conflict is expected. Remove plant debris, personnel and equipment that could interfere with an activity or event prior to the activity.
- B. Planting Seasons: The times of year in which planting is permitted is limited by the planting seasons for plant types as stipulated by the appropriate regional jurisdictional agency. Authority planting seasons are as follows. These time periods also include the time required, after initial planting, for staking, pruning and mulching operations.
1. Evergreen material:
    - a. Fall planting: September 15 through November 30.
    - b. Spring planting: March 1 through May 15.
  2. Deciduous material:
    - a. Planting period: October 15 through April 30.
    - b. White and Willow Oaks, Ironwood, dogwoods and other species as specifically directed, may be planted in spring only: March 1 through April 30.
  3. Subject to the Engineer's approval, extend or reduce planting season as required by weather and soil conditions. Preparations for planting may begin earlier than the specified seasons if weather permits and if the staking of plant locations has been approved.

#### **1.07 WARRANTY:**

- A. Six months in addition to the requirements of the General Provisions for a total of 18 months, commencing the day the landscaping is accepted.
- B. Contractor has the responsibility for plant material locations that may be considered by the Contractor to be affected by adverse conditions, such as undesirable soil pH, water table factors, or poor drainage. Contractor also has responsibility during and following adverse weather conditions such as periods of excessive precipitation, extreme temperatures, wind and drought.
- C. As specified in Part 3, Concurrent Maintenance and Warranty Period, seasonally replace dead plants and plants that have died back beyond normal pruning lines as determined by the Engineer and at no additional cost to the Authority.

## PART 2 - PRODUCTS

### 2.01 MATERIALS:

#### A. Plants and Plant Materials:

1. Provide plants meeting the requirements of the plant schedule as shown, identified by botanical and common names and in accordance with applicable standards of quality, size, condition and type listed.
2. Supply only plants free from disease, well-branched, in full foliage when in leaf and with healthy normal root systems. Have plants freshly dug, nursery-grown, and meeting the other specified requirements. Cold storage plants are unacceptable.
3. Plants in marked cans, pots, or other containers on the plant schedule are to have been grown in the containers for a minimum of three months and a maximum of two years. Ensure that plant roots filling the containers show no evidence of being or having been root-bound.
4. B&B plants: Use B&B plants that meet the Recommended Balling and Burlapping Specifications of ANSI Z60.1. Specifically: freshly dug by hand or with a mechanical tree digger in good condition, free of hydraulic leaks, with blades aligned and free of damage; roots wrapped firmly with untreated burlap, and bound carefully with untreated sisal or jute twine, cord or ungalvanized wire mesh; in a manner so as not to damage the bark, break branches, or destroy the natural shape.
5. Root ball: Dig trees so that the root crown is at the top of the root ball. Make diameter and depth of root balls sufficient to encompass fibrous and feeding root systems.
6. Provide genus, species and cultivar names which agree with the nomenclature of the most current edition of Hortus III by L.H. Bailey, Hortorium, Cornell University.

#### B. Topsoil:

1. Weathered surface soils or natural friable loam obtained from approved sources, free of subsoil, hard fragments and stones larger than one-half inch across greatest dimension, objectionable salts, noxious weeds and plants, debris and other materials inferior to surface soils or that would be toxic or harmful to growth; containing not less than 1.5-percent organic matter as determined by the Walkley-Black Method; capable of sustaining normal, healthy growth and development of seed and sod scheduled and specified.
2. Grading analysis:
  - a. All material must pass through a two-inch screen. Remove all material larger than two inches from the site.

SIEVE	MINIMUM PERCENT PASSING
2 inches	100
½ inch	90
¼ inch	80
No. 10	70

3. Test and analysis of proposed topsoil material: Performed by local state agricultural experiment station or agricultural laboratory recommended by U.S. Department of Agriculture and meeting the following requirements:
  - a. Soil pH range: Between pH 5.0 and pH 7.6 inclusive.
  - b. Soil salinity by electrical-conductivity measurement: 500-ppm soluble salt maximum.

- c. Soil fertility: Rated high in natural nutrients in pounds-per-acre based on the standard soil test in laboratory.
  - d. Soil texture: Classification consisting of 5 to 25-percent clay, 20 to 60-percent sand, and 15 to 45-percent silt as determined by hydrometer or pipette method. Sand, silt and clay as defined by USDA-SCS.
- C. Fertilizer:
  - 1. Commercial fertilizer: FS O-F-241, Type I, of grade noted, Level B, composite and bearing manufacturer's guaranteed statement of analysis. Unless otherwise shown or specified, use 10-10-10 , slow-release, meeting the following minimum requirements:
    - a. Nitrogen content: Ten percent; slow-release, 50-percent organic.
    - b. Available phosphoric acid: Ten percent.
    - c. Potash content: Ten percent.
  - 2. Soluble fertilizer: Standard commercial grade, 15-30-15 or higher analysis, Rapid-Gro or equal.
  - 3. Packet tree and shrub fertilizer, minimum two-year time release: Root-Contact Packet, Sando Products, Inc., Prairie du Chien, Wisconsin 53821; Eeesy Grow, Specialty Fertilizer, Inc., Suffern, New York, 10901; 21 Gram, Planting Tablets, 200-10-5 Agriform International Chemicals, Inc.; or equal.
- D. Stable manure: Well-rotted cow manure. Free from fresh manure, sawdust, wood chips, tanbark, long straw, stones, chemicals used to hasten decomposition artificially, or other substances injurious to plants.
- E. Perlite: Granules, sterile, uniform gradation, insoluble, high water-holding capacity; as available from Pennsylvania Perlite Corporation, Lehigh Valley, Pennsylvania 18001 or equal.
- F. Mulch:
  - 1. Mulch blanket: Knitted construction of bio-degradable yarn with uniform openings, Hold-Gro as manufactured by Gulf States Paper Corporation, Tuscaloosa, Alabama 35401 or equal.
    - a. 150-foot lengths or greater.
    - b. U-shaped staples: As supplied by mulch-blanket manufacturer.
  - 2. Shredded hardwood or shredded pine bark: Sound, non-decomposed bark free from sticks, stones, clay and other foreign and toxic substances, with 50 percent over the minimum size indicated.
    - a. Regular size: 1/2-inch to two inches.
    - b. Extra-Coarse size: One inch to three inches.
    - c. Sources: Cove Dehydrated Products, Martinsburg, Pennsylvania 16662; Weyerhaeuser Garden Bark, Weyerhaeuser Company, Silva Products Department, Takoma, Washington 98401; or equal.
- G. Crushed Stone: ASTM D448, Size 57.
- H. Pea Gravel: Smooth, rounded pieces of gravel, clean and free from objectional materials, such as soft particles, coal and lignite particles, or friable particles, graded from 1/4 to 3/8 inch in size.
- I. Sand: Sharp, common, coarse, wet sand as approved, for use under plants.
- J. Peat Moss: Type 1 sphagnum peat moss (at least 75-percent), finely divided, with a pH of 3.1 to 5.0, moistened prior to and at time of use.
- K. Perforated Plastic Pipe: ASTM D2729.

- L. Landscape Fabric and Weed Barrier: Porous geotextile fabric for water and nutrient exchange; tear-resistant, minimum four ounces per square yard; Typar Landscape Fabric, DeWitt Earthmat, Pro 5, or equal.
- M. Limestone: Agricultural or dolomitic, ASTM C51, capable of neutralizing soil acidity and containing not less than 85 percent of total carbonates. Containers or sacks labeled to show chemical and mechanical analysis.
- N. Plant Hormone: Vitamin powder; Transplantone, American Chemical Paint Co., Ambler, Pennsylvania 19002; Super Thrive, Vitamins Institute, 5409 Satsuma Avenue, North Hollywood, California 91601; or equal.
- O. Antidesiccant for Retarding Excessive Loss of Plant Moisture and Inhibiting Wilt: Sprayable, water-insoluble vinyl-vinylidene complex which will produce a moisture-retarding barrier not removable by rain or snow. Capable of forming a film at temperature commonly encountered out-of-doors during planting season and with the moisture-vapor transmission rate of the resultant film not more than 10 grams per 24 hours at 70-percent humidity; Wilt-Pruf, as manufactured by Wilt-Pruf Nursery Specialty Products, Inc., Greenwich, Connecticut 06830; Vapor Gard as manufactured by Miller Chemical Company, Hanover, Pennsylvania 17331; or equal.
- P. Tree Stakes and Guys:
1. Stakes: Sound No. 2 Douglas fir or rough sawn straight-grain oak of uniform size.
    - a. Type 1: Two-inch square or 2-1/2 inches in diameter, eight feet long, with six-inch point at one end. Paint with two heavy brush coats of dark walnut oil stain before installation. After installation, cut off stakes square to a level two inches above the wires.
    - b. Type 2: Two-inch square by 30 inches long and notched to bold wires.
  2. Metal stakes: Steel angle, zinc-coated, ASTM A153, 1/4-inch thickness, 1-3/4 inches by 1-3/4 inches by 30 inches long.
  3. Pipe: ASTM A53, hot-dip galvanized, 1-1/4 inch OD eight feet long.
  4. Wood flags: 1/2 inch by two inches by ten inches, painted white.
  5. Turnbuckles: Galvanized, ASTM A153, three-inch minimum adjustment and 5/16-inch minimum diameter threaded opening fitted with screw eyes.
  6. Wires: Zinc-coated steel, No. 12 wire.
  7. Wire guards: Sound, two-ply, 5/8-inch inside diameter, round hose of fabric and rubber, black or green color.
  8. Ring bolts: 1/4-inch by three-inch tie-wire anchor HILTI HKT 14, HILTI Fastening Systems, Langley Park, Maryland 20783; or equal.
- Q. Wrapping Material:
1. Tree wrap: Two thicknesses of crinkled paper cemented together with bitumen, waterproof, four inches wide; as manufactured by Bemis Bag Company, Chase Bag Company, Sisakraft or equal. Use as directed by Engineer or required by jurisdiction, always applicable for plants subject to sun scald.
  2. Twine: Lightly tarred medium or coarse sisal yarn.
- R. Watering Pipe: As shown.
- S. Marker Stakes: Sound No. 2 Douglas fir, or equivalent grades of rough sawn straight-grain oak, rough sawn cypress, hard pine, cedar, or locust; straight, of uniform size, 3/4-inch x 2-inch x 18 inches, pointed at one end.
- T. Tree Grates, Tree Grate Frames and Tree Guards:

1. Round tree grates: As shown, or with five-foot diameter, radial pattern, and expandable, as approved.
  2. Square tree grates: As shown.
  3. Guards: As shown.
  4. Cast iron: ASTM A48.
  5. Steel angles, plates and collars: ASTM A36.
  6. Steel tubing: ASTM A501.
  7. Bolts and washers: ASTM A307, zinc-coated.
  8. Screws: Stainless steel, ASTM F593, Alloy S30400.
  9. Tubing and collars: Shop-painted in accordance with Section 05500; finished as shown.
  10. Steel bars: ASTM A36.
- U. Hedge Guards: PVC-coated chain link fencing and accessories as specified in Section 02820, and as shown; consisting posts, fabric, tension wire and ties.
- V. Water: Potable.
- W. Composted screened leaf mold:
1. Processed leaves aerobically composted, free from litter such as glass, paper, plastic and other foreign substances, as approved.
  2. Source: Leaf-Gro as available from Maryland Environmental Services, 2020 Industrial Drive, Annapolis, Maryland 21401 (301) 261-8596, or equal. Do not use composted sewage sludge.

## **2.02 PLANTING MIXTURES:**

- A. Planting Mixture A:
1. Use: For backfilling plant pits of deciduous and evergreen trees, shrubs, excluding azaleas:
  2. Mixture: Four parts topsoil and one part leaf mold or decomposed cow manure plus five pounds of 10-10-10 fertilizer per cubic yard, mixed on site to an approved consistency.
- B. Planting Mixture B:
1. For backfilling plant pits of deciduous and evergreen groundcover and vines and all azaleas:
  2. Mixture: Four parts topsoil, one part leaf mold and one part perlite plus five pounds of 10-10-10 slow-release fertilizer per cubic yard, all mixed on site to an approved consistency.

## **2.03 EQUIPMENT:**

- A. Use only equipment that meets federal OSHA, state and local safety requirements and that is properly licensed. This includes but is not limited to equipment such as bucket trucks, aerial lifts, chipper trucks, wood trucks and stump grinders, which may be needed to correctly perform landscaping, maintenance, and tree pruning and removal in accordance with the requirements.
- B. Have the name or logo of the Contractor or subcontractor clearly displayed on trucks used on the job.
- C. Use equipment of sizes that clear access routes, protective markers and barriers by 2 feet or more on each side.
- D. Do not use material storage devices or equipment that could increase compaction of existing, undisturbed soils.

## **PART 3 - EXECUTION**

### **3.01 PREPARATION FOR PLANTING:**

- A. See Article above on Scheduling and Coordination.
- B. Pre-Planting Conference: See Article above, under Quality Assurance.
- C. Locate and mark location of each underground utility.
- D. Mark outlines on the ground for locations of individual trenches and planting beds as approved. Have the Engineer approve marked locations before excavating.
  - 1. Drive marker stakes with at least eight inches projecting above surrounding ground cover.
  - 2. Paint top four inches of each stake according to the following color schedule and mark stakes with plant common name and sizes for each location:
    - a. Evergreens: Blue.
    - b. Deciduous trees: Red.
    - c. Flowering trees: Yellow.
- E. Do not permit personnel, vehicles, or equipment not directly associated with the work into the planting areas.
- F. Inspect Plants: Do not plant if plants appear damaged, unhealthy, insect infested, or if the root ball is cracked or broken either before or during planting operation.

### **3.05 PRESERVATION OF EXISTING PLANTS:**

- A. Preserve and protect existing plants in accordance with the existing Plant Schedule as shown and with the requirements of Section 02205.

### **3.02 EXCAVATION FOR PLANTING:**

- A. Exercise care during entire time of excavation and planting work so as to prevent contact with, disturbance of or unearthing of utilities and devices. Hand excavate wherever necessary to ensure this level of care.
- B. Exercise care in excavating tree pits at locations with existing drainage systems so as to prevent contact with, disturbance of or unearthing of drainage systems. Hand excavate wherever necessary to ensure this level of care. Place landscape fabric as shown. Staple per manufacturer's directions.
- C. Plant Locations: Locate plants as shown on the Contract Drawings, from dimensions shown, and as approved by the Engineer after locations are marked per the Preparation for Planting requirements specified above.
- D. Excavate pits, trenches, and beds with vertical sides and flat bottoms, to dimensions shown.
- E. Excavate pits to a minimum depth of 24 inches, measured from finished grades, or as shown.
- F. Make pits for bare-root plants to diameters at least 12 inches larger than the maximum spread of the roots and to minimum depth of at least 12 inches below the roots of the plant as placed.

- G. Make pits for balled or potted plants, with ball or container less than 12 inches in diameter, to diameters at least 16 inches larger and depth to size of ball or container. Alleviate hardpan compaction by rototilling or discing sub-soil beneath plant.
- H. Make pits for balled or potted plants, with ball or container 12 inches or greater in diameter, to diameters at least 24 inches larger and minimum depth to size of ball or container.
- I. Install trench drain for trees on slopes greater than 3:1 in locations as shown. Excavate four to six inches wide. Start bottom of trench at elevation of bottom of plant ball and extend away on low side of plant location until daylighted. Fill bottom twelve inches of trench with pea gravel. Backfill to surface with excavated material from trench. Blend surplus over area next to trench. Cover surface with material to match the surrounding area.
- J. Make beds for ground cover plants to the length and width shown with minimum depth of six inches. Install landscape fabric beneath mulch layer, stapling per manufacturer's directions.
- K. Backfill plant pits that are abandoned due to unsuitable conditions with same excavated material, grade and seed.
- L. Before the close of each working day, barricade open pits. When pits are excavated more than fourteen days in advance of planting, backfill the excavations with the planting mixture specified.
- M. Remove and dispose of rocks, debris and excess excavated material off site. Set aside excavated soil needed for backfill mix and to form saucers.

### **3.03 PLANTING:**

- A. Set plants plumb and straight with allowance for settlement. Set watering pipe as shown.
- B. Place balled plants so that the top of the root ball bears the same relation to finish grade as it bore to previous finish grade in nursery, or 1/8 higher than depth of root ball= approximately two inches higher. Place fertilizer packets or tablets in accordance with manufacturer's recommendations alongside the base of root ball. Backfill with specified planting mixture in 12-inch layers and tamp each layer to fill voids until planting mixture is at grade. Cut and remove burlap and lacing six inches away from trunk, or as approved. Leave remainder of burlap and lacing intact. Soak plant with water containing plant hormone.
- C. Open and remove containers from potted plants. If the growing medium is comprised of 75 percent or more of peat, perlite, sand or like material other than soil, pull visible roots away from container medium leaving the roots partially exposed. Place plants in plant pit or trench and carefully place backfill planting mixture among exposed roots. Continue backfilling and tamping in six-inch layers until finish grade is reached. Soak with water containing plant hormone.
- D. Remove and store existing tree grates and replace when planting is complete.
- E. Placement of bare-root plants: Place in pit or trench, cut off broken or frayed roots, spread root system, backfill with planting mixture in six-inch layers, settle to finish grade with water containing plant hormone.
- F. Create saucer around isolated plants with soil to retain water unless otherwise shown. Bring beds to smooth, even surfaces which will conform to established grade after full settlement has occurred. Plant shrubs as a bed, using weed barrier fabric beneath mulch when shrubs are spaced less than six foot on center (6' O.C.), unless otherwise detailed.

- G. Place specified planting mixture in groundcover bed at six-inch depth or as otherwise shown in contract drawing detail , place landscape weed barrier and then top with a layer of mulch to depth of three inches after compaction.
- H. Remove groundcover plants from pots with root system intact and set in mulched planting beds, cut through weed barrier, in the spacing and arrangement shown. Work soil firmly around each plant and restore the mulching material. Settle to finish grade with water containing plant hormone. On slopes greater than 2:1, after preparing planting beds and mulching, but prior to planting, apply mulch blanket as directed and staple according to manufacturer's instructions.
- I. When pits are dug in wet areas or where subsoil will not permit drainage as shown, set plant higher than normal using extra depth of crushed stone or sand, up to 12 inches total depth, to keep ball from settling. Set top of plant root ball up to six inches higher than grade, as directed. Blend the immediate area outside the saucer with suitable soil to meet existing grade.
- J. Topsoil or approved fine, dry subsoil excavated or augered from plant pits may be used to form saucers. If plant pits are augered, break down side of the hole to permit root penetration.
- K. Create soil berm around downhill portion of planting pits on slopes.
- L. Cultivating: Cultivate trenches and shrub beds to the line shown. Cultivate area around isolated plants at least six inches beyond diameter of pit.
- M. Mulching: After planting and cultivating are completed, spread a layer of mulch on finished grade around plants to a depth of three inches after compaction. Lay landscape fabric beneath shrubbery beds, groundcover areas, and in tree pits, stapling as necessary per manufacturer's directions. Spread mulch around isolated plants over an area at least six inches greater than diameter of the pit and extend mulch over berm saucers as shown. Completely cover trenches and shrubbery beds with mulch. In planters and beds, spread a layer of mulch to depth of three inches after compaction.
- N. Pruning: Prune plant material after installation as approved to thin branches and foliage and yet retain species shape and trim hedges as shown. Do not cut leaders.
1. Remove limbs, branches, canes and runners which require trimming with a clean cut flush with trunk or adjacent stem.
  2. When pruning lateral branches, cut at the same angle as that at which the buds are growing from the branches. Cut at a distance of 1/8-inch to 1/4-inch beyond the buds to avoid injuring them.
  3. Sterilize cutting tools with alcohol before proceeding to next plant after pruning out infected twigs and branches.
- O. Planting in Planters: Install crushed stone, landscape fabric and weed barrier, planting mixture and mulch as shown. Mound planting mix as shown for positive drainage. Do not work soil when frozen.
- P. Flower Beds: Plant flowers as shown, at planting seasons recommended by regional jurisdictions and/or growers.
- Q. Wrapping: Check with Engineer for necessity. For plants prone to sun scald use immediately after planting, spirally wrap trunk and main branches of trees with an overlay of two inches starting at the bottom. Tie wrap securely in place with twine.

- R. Guying: Within three days after planting, guy each tree four-inch caliper or larger as shown. Protect trees at points of contact by use of wire guards. After installation, cut stakes square to a level two inches above the wires.
- S. Staking: Support trees smaller than four-inch caliper within three days after planting by staking at perimeter line of ball as specified and to sufficient depth to hold tree rigid. Drive stakes vertically to achieve uniform height of five feet-six inches above finish grade or as directed. Do not twist or pull. Wire tree with wire guards interlocked to each stake at four inches above finish grade, or as directed.
  - 1. Planting areas: Three stakes, 120-degrees apart.
  - 2. Trees with grates: Four stakes, 90-degrees apart.
- T. Installation of Hedge Guard: Space hedge guard posts at a maximum of eight feet on centers. On curves with radii less than 100 feet, space hedge guard posts at a maximum of four feet on centers. Drive posts plumb to a height of three feet-six inches; protect end of pipe. Install one-cubic foot of concrete around base of end post in each run to serve as pull anchor. Secure fabric to posts with ties spaced 12 inches on centers. Install tension wire two inches below top of fabric. Install permanent caps on posts.
- U. Removal of Seals and Tags: As approved.

### **3.04 EXISTING TREE PRUNING AND REMOVAL:**

- A. Safety:
  - 1. Conduct operations in accordance with national and local fire and safety codes, laws, rules, regulations and ANSI Z133.1 Safety Requirements for Pruning, Trimming, Repairing, Maintaining and Removing Trees and Cutting Brush.
  - 2. Have employees wear reflective, bright orange vests while conducting operations in or adjacent to roadways.
  - 3. Do not permit any one except the operator within six feet of a power saw.
  - 4. Block off the work area to pedestrians, other workers and vehicles.
  - 5. Look for, note and report to the Engineer in writing the presence of the slightest structural weakness, disease conditions, decayed trunk or branches, split crotches or branches, or other hazardous condition that has potential for damage to property or personal injury.
- B. Tree Pruning:
  - 1. Prune and thin trees when in foliage according to the Pruning Standards for Shade Trees (revised 1988) by the National Arborist Association. The classes of pruning are as follows:
    - a. Class I Fine Pruning: Fine pruning consists of removing dead, dying, diseased, interfering, objectionable, obstructing and weak branches, as well as selective thinning to lessen wind resistance. Removal of such branches includes those on the main trunks as well as those within the leaf area. An occasional branch as described above up to ½-inch in diameter may remain within the main leaf area where it is not practical to remove.
    - b. Class II Medium Pruning: Medium pruning consists of removing dead, dying, diseased, interfering, objectionable and weak branches on the main trunk as well as those within the leaf area. An occasional branch up to one inch in diameter may remain within the main leaf area where it is not practical to remove.
    - c. Class III Coarse Pruning: Coarse pruning consists of removing dead, diseased, or obviously weak branches, two inches in diameter or greater.
    - d. Class IV Cutting Back or Drop Crotch Pruning: Cutting back or drop crotch pruning consists of reducing tops, sides, underbranches or individual limbs.

- 1) Undertake this practice only in cases of utility line interference, or where certain portions of the roots or root systems have been severely damaged, or when there is unusual and rapid tree growth, where it is necessary to reduce the top, sides or underbranches, or for specific topiary training or dwarfing.
  - 2) When cutting back, do not reduce more than 1/3 of the total area as a single operation. When cutting back trees, only drop crotch as much as necessary. Make every effort to cut back to a lateral, one-third of the diameter of the cut being made.
  - 3) In reducing overall size, give attention to the symmetrical appearance. Keep top higher and sides reduced in order to maintain a tree-like form.
  - 4) Contact the Engineer prior to pruning a tree specified as Class I or Class II pruning if said pruning will reduce the surface area of the tree by more than 25 percent. Report tree structural problems.
2. Cut back dead, diseased and dying wood into healthy wood.
  3. On trees known to be diseased, disinfect tools after use on each tree with methyl alcohol at 70 percent (denatured wood alcohol diluted appropriately with water) or Chlorox bleach solution.
  4. Remove weak crotches, defined as split or rotted wood between two trunks of limbs that may break and fall during high wind.
  5. Where branches cross and rub together or are forming a V-crotch, remove one branch without ruining the appearance of the tree.
  6. Selectively prune trees which are developing more than one dominant leader in order to promote a single dominant leader by sub-dominating the other competitive branches. Make selection of the dominant leader with consideration of the tree's natural form, health, and structure.
  7. Inspect old injuries. Where appropriate, trace those not closing properly and where callus growth is not already completely established.
  8. Remove girdling roots.
  9. Trimming for clearance:
    - a. Trim trees to provide three feet of clearance from adjacent buildings and structures.
    - b. For street trees and trees over walks, trails, and picnic areas over six inches diameter at breast height (dbh), remove lateral limbs and water sprouts from the main trunk of the tree to a height of 12 feet above the ground. For trees over 10 inches dbh, remove lateral limbs and water sprouts from the main trunk of the tree to a height of fourteen feet above the ground.
    - c. Prune trees in the vicinity of electrical or phone lines so as to provide six to eight feet of clearance between lines and the nearest limb.
  10. Remove branches with a slanting cut starting just above a vigorous bud or shoot and running back across the limb at a 45 degree angle. Make cuts sufficiently close to the trunk or parent limb, without cutting into the branch collar or leaving a protruding stub, so that closure can readily start under normal conditions. Make clean cuts.
  11. Precut branches that are too heavy to handle to prevent splitting or peeling the bark. Where damage to other trees, foliage or property is possible, lower branches safely to the ground by ropes or equipment. Under no circumstances drop branches or main trunks freely onto a road, shoulder or paved surface.
  12. Trim salvageable branches by removing smaller branches flush with the surface of the main branch.
  13. Do not remove entire or large portions of healthy, sound limbs in order to facilitate the removal of dead or dying terminals.
  14. Complete required pruning and removals at the site of each tree, including removal of logs and debris, before initiating work on the next tree.
  15. Do not use chain saws or circular power blades to remove branches less than two inches in diameter.

16. Do not use wounding paint,
17. Do not use climbing hooks while pruning.

C. Tree and Stump Removal:

1. Take every reasonable precaution, including but not limited to topping, sectioning and lifting of trees, diagnosing soundness of existing wood, and planning escape routes for workers to prevent damage to other vegetation, property, utility lines and persons and to prevent gouging and erosion of soils as a result of removal operations.
2. Fell trees only when there is an adequate felling area at least equal in radius to the height of the tree. Top and remove in sections trees that cannot be felled due to proximity of buildings, conductors, adjacent trees, or lack of an adequate felling area.
3. Properly rope, guy, or anchor trees to be felled that may cause damage to property or existing vegetation.
4. Climbing hooks may be worn for tree removal work.
5. Remove stumps to a depth of 12 inches below grade. Backfill and level the stump hole with clean wood-waste material.
6. Completely remove each tree, including removal of logs and debris, before initiating work on the next tree.

D. Debris removal:

1. Cut branches over six inches into 18 to 24 inch lengths.
2. Chip material less than six inches in diameter.
3. Collect, deliver, and unload wood and chips to a location specified by the Engineer. If approved, chips may be blown into adjacent natural areas.
4. Remove wood, debris and chips on a daily basis. Sale of wood is not permitted on the project site.

**3.05 INTERIM MAINTENANCE (UNTIL SCI):**

- A. While planting is in progress, perform interim maintenance and management practices on work completed. During the post-planting period and until the SCI, properly care for plants furnished; performing watering, cultivating, and other maintenance tasks necessary to keep the plants in a live, healthy condition.
- B. Maintain plants and work incidental thereto by performing the following and other operations of care to promote root growth and plant health so that plants are in an approved condition throughout the interim maintenance period. Perform work in a manner which maintains the original intent of the reforestation and landscape design. Submit maintenance reports and schedules as specified.
1. Watering and draining: Water plants as required twice each month, or more frequently if weather conditions require such, as directed.
  2. Weeding: Weed by hand the mulched area around each plant and within bedded areas, at least twice each month during the growing season. Remove weeds from the site immediately. As directed, approved chemical weed killers may be used with precautions to prevent undesired damage resulting from such use. Submit Herbicide spill plan and daily use log, when required by jurisdictional agency.
  3. Pruning: Prune plants to ensure a desired growth habit and to remove dead wood, as directed and approved.
  4. Mulching: Mulch to maintain the depth as indicated or as directed.
  5. Securing stakes: Replace or adjust as necessary to maintain stability.

- C. Periodically inspect plants during the interim maintenance period and notify the Engineer in writing of suspected problems. The Contractor is responsible for insect and disease control on Authority property. Take necessary measures to ensure effectiveness of the treatment and plant survival. Insect and disease control are the responsibility of the NPS and MNCPPC, unless brought in by Contractor's plant source.

**3.06 SOIL DENSITY ADJUSTMENT:**

- A. After completion of work and before Substantial Completion Inspection (SCI), have the soil-proctor testing along work routes and storage areas performed as required above under Submittals, Documentation.
- B. Adjust unacceptably compacted soil to a maximum of 75 percent maximum dry density in accordance with the Engineer's directions and at no additional cost to the Authority. In root protection zone, use of decompaction machinery is unacceptable.

**3.07 SUBSTANTIAL COMPLETION INSPECTION (SCI):**

- A. A Substantial Completion Inspection will be held by the Engineer after completion of planting to verify that the work was performed as defined in the Contract Documents.
- B. Do not remove tags, labels, etc. after SCI. These are needed during Concurrent Maintenance and Warranty period. Remove such identifications only at final acceptance.
- C. SCI commences the Concurrent Maintenance and Warranty Period of the Contract for items accepted as of this inspection.

**3.08 CONCURRENT MAINTENANCE AND WARRANTY PERIOD:**

- A. See warranty requirements in General Provisions, General Requirements, and specified in Part 1 of this section.
- B. After the Engineer has accepted the completed work in accordance with SCI, perform post-planting maintenance and plant management concurrent with the warranty period. During this period, properly care for plants; performing the following and other beneficial operations of care for promotion of root growth and plant life so that each plant is in an approved condition at the Substantial Completion Inspection and throughout the maintenance period:
  - 1. Watering and draining: Water plants as required twice each month. Every two weeks during the growing season, examine or sound the watering pipe at each plant to determine if too much water is collecting in the plant pit. Remove surplus water by pump or syphon without staining the pavement. Bi-weekly check relative moisture content of soil for typical tree and typical area of shrub or hedge planting; weekly during the months of July and August. Use Peerless Moisture Indicator, Tree-Type; or equal; following manufacturer's recommendations. Provide sufficient water to maintain relative moisture content of 25 to 30 percent. Provide water, fittings, hose, and water tanks as required to perform watering operation.
  - 2. Weeding: As necessary, perform seasonal weeding in the mulched area around each plant and in bedded areas, at least twice each month. Pull roots by hand or use approved chemical weed killers. Submit Herbicide spill plan and daily use log, when required by jurisdictional agency. Correct any damage resulting from such use and do not spray when winds are over. Remove weeds from the site.

3. Controlling insects and diseases: Treat plants year-round with an approved chemical spray or systemic chemical as necessary to prevent insects, disease and fungus. Take necessary measures to ensure effectiveness of the treatment and plant survival. Submit Pesticide spill plan and daily use log, when required by jurisdictional agency. Protect vehicles and construction in the vicinity from damage or staining.
  4. Pruning: Prune plants during each growing season to develop a desired growth habit and to remove dead wood.
  5. Fertilizing: Fertilize trees, shrubs, hedge plants and groundcover once between May 15 and July 1 with 15-30-15 soluble fertilizer, or equal, at the manufacturer's recommended rate.
  6. Edging: At least twice during the growing season, edge around the mulched area of each plant.
  7. Mulching: Mulch to maintain the depth as shown.
  8. Wrapping: Rewrap to maintain protection and a neat appearance. Remove wrapping at end of first winter period after planting as approved. Repair damaged areas previously covered by wrapping.
  9. Securing guys and stakes: Replace or adjust to maintain stabilization. Before end of maintenance period, remove stakes and guys above grade.
- C. Removing and Replacing Plants: After early Spring and early Fall seasonal inspections and written notification by the Engineer of the plant material to be removed and replaced, proceed as follows:
1. Remove or cut off at ground line said plant materials that are dead or in an unhealthy, unsightly or badly impaired condition, within three weeks after notification.
  2. Replace the plant materials during the next specified planting season with healthy plants of the same kinds and sizes as originally specified. Make such replacements in the same manner as specified for the original planting. Notify the Engineer prior to performing the work.
  3. Attach color-coded tag indicating replacement, and mark with the date of replacement in weather-resistant ink, keyed to the Plant Schedule shown. Securely attach tag to each plant in a manner that will not restrict growth. Maintain tag on plants until removal is directed by the Engineer.
  4. Failure to notify Contractor of plant material to be removed or replaced does not relieve the Contractor from warranty obligations.
- D. The Contractor will not be held responsible or liable for damage by animals, by malicious or careless human agencies over which the Contractor has no control, by fire or storm, or by vehicular accidents by others that occur after the Substantial Completion Inspection.
- E. Clean-Up: Leave paved surfaces broom clean and stain free. Remove rubbish and debris caused by this work. Keep site clean during maintenance period.

### **3.09 FINAL ACCEPTANCE:**

- A. Prior to final acceptance, perform final cleanup, including removal of stakes above grade, guys, signs and other items as directed by the Engineer, and for remulching plants and beds to a loose measurement as specified. Place no mulch against a trunk or stem.
- B. Cut off watering pipe projecting above the mulch level.
- C. Replace rejected plants as specified.
- D. Submit maintenance reports and schedules as specified.

- E. Request inspection for final acceptance at least 10 days before the end of the Concurrent Maintenance and Warranty Period.

**PART 4 - MEASUREMENT AND PAYMENT**

**4.01 BASIS:**

- A. Compensation for work specified in this section will be made in the following manner for work done satisfactorily based upon the lump sum price for the work of this section:
1. Installation: 70-percent of lump sum price, pro-rated monthly during planting operations.
  2. Concurrent Maintenance and Warranty: 20-percent of lump sum price, pro-rated monthly or quarterly after planting operations.
  3. Final Acceptance: 10-percent of lump sum price, for satisfying Contract requirements pertaining to Final Acceptance.

<b>TABLE 02930-1: MATERIALS SUBMITTAL CHART</b>			
This chart indicates the minimum length of time required for the approval process before intended use and by which submittals must be made, as well as the minimum quantity for each sample. Useable samples will be returned.			
ITEM	TIME	QUANTITY	COMMENT
Fertilizer	14 days	50 pounds (25 kilograms)	Sample of each type to be used in unopened container.
Mulch	7 days	10 pounds (5 kilograms)	--
Crushed Stone	7 days	10 pounds (5 kilograms)	--
Sand	7 days	10 pounds (5 kilograms)	--
Plastic Pipe	7 days	3 feet (1 meter)	--
Mulch Blanket	7 days	1 square yard (1 square meter)	Include staples.
Pea Gravel	7 days	10 pounds (5 kilograms)	--

ITEM	TIME	QUANTITY	COMMENT
Plant Hormone	14 days	10 pounds (5 kilograms)	--
Antidessicant	7 days	1 pint (0.5 liter)	--
Tree Stakes and Guys	14 days	1 each	Sample of complete guying system to be used.
Wrapping Material	14 days	1 foot (30 centimeters)	Sample of complete wrapping system to be used.
Landscape Fabric and Weed Barrier	7 days	1 square yard (1 square meter)	--
Marker Stakes	7 days	1 each	--
Tree Grates and Guards	14 days	1 each	Sample of complete system to be used.
Perlite	14 days	10 pounds (5 kilograms)	--
Peat Moss	14 days	10 pounds (5 kilograms)	--
Limestone	14 days	50 pounds (25 kilograms)	Sample in unopened container.
Hedge Guard	14 days	6 feet (2 meters)	Sample of complete system to be used.

ITEM	TIME	QUANTITY	COMMENT
Topsoil	28 days	25 pounds (15 kilograms)	--
Screened Leaf Mold	14 days	50 pounds (25 kilograms)	Sample in unopened container
Herbicide	14 days		Supply MSDS and use directions
Other Material	--	--	As directed.

**END OF SECTION**

**DIVISION 3 - CONCRETE**

03100	CONCRETE FORMWORK
03200	CONCRETE REINFORCEMENT
03300	CAST-IN-PLACE STRUCTURAL CONCRETE
03331	CAST-IN-PLACE ARCHITECTURAL CONCRETE
03370	SHOTCRETE
03400	STRUCTURAL PRECAST CONCRETE
03415	PRESTRESSED CONCRETE
03450	PLANT - ARCHITECTURAL PRECAST CONCRETE

**END OF SECTION**

## SECTION 03100

### CONCRETE FORMWORK

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies formwork for concrete structures and other facilities.
- B. Related Work Specified Elsewhere:
  - 1. Concrete reinforcement: Section 03200.
  - 2. Cast-in-place structural concrete: Section 03300.
  - 3. Structural precast concrete: Section 03400.
  - 4. Prestressed concrete: Section 03415.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ACI: 347, Publication # 4
  - 3. Western Woods Producers Association : Western Lumber Grading Rules.
  - 4. CE: CRD-C 572.
  - 5. AASHTO: M153.
  - 6. ASTM: D1056, D1149, D1692.
  - 7. APA: HDO Plywood Exterior Grade.
  - 8. U.S. Product Standard : PS 1
- B. Responsibilities:
  - 1. Design and construction of formwork is the responsibility of the Contractor, subject to review by the Engineer.
- C. Design Criteria:
  - 1. Design formwork for vertical loads and lateral pressures in accordance with ACI 347.
  - 2. Design formwork system which is adequately braced and has adequate strength and stability to ensure finished concrete within the specified tolerances.
  - 3. When necessary to maintain the specified tolerances, design camber into the formwork to compensate for anticipated deflection and creep due to the weight and pressure of the fresh concrete, prestressing forces and construction loads.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Working Drawings:
    - a. Include details of form types, methods of form construction and erection, design computations and location of form joints and form ties, location and dimensions of blockouts and openings in structure, and embeds.
  - 2. Samples:
    - a. Each type of waterstop proposed for use, each one foot long: Two.
    - b. Each type of premolded expansion-joint filler proposed for use, each six inches by 12 inches: Two.
    - c. Proposed dovetail anchor slot, each twelve inches long: Two.
    - d. Snap-off form ties: Two.

3. Certification:
  - a. Manufacturer's certificates.
  - b. Certified test reports of specified concrete tests.
4. Documentation:
  - a. Calculations: Early form removal calculations as specified certified by a professional engineer registered in the area where the work is to be performed. Submit in advance for obtaining approval prior to form removal.

## PART 2 - PRODUCTS

### 2.01 MATERIALS:

- A. General:
  1. Wood forms:
    - a. All framing lumber stress-graded.
    - b. Lumber in direct contact with concrete, dressed on at least the contact side, with dressed or tongue-and-groove edges; other lumber may be dressed or rough.
    - c. Where vertical board finish is shown or specified, use the following:
      - 1) Form board: Tongue-and-groove, Number 1 Common or better, Ponderosa or White pine, in accordance with the Western Lumber Grading Rules book published by WWPA (not the Southern Pine Inspection Bureau grading rules), one-inch nominal thickness, four-inch nominal width, groove S2S milled or beveled one side only and center matched with 45-degree beveled edges to produce sharp V-shaped 3/8-inch wide in concrete. Four-inch tongue-and-groove boards to be toenailed at edge or face-nailed to backer board.
      - 2) Smooth concrete: Tongue-and-groove, square cut unturned edges, Number 1 Common or better, Ponderosa or White pine, in accordance with the Western Lumber Grading Rules book published by WWPA (not the Southern Pine Inspection Bureau grading rules), one-inch nominal thickness, four inches nominal width, S2S and center-matched.
  2. Plywood forms:
    - a. APA grade-marked:
      - 1) B-B Plyform Exterior grade Group I or II for unexposed finished concrete.
    - b. APA High-Density Overlay (HDO) plywood;
      - 1) B or better face veneer Exterior grade Group I for exposed to public view finished concrete..
    - c. USPS : PS 1
  3. Tubular fiber forms:
    - a. Spirally constructed of laminated plies of fiber.
    - b. Wall thickness as recommended by the manufacturer to meet load requirements of various uses and sizes.
    - c. Outside surface wax-coated for moisture resistance.
    - d. Inside surface of column forms coated with bond-breaker compound and fabricated so that finish concrete surfaces are smooth and free of spiral and seam marking.
  4. Fibrous-glass reinforced plastic forms:
    - a. One-piece dome system forms, fabricated of plastic reinforced with fibrous glass.
    - b. Molded under heat and pressure using matched metal dies.

- c. Special sizes and cross sections with thickness, reinforcement and surface finish as necessary to form concrete surfaces that are smooth and free of irregularities.
- 5. Steel forms:
  - a. One-piece dome system forms.
  - b. Special sizes and cross sections as shown, with metal gauges, reinforcement, stiffeners and surface finish as necessary to form concrete surfaces that are smooth and free of irregularities and concrete stain.
- 6. Hardboard:
  - a. For concrete not exposed to public view: tempered, smooth-one-side (S1S) panels not less than 3/16-inch thick, in accordance with AHA IS 1.
- 7. Form ties:
  - a. Factory-fabricated, snap-off metal type, of adequate design to minimize form deflection and preclude concrete spalling upon removal.
  - b. Fabricated so that set-back in concrete is such that portion of tie remaining after snap-off and removal of exterior portions is at least 1-1/2 inches below concrete surface.
- 8. Form release agent: Chemically reactive liquid product that will not bond with, stain, or impair concrete surfaces. Follow form panel manufacturers approved product and recommendations for application. Agents containing castor oil are prohibited
- 9. Preformed expansion joint filler: AASHTO M153.
  - a. Type I: Sponge rubber.
  - b. Type II: Cork. Type III: Self-expanding cork.
- 10. Waterstops: PVC, CE CRD-C 572.
- 11. Dovetail-anchor slots: 22-gauge electrogalvanized steel, with removable felt filler.
- 12. Chamfer strips: Except where other sizes are shown, 3/4-inch by 3/4-inch triangular fillets milled from clear, straight-grain pine, surfaced-each-side, or extruded-vinyl tape.
- 13. Miscellaneous preformed strips for reveals, rustications and similar joints: Fabricated of wood, metal, plastic or other approved material formed to cross sections shown.
- 14. Hydraulic-cylinder well casing: Assembly of pipe, coupling and bottom end cap, of thermosetting-polymer vinylester resin reinforced with fibrous glass, with integral waterstop and anchor flange at invert slab as shown and concrete contact area surfaced with alkaline-resistant barrier, with the following additional requirements:
  - a. Properties.
    - 1) Minimum density at 73F: 0.060 pound per cubic inch.
    - 2) Minimum tensile strength at 73F: 12,000 psi.
    - 3) Minimum compressive strength: 18,000 psi.
    - 4) Minimum flexural strength: 20,000 psi.
    - 5) Minimum flexural modulus of elasticity at 73F: 1,500,000 psi.
    - 6) Maximum fire-spread rate: 25.
    - 7) Maximum heat-distortion temperature at 264 psi: 215F.
    - 8) Maximum water absorption in 24 hours at 73F: 0.02 percent.
  - b. Wall thickness: As shown but not less than 3/8 inch.
  - c. Inside diameter: 20 inches.
  - d. Pipe furnished with fewest number of joints, watertight, developing full strength of section, made true and straight, with not more than 1/2-inch deviation from vertical for entire length of pipe.
- 15. Conduit: Schedule 40, black steel pipe, butt-welded as specified in Section 15205.
- 16. Premolded Elastic Filler for elevator hoistways:
  - a. Closed-cell neoprene:
    - 1) ASTM D1056, Grade SCE-45.
    - 2) Water absorption: No increase in weight in excess of two percent when tested in accordance with ASTM D1056 and completely immersed in water for 70 hours at room temperature.

- 3) Flame resistance: Self-extinguishing when tested in accordance with ASTM D1692.
  - 4) Resistance to ozone cracking: No cracking when tested in accordance with ASTM D1149, after exposure to 100-pphm ozone in air for 100 hours at 100F with specimens under 20-percent strain.
17. Bonding adhesive: As recommended by manufacturer of premolded elastic filler.

## **PART 3 - EXECUTION**

### **3.01 CONSTRUCTION AND WORKMANSHIP:**

- A. Concrete finishes and usage locations of various types of forms and form lining: As shown or specified.
- B. Unless otherwise shown for concrete surfaces exposed to public view, use HDO Plywood in largest practicable continuous panels to produce plane, smooth surface free from grain imprint, patchmarks, and discoloration.
- C. Construct adequately braced formwork so that resulting concrete surfaces conform to specified tolerances.
- D. Brace forms, falsework and centering adequately to retain forms in position as shown on approved working drawings.
- E. Provide mortar-tight forms of wood, plywood, fibrous-glass-reinforced plastic, steel or other approved materials which conform to shapes, lines and dimensions shown and produce smooth surface without fins and projections.
- F. Where shown or directed because of lagging or form irregularity, and where concrete surfaces will not be exposed to public view, line inner form surfaces with hardboard as follows:
  1. Use widest available width of hardboard.
  2. Line areas less than four feet wide with single-width piece of hardboard.
  3. Offset lining joints from those in backing.
  4. Fasten securely to backing with galvanized or aluminum nails driven flush.
- G. Forms shall be clean of any rust, molds, concrete scale..etc.

### **3.02 FIELD QUALITY CONTROL:**

- A. Allowable Tolerances:
  1. Construct elements except concrete linings of tunnels to meet allowable tolerances of dimensions, elevations and positions shown and specified in Section 03300.
  2. Prior to installation, test hydraulic cylinder well casing assembly hydrostatically at 60 psi pressure for two hours in the presence of the Engineer.

### **3.03 COATING FORMS:**

- A. Lightly coat form panels with chemically reactive release agent prior to initial concrete placement and before each subsequent placement.
- B. Do not allow excess coating material to stand in puddles in forms nor to come into contact with concrete against which fresh concrete is to be placed.

- C. Coat with release agent bolts and rods that are to be completely removed or to be free to move

**3.04 EMBEDDED ITEMS:**

- A. Ensure that items to be embedded in concrete are free from oil and foreign matter that would weaken bond of concrete to such items.
- B. Install in formwork inserts, anchors, sleeves and other items specified elsewhere. Close ends of conduits, piping and sleeves embedded in concrete with caps or plugs.
- C. Install continuous dovetail-anchor slots where shown.
- D. Complete tests on piping and other items before starting concrete placement.
- E. Before depositing concrete, check location and support of piping, electrical conduits and other items which are to be wholly or partially embedded.

**3.05 OPENINGS AND RECESSES IN CONCRETE:**

- A. Provide openings and recesses; place sleeves furnished by other trades.

**3.06 JOINTS:**

- A. Unless otherwise directed, make contraction, expansion and construction joints only where shown. Where concrete will be exposed to public view, use largest practicable size sheets to minimize joints.
- B. Form keyways as shown.
- C. Continue reinforcing steel and wire fabric across joints unless they are shown as being free to move.
- D. Make maximum distance between transverse contraction joints 50 feet or as shown, as measured along centerline of track on tangent alignment.
- E. Install premolded joint filler at locations shown. Extend filler from bottom of concrete up flush to finish concrete surface or hold down below finish surface as shown.
- F. Make splices in premolded filler in manner to preclude penetration of concrete between joint faces.
- G. Where premolded joint filler is held below finish concrete face, install in the form a water-soaked wood strip of dimensions shown, to form, after removal, proper size slot to receive sealant compound specified in Section 07900.

**3.07 WATERSTOPS:**

- A. Install waterstops in construction joints below grade and where shown. Use six-inch minimum width, except use nine-inch minimum width in tunnel structures, or as shown.
- B. Support and protect that portion of waterstop which extends beyond bulkhead, during placing of concrete and subsequent removal of forms.

- C. Position waterstops so as to clear reinforcement. Ensure that the waterstop does not get misaligned or misplaced during concreting.
- D. Make field splices by heat-sealing square cut ends of waterstop using hot metal plate or thermostatically controlled electric-heating iron designed for such purpose. Join ends when material becomes molten, maintaining continuity of ribs and bulbs; allow to cool before stressing.
- E. Make field splices to develop watertightness equal to that of unspliced material and tensile strength of not less than 50 percent of unspliced material. Have 90-degree splices and as many other splices as possible made in the factory.

**3.08 REMOVAL OF FORMS, FALSEWORK AND CENTERING:**

- A. Maintain forms, falsework and centering in place until the concrete has attained minimum percentage of specified design strength in accordance with Schedule 1:

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Structural Member	Minimum Percentage of Specified Design Strength	
	Schedule 1	Schedule 2
Footings; inverts; sides of beams; slabs and girders; slabs and beams on grade	25	20
Free-standing walls, columns and piers	40	30
Cut-and-cover box structure exterior walls; retaining walls	50	30
Cut-and-cover box structure roofs	80	40
Stairways	80	60
Soffits, beams, slabs and girders; clear span between supports,		
under 20 feet	80	60
over 20 feet	90	70
Tunnels, except intersecting sections	80	35
Station arches, except intersecting sections	80	40
Cantilevers	90	70

- B. Early removal of forms, falsework and centering will not be allowed for concrete strength values below Schedule 2, but will be allowed for concrete strength values between Schedule 1 and Schedule 2 only after:
1. The Engineer has approved calculations showing anticipated concrete strengths at time of proposed early removal based on:
    - a. Ratio of dead load over live load.
    - b. Span, height and shape.
    - c. Ratio of rise over span.
    - d. Reshoring.
    - e. Loads, resultant stresses and deformations to which concrete and reinforcing steel will be subjected at time of removal, subsequent to removal and until concrete has attained design strength.
    - f. Prevailing site conditions.
  2. Concrete strength attained prior to form removal has been determined by analysis of quality-assurance data in accordance with Section 03300.
- C. Do not remove wood board forms within 48 hours of pouring concrete.
- D. Do not alter loading conditions on concrete subsequent to removal of forms if it results in exceeding permissible stresses and deformations at attained concrete strengths.

- E. The Engineer may permit early removal of concrete support without submittal of calculations prior to attainment of specified design strength if he considers such submittals to be unnecessary.

**3.09 INSTALLATION OF HYDRAULIC-CYLINDER WELL CASINGS:**

- A. Cement bottom end cap to casing pipe with solvent cement prior to installation. Solvent cement, procedures, environmental requirements and instructions for proper cementing as recommended by pipe manufacturer.
- B. Accurately position, plumb and set as shown. Separate casing, including anchor flange, two inches minimum from reinforcing steel and other metallic material.
- C. Except as otherwise specified, perform excavation and backfill as specified in Section 02320. Do not jack or drive casing. Backfill excess excavation around exterior of casing with sand.
- D. Recheck casing for orientation and secure immediately prior to pouring of concrete slabs in which it is to be set.
- E. Deviation of alignment of centerline of casing not more than 1/2 inch from true vertical, end-to-end.

**END OF SECTION**

## SECTION 03200

### CONCRETE REINFORCEMENT

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies reinforcement for concrete structures and other facilities.
- B. Related Work Specified Elsewhere:
  - 1. Concrete formwork: Section 03100.
  - 2. Cast-in-place structural concrete: Section 03300.
  - 3. Structural precast concrete: Section 03400.
  - 4. Prestressed concrete: Section 03415.
  - 5. Asphalt or bitumen fill in concrete notches at copper bonding: Section 07125.
  - 6. Additional copper bonding work adjacent to traction power substations: Section 16060.
- C. Definitions:
  - 1. Cover: Thickness of concrete between outside surface of reinforcement and outside face of concrete.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ACI: SP-66, 318.
  - 3. CRSI: Manual of Standard Practice; Placing Reinforcing Bars.
  - 4. AASHTO: Standard Specifications for Highway Bridges.
  - 5. ASTM: A82, A185, A615, A775, A706.
- B. Allowable Tolerances:
  - 1. Cut and bend reinforcing steel to conform to dimensions shown within the following tolerances:
    - a. Sheared length: Plus-or-minus one inch.
    - b. Depth of truss bars: Plus zero or minus 1/2 inch.
    - c. Stirrups, ties and spirals: Plus-or-minus 1/2 inch.
    - d. All other bends: Plus-or-minus one inch.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Detail reinforcing in accordance with ACI SP-66.
    - b. Bar lists showing the individual weight of each bar, total weight of each bar size and total weight of bars on list. Base calculated weights on theoretical unit weights shown in ASTM A615, Table 1.
    - c. Details showing bonding of reinforcement for stray current and cathodic protection.
  - 2. Certification:
    - a. Manufacturer's certificates.
    - b. Mill tests on each heat showing chemical and physical analyses performed in accordance with ASTM A615, as modified by ACI 318.

- c. Record of mill tests traceable to individual reinforcement bars supplied to the project.

#### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Ship reinforcing steel in bundles limited to one size and length.
- B. Tag each bundle at mill with waterproof tag showing name of mill, heat number, grade and size of bars and identifying number.
- C. Protect reinforcing steel and wire fabric from damage; foreign matter such as dirt, oil and grease; and rust-causing conditions.

### **PART 2 - PRODUCTS**

#### **2.01 MATERIALS:**

- A. Reinforcing Steel Bars:
  - 1. ASTM A615, Grade 60, modified in accordance with ACI 318.
  - 2. ASTM A706, for all welding reinforcing bars, except for electrical bonding.
  - 3. Epoxy Coating: ASTM A775, as shown.
- B. Spiral Reinforcement: ASTM A82 or ASTM A615, Grade 60.
- C. Welded Steel-Wire Fabric: ASTM A185.
- D. Metal Accessories: As recommended by CRSI Manual of Standard Practice. Where concrete surfaces will be exposed to public view in finish structure, use supports with plastic-protected legs or stainless steel legs.

### **PART 3 - EXECUTION**

#### **3.01 CUTTING AND BENDING:**

- A. Perform cutting and bending in the shop. Bend steel cold. Do not bend or straighten bars so as to damage material.
- B. Do not bend bars in the field except to correct minor errors and damage occurring during shipping and handling.

#### **3.02 BAR SUPPORTS AND SPACERS:**

- A. Support bars by means of bolsters or chairs with no less than minimum required by ACI SP-66.
- B. Reinforcing steel in bottom of slabs resting on earth may be supported by concrete brick or mortar blocks.
- C. In walls, columns, piers and abutments hold reinforcing steel in position by means of mortar blocks, bar supports or spacers wired to reinforcing steel.
- D. Do not use stones, clay bricks, wood blocks or pieces of broken concrete to support reinforcing steel.
- E. Do not place bars or fabricated mats on layers of fresh concrete as work progresses.

### **3.03 PLACING AND FASTENING:**

- A. Arrange and place reinforcing steel as shown.
- B. Secure reinforcement positively against displacement during placing of concrete.
- C. Wire or clip bars together as recommended in CRSI Placing Reinforcing Bars.
- D. Maintain reinforcing steel accurately in locations shown in tops of inverts to permit arrangements of anchor bolts for rail-tie plates.
- E. Before placement, ensure that reinforcement is free from dirt, mill scale, rust scale, oil, grease and other foreign matter.

### **3.04 SPLICING:**

- A. Furnish reinforcing bars in full lengths as shown on the Contract Drawings and approved shop drawings.
- B. Do not splice bars unless approved in writing.
- C. Make splices when authorized, in accordance with ACI 318, except make all butt splices by welding with a capacity of not less than 125 percent of minimum yield strength of bar. Mechanical connections for tensile splice shall be by cadweld only. connections for t Cadweld only. However, mechanical connection for precast prestressed structures and parking garages, when the splice is located inside the precast member, may be made by NMB Splices instead of the Cadweld, with prior approval of the Authority.

### **3.05 ELECTRICAL BONDING:**

- A. Weld steel straps to transverse end reinforcing bars and longitudinal reinforcing bars adjacent to joints between pour sections at locations shown.
- B. No electrical bonding is required for epoxy coated rebars.
- C. Thermit weld or cadweld stranded, bare-copper conductors to adjacent steel strips at specified end locations. Likewise, weld copper conductors to lapped, welded-wire fabric at joints in slabs at locations shown.
- D. Additional copper bonding work adjacent to traction power substations: Section 16060.
- E. Asphalt or bitumen fill in concrete notches at copper bonding: Section 07125.

### **3.06 STUDS:**

- A. Install welded studs in track invert slabs on top of transverse bars 10 feet on center and on first transverse bar at each end of units. Expose tops of studs and set flush with top surface of slab.

### **3.07 INSPECTION:**

- A. Placement of concrete prior to approval of reinforcement and electrical bonding work is prohibited.

### 3.08 CONCRETE PROTECTION FOR REINFORCEMENT (COVER):

- A. Underground Box Section Structures:
  - 1. Invert slab:
    - a. Top steel: Two inches.
    - b. Bottom steel: Three inches.
  - 2. Roof slab:
    - a. Top steel: Two inches.
    - b. Bottom steel: 1-1/2 inches.
  - 3. Exterior walls:
    - a. Outer-face steel: Three inches.
    - b. Inner-face steel: 1-1/2 inches.
  - 4. Center walls: 1-1/2 inches.
  - 5. Beams, girders and columns: 1-1/2 inches.
  - 6. Intermediate floors, platform slabs and stairs: 3/4 inches.
- B. Retaining Walls:
  - 1. Footing:
    - a. Top steel: Two inches.
    - b. Bottom steel: Three inches.
  - 2. Wall:
    - a. Outer-face steel: Three inches.
    - b. Inner-face steel: Two inches.
- C. Other Underground Structures:
  - 1. Outer-face steel: Three inches.
  - 2. Inner-face steel: Two inches.
  - 3. Drainage slot: Two inches.
  - 4. Safety walk: 1-1/2 inches.
  - 5. Beams, girders and columns: 1-1/2 inches.
  - 6. Intermediate floors, platform and slabs and stairs: 3/4 inch.
- D. Above-Ground Structures:
  - 1. Prestressed concrete bearing highway or transit loads: In accordance with AASHTO Standard Specifications for Highway Bridges.
  - 2. Ancillary structures including precast prestressed structures: : ACI 318.

### 3.09 EPOXY COATING:

- A. Preparation of surface: Perform the following in order given:
  - 1. Clean surface contaminated with oil and grease using naphtha or xylol.
  - 2. Remove weld slag, rust and mill scale from surfaces by wire brushing.
  - 3. Coat surfaces immediately with methyl-methacrylate primer.
  - 4. Apply coating only to surfaces which are dry and free of contaminants.

**END OF SECTION**

## SECTION 03300

### CAST-IN-PLACE STRUCTURAL CONCRETE

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing portland-cement cast-in-place concrete.
- B. Related Work Specified Elsewhere:
  - 1. Concrete pavement: Section 02750.
  - 2. Curbs, gutters and walks: Section 02772.
  - 3. Chemical grout: Section 2415.
  - 4. Concrete formwork: Section 03100.
  - 5. Concrete reinforcement: Section 03200.
  - 6. Structural precast concrete: Section 03400.
  - 7. Prestressed concrete: Section 03415.
  - 8. Asphalt or bitumen fill: Section 07125.
  - 9. Copper bonding work: Section 16060.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ACI: 201.2R, 211.1, 304, 309, 318, 318.1.
  - 3. AASHTO: M182, T26.
  - 4. NBS: Handbook 44.
  - 5. USBR: Concrete Manual.
  - 6. FS: A-A-341A, HH-I-521, K-P-146.
  - 7. ASTM: A43, A47, A48, C31, C33, C39, C40, C42, C87, C88, C94, C131, C150, C171, C172, C260, C295, C309, C311, C330, C494, C535, C586, C595, C618, C665, C685, C881, C989, C1107, C1260, D98, E328.
  - 8. CPMB (Concrete Plant Manufacturer's Bureau): Concrete Plant Standards.
- B. Testing Laboratory:
  - 1. Furnish the services of an independent testing laboratory. Employment of an independent laboratory does not relieve the Contractor of the obligation to perform the work in accordance with requirements of the Specifications and Drawings. Submit certified results of the tests performed.
  - 2. Furnish proof that the laboratory satisfies the requirements of the American Council of Independent Laboratories' Recommended Requirements for Independent Laboratory Qualification. Laboratory need not be a member of the American Council of Independent Laboratories.
  - 3. Certify that testing equipment has been calibrated by an accredited calibration agency at not more than 12-month intervals using devices of accuracy traceable to the National Institute of Standards and Technology (NIST) or accepted values of material physical constants
- C. Properties of Concrete:
  - 1. General:
    - a. Design mixes to produce concrete of proper workability, durability, strength, maximum density, minimum shrinkage and permeability.
    - b. Design mixes to have minimum water content per cubic yard of concrete, cement content corresponding to appropriate water-cement ratio, largest

- permissible maximum size specified of coarse aggregate available and optimum percentage of fine aggregate.
- c. Use maximum size of coarse aggregate in accordance with ACI 211.1.
  - d. Use same brand from same source throughout the work.
  - e. Use aggregates from same source throughout the work.
  - f. Use ground-iron blast-furnace slag and fly ash from the same sources respectively throughout the work.
2. Durability:
- a. Maximum water cementitious materials ratio as per ACI 318, Chapter 4 and ACI 201.2R.
  - b. Use a suitable combination of approved air-entraining admixture and water reducer to reduce water content and permeability of the concrete, provided such admixtures do not adversely affect other specified properties of concrete.
  - c. For precast prestressed parking garages -
    - 1) The four-inch thick cast-in-place concrete overlay topping over the double tees on top level of the Parking Structure, the concrete shall attain 28 days minimum compressive strength of 7,000 psi with a water-cement ratio of 0.38 or less. The cast-in-place concrete overlay topping wash strips over the inverted tee beams on top level and wash strips over the inverted tee beams on all other levels, and all cast-in-place concrete wash areas over the double tees, the concrete shall attain 28 days minimum compressive strength of 5,000 psi with a water-cement ratio of 0.40 or less. And for all other cast-in-place concrete, the concrete shall attain 28 days minimum compressive strength with a water-cement ratio of 0.45 or less.
    - 2) Use a calcium nitrite-based corrosion inhibitor as specified in Section 03300.2.1.T, in the cast-in-place wash strips or areas, in the cast-in-place concrete overlay topping.
3. Workability:
- a. Use approved chemical admixtures as needed for workability so that concrete can be placed, consolidated, and finished without segregation or excessive bleeding.
4. Strength:
- a. Design mix for each class and type of concrete of each specified strength based on overdesign factor in accordance with ASTM C94. Unless otherwise shown, working-stress method applies to structures.
  - b. Design each class of concrete in accordance with the following:
    - 1) Not more than the following percentages of strength tests to have values less than specified strength:
    - 2) Working-stress method: 20 percent.
    - 3) Ultimate-strength method: 10 percent.
    - 4) Prestressed structures: 10 percent.
    - 5) Average of the following numbers of consecutive strength tests to be equal to or greater than specified strength:
      - a) Working-stress method: Six.
      - b) Ultimate-strength method: Three. Prestressed structures: Three.
  - c. When number of tests totals six or less, average to be in accordance with Note 21 of ASTM C94.
5. Appearance:
- a. Cured concrete exposed to public view shall be uniform in color, texture and finish with no discernible form or patch marks, grain imprint, joint irregularities or discoloration. Use only manufacturer approved chemically reactive release agents on HDO plywood forms.
  - b. Final selection and approval for color shall be made by the Engineer.

- D. Method of Proportioning:
  - 1. Proportion mixes as described in ACI 211.1.
  - 2. Approximate mixing-water and air-content requirements for mixes of different slumps and nominal maximum sizes of aggregates as specified in ACI 211.1, Table 5.3.3.
  - 3. Do not vary proportions of ingredients of approved mixes without written approval.
- E. Demonstration Section:
  - 1. Before proceeding with tunnel lining, completely seal a 25-foot long demonstration section using materials and methods to be used in the work in accordance with specified requirements.
- F. Ready-Mixed Concrete: ASTM C94.

### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Product Data: Manufacturer's literature completely describing each material, standard, test data, installation instructions and special instructions or safety precautions applicable to the materials.
    - a. Samples:
      - 1) Concrete surface sealer: Two, each one pint.
      - 2) Membrane-forming curing compound: Two of each type, each one pint.
  - 2. Sandblast finish:
    - a. Number 6 sandblast finish as specified, each 12 inches square by two inches: Two.
    - b. Seal 1/2 of face of each sample with concrete surface sealer.
    - c. If samples are not approved or if concrete mix is changed, submit additional samples until approved.
    - d. When samples have been approved, submit details of procedures followed to produce approved surface finish including, but not limited to, the following:
      - 1) Size and type of nozzle.
      - 2) Air pressure.
      - 3) Distance of nozzle from surface blasted.
      - 4) Duration of blast.
  - 3. Concrete panels of each type of concrete used in the work: Two each, 18 inches square by two inches thick.
  - 4. Certification:
    - a. Ingredients:
      - 1) Submit with mix design, laboratory test reports and mill or manufacturer's certificates verifying that ingredients conform to specified requirements. Use ingredients in design mix which are representative samples of materials to be used in the work.
      - 2) Submit test results whenever the aggregates, cement or other additives to be used in the concrete come from a different lot, source, other area of the quarry, different quarry or from other than the representative stockpile or batch from which the original material was tested and approved.
    - b. In case the source, brand or characteristic properties of ingredients need to be varied during the term of the Contract, submit revised laboratory-mix report in accordance with procedures specified for original mix design.
    - c. Batch tickets:

- 1) Before unloading at the site, submit certification or delivery ticket from concrete supplier with each batch delivered to the site bearing the following information:
    - a) Name of supplier.
    - b) Name of batching plant and location.
    - c) Serial number of ticket.
    - d) Date.
    - e) Truck number.
    - f) Specific job designation: Contract number and location.
    - g) Volume of concrete in cubic yards.
    - h) Class and type of concrete.
    - i) Time loaded.
    - j) Type and brand of cement.
    - k) Weight of cement and fly ash or ground-iron blast-furnace slag.
    - l) Maximum size of aggregates.
    - m) Weights of coarse and fine aggregates.
    - n) Maximum amount of water to be added and amount of water added at the site.
    - o) Kind and amount of admixtures.
5. Documentation:
- a. Proposed methods for controlling concrete temperature and plans for placing concrete taking into account sun, heat, wind, ambient air temperature or other limitations of facilities that will prevent proper finishing or curing.
  - b. Quality control plan for floor treatment. Submit as specified prior to installation.
  - c. Quality control reports. Submit as specified after installation.
  - d. Design mixes:
    - 1) Prior to placing concrete, submit design mixes for each class and type of concrete, certifying that proposed concrete ingredients and proportions will result in concrete mix meeting specified requirements.
    - 2) Include for each class and type of concrete as many mix designs as there are combinations of different ingredients or types of ingredients anticipated to cover requirements of the work.
    - 3) Establish mix designs through an approved design laboratory.
    - 4) Design concrete mix for protection against alkali-aggregate reactivity.
    - 5) The Contractor may present for approval a concrete mix previously approved for Authority work provided such mix is made with proposed ingredients that meet requirements and provided that concrete has complied with compressive-strength requirements based on control record of at least 30 consecutive-strength tests recently obtained.

#### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Aggregates :
1. Transport and stock pile aggregate separately according to sources and gradations. Handle so as to prevent segregation, loss of fines and contamination by earth or other foreign materials.
  2. If aggregates show segregation or if different grades become mixed, rescreen before placing in proportioning bins.

3. Do not combine aggregate from different sources or of different gradations except to obtain different gradations.
  4. Do not transfer aggregates directly from trucks, railroads cars or barges to proportioning bins when moisture content is such that it will affect accurate proportioning of concrete mixture. In such cases, stockpile aggregate until excess moisture drains off.
- B. Packaged Cement:
1. Deliver to project site in original sealed packages labeled with weight, name of manufacturer, brand and type.
  2. Store packages in watertight building.
  3. Do not use cement which has been reclaimed by cleaning bags.
  4. Do not use cement which has been exposed to moisture or contaminated.
  5. Deliver packages conforming to weight specified.
  6. Packaged cement will be subject to testing.
- C. Bulk Cement:
1. Store bulk cement separately from other cement and protect to prevent exposure to moisture and contamination.
  2. In ready-mix plant, provide facilities to maintain separation of cement meeting specified requirements from other cement.
  3. Provide in cement manufacturer's plant, facilities for sampling cement at weighing hopper or in feed line immediately before entering hopper.
- D. Ready-Mixed Concrete: ASTM C94.
- E. Blast-Furnace Slag or Fly Ash for use with Portland Cement:
1. Transport in covered carriers.
  2. Store in watertight bins or silos to provide protection from dampness and contamination. When compartmented bins are used, conduct periodic, but not less than weekly checks between adjacent bins to avoid contamination of either of the stored materials.
- F. Concrete Additives, Sealers and Corrosion Inhibitor . As required by the manufacturer.

## **1.05 WARRANTY**

- A. Penetrating Concrete Sealer: Provide a minimum effective service life warranty of 10 years for the penetrating concrete sealer.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS:**

- A. Cementitious Materials:
1. Portland Cement: ASTM C150, Types I and II. Use Type II only for underground structures.
    - a. Alkali content not to exceed 0.6 percent.
  2. Blended Hydraulic Cement: ASTM C595 Type IS and IP.
- B. Ground-Iron Blast Furnace Slag: ASTM C989, Grade 100 or 120.
- C. Fly Ash: ASTM C311 and ASTM C618, Class F:
1. Loss on ignition not to exceed 4 percent.

2. Maximum available alkalis (for combination of cement and fly ash) not to exceed 0.6 percent based on proportions to be used and alkalinity measurements for cement and fly ash individually or in combination.
  - a. Fly ash used to be qualified for each source.
3. Uniform color when used in concrete exposed to public view.

D. Aggregates:

1. Aggregates for normal concrete and shotcrete: ASTM C33 with the following additional requirements:

- a. Coarse aggregate: Gravel, crushed gravel or crushed stone.

- 1) Deleterious substances:

- a) Maximum allowable amounts:

<u>Substance</u>	<u>Maximum Allowable Percentage by Weight</u>
(1) Soft particles:	5.0
(2) Coal and lignite particles:	0.5
(3) Friable particles:	0.25
(4) Material passing Size 200 sieve:	1.0
(5) Thin or elongated pieces:	15.0
(6) Other local deleterious substances:	1.0

- b) Soft particles: Higher percentage may be approved where concrete is not subject to abrasion, provided concrete strength is achieved without the use of excess cement.

- c) Crushed aggregates: If material finer than Number 200 sieve consists of dust of fracture essentially free from clay or shale, percentage may be increased to 1.5.

- d) Thin or elongated pieces: Length of pieces to be greater than five times the smallest dimensions of a circumscribing rectangular prism.

- 2) Percentage of wear: 45 maximum when tested in accordance with ASTM C131 and ASTM C535.

- 3) Weighted percentage of loss: 15-percent maximum by weight when subjected to five cycles of magnesium sulphate soundness test in accordance with ASTM C88.

- 4) Gradation: In accordance with ASTM C33, Table 2, and represented by a smooth gradation curve within required limits.

- b. Fine aggregate:

- 1) Washed natural sand or washed stone sand. Stone sand may be subject to special gradation requirements as directed.

- 2) Gradation in accordance with ASTM C33.

- a) Minimum percentages of material passing Size 50 and Size 100 sieves may be reduced to five and zero, respectively, if aggregate is to be used in concrete with three percent minimum air entrainment, or in concrete containing more than 517 pounds of cement per cubic yard.

- 3) Weighted percentage of loss not more than 12 percent by weight when subjected to five cycles of magnesium sulphate soundness test in accordance with ASTM C88.

- 4) Deleterious Substances:

<u>Substance</u>	<u>Maximum Allowable Percentage by Weight</u>
a) Friable particles:	1.0
b) Coal and lignite:	0.5
c) Material passing the Size 200 sieve:	5.0
d) Other deleterious substances, such as shale, alkali, mica, coated grains, soft and flaky particles:	2.0
5) Free from injurious amounts of inorganic impurities as determined by ASTM C40. Should materials fail to pass test for organic impurities in sand for concrete, retest in accordance with ASTM C87. If fine aggregate shows by colorimetric test a darker color than that of sample originally approved for the work, stop using such aggregate until approved tests have been made to determine whether change in color is indicative of injurious amount of deleterious substances.	
c. Evaluate for potential alkali aggregate reactivity:	
1) Perform a petrographic examination in accordance with ASTM C295. The petrographic analysis will identify the constituents of the fine and coarse aggregate and will also identify aggregate found to be potentially alkali-carbonate reactive. Fine and coarse aggregate containing more than the following quantities of constituents is unacceptable:	
a) Optically strained, microfractured or microcrystalline quartz exceeding five percent (a common constituent of granite and granite gneiss).	
b) Chert, Metaquartzite, Chalcedony or combination thereof exceeding three percent. However, fine aggregate may contain up to eight percent provided that mortar bar test results are acceptable.	
c) Tridymite or cristobalite exceeding one percent.	
d) Opal exceeding five percent.	
e) Natural volcanic glass in volcanic rocks exceeding three percent.	
2) Test aggregate for alkali-silica reactivity in accordance with ASTM C1260. Aggregate sources that exhibit a C1260 mean mortar bar expansion at 16 days greater than 0.08 percent are unacceptable.	
3) Aggregate identified by the petrographic analysis to be potentially alkali-carbonate reactive is to be further evaluated in accordance with ASTM C586. Expansion of test specimen cylinders not to exceed 0.10 percent after 28 day immersion in NaOH solution.	
d. Aggregate which fails the evaluation criteria for potential alkali aggregate reactivity may be reclassified as acceptable if prior field performance demonstrates that the aggregate is nonreactive. Include service records (material records, batch quantities, exposure conditions, and petrographic evaluation) demonstrating the aggregate to be nonreactive in the mix design submittal.	
2. Aggregates for Lightweight Structural Concrete: ASTM C330, with the following additional requirements:	
a. Coarse aggregate:	
1) Composition: Expanded shale, clay or slate, predominantly lightweight, cellular and granular.	

- 2) Percentage loss: 10-percent maximum by weight when subjected to five cycles of the magnesium sulphate soundness test in accordance with ASTM C88.
- 3) Gradation: In accordance with ASTM C330, Table 1.
- 4) Unit weight: In accordance with ASTM C330, Table 2.
- b. Fine aggregate:
  - 1) Composition: Particles of expanded shale, clay, slate or ASTM C33 natural sand as necessary to obtain specified compressive strength and comply with specified air-dry unit weight for lightweight structural concrete.
  - 2) Gradation: In accordance with ASTM C330, Table 1.
  - 3) Unit weight: In accordance with ASTM C330, Table 2.
  - 4) Percentage loss: 10 percent maximum by weight when subjected to five cycles of magnesium sulfate soundness test in accordance with ASTM C88.
- E. Water:
  - 1. Natural potable water with no pronounced taste or odor.
  - 2. Containing no impurities, suspended particles, algae or dissolved natural salts in quantities that will cause:
    - a. Corrosion of reinforcing steel.
    - b. Volume change that will increase shrinkage cracking.
    - c. Efflorescence.
    - d. Excessive air entraining.
  - 3. pH: Not less than five.
  - 4. When tested in accordance with AASHTO T26, standard mortar-briquette tests to show no indication of unsoundness, no change in setting time in excess of plus-or-minus 30 minutes and no reduction in strength in excess of 10 percent.
- F. Ready-Mixed Concrete: ASTM C94, Option C.
- G. Admixtures:
  - 1. In accordance with the following:
    - a. Air-entraining admixtures: ASTM C260.
    - b. Chemical admixtures: ASTM C494.
  - 2. Approved brands: Chlorides may be present in admixtures provided total chloride in mixing water of proposed concrete mixture, including chloride ions contributed by admixture or admixtures, aggregate and mixing water is not in excess of 150 ppm.
  - 3. Meeting requirements of reference standards or documented to have five-year minimum history of demonstrably satisfactory performance for similar structures under equivalent conditions.
- H. Aluminum Powder: FS A-A-341A, free of oil, grease, soluble alkalis and organic materials, gradation as approved.
- I. Ferrous Aggregate:
  - 1. Cast-iron particles, ASTM A43, ASTM A47, or ASTM A48, free of oil, grease, soluble alkalis and organic materials.
  - 2. Aggregate graded as follows:

<u>Sieve Designation</u>	<u>Percentage by Weight</u>
<u>US Standard Square Mesh</u>	<u>Passing Individual Sieves</u>
3/8 inch	—
Size 4	100
Size 8	90 - 100
Size 16	75 - 90

Size 30	45 - 60
Size 50	15 - 25
Size 100	10 - 20

3. If recommended by manufacturer and approved, in lieu of the above gradation use lower percentage of aggregate passing Size 100 sieve.
- J. Abrasive Aggregate: 60 to 75 percent silicon-carbide abrasive, bonded by vitreous ceramic material, black, graded from 12 to 30.
- K. Floor Treatment:
1. Sealer: Zinc or magnesium fluosilicate and wetting agent formulated and mixed with water in concentration recommended by manufacturer.
  2. Floor hardener system:
    - a. Floor hardener:
      - 1) Free from non-ferrous metallic particles, filler material, silica sand, natural aggregates, rust and materials which disguise rust.
      - 2) Ready-to-use formulation proportioned, mixed and packaged at factory ready for application.
      - 3) Ingredients proportioned to maintain two parts well-graded iron aggregate to one part consisting of cement, plasticizing agents and other ingredients designed to absorb moisture from floor slab.
      - 4) Color: Per sample, or as selected by the Engineer.
      - 5) Masterplate 200, Master Builders, or equal.
    - b. Floor curing compound:
      - 1) Clear modified-acrylic resin.
      - 2) Moisture retention: In accordance with ASTM C309 when applied at a rate of 400 square feet per gallon.
      - 3) Masterkure, Master Builders, or equal.
- L. Penetrating Concrete Sealer:
1. Penetrating silane sealer, which is readily absorbed into concrete substrate and which reacts chemically to provide a hydrophobic barrier that will not wear off when exposed to sunlight or wheel traffic; which allows concrete to breath, allowing the escape of water vapor but preventing the absorption of surface water; colorless; not altering the surface texture of the concrete substrate. See Warranty requirements.
  2. Provide one of the following:
    - a. Chem-Trete BSM 40, Hüls America, Inc. (1-800-828-0919).
    - b. Penetrating 40, Sonneborn Division Chemrex (1-800-CHEMREX).
    - c. Master Seal SL40, Master Builders Technologies.
- M. Curing Materials:
1. Plastic sheeting: Polyethylene, ASTM C171.
    - a. Curing sheet: Type 1.1.1 and 1.1.2.
    - b. Vapor barrier: Clear 10-mils thickness.
  2. Burlap sheet: AASHTO M182, Class 3 or 4.
  3. Tarpaulin: FS K-P-146.
  4. Blanket insulation: FS HH-I-521.
  5. Membrane-forming curing compound: ASTM C309, Type 1-D, 100 resin with fugitive dye, and Type 2.
- N. Epoxy Mortar:
1. Epoxy: ASTM C881, Type III-C, grey.
  2. Sand: Clean, dry, well-graded particles, passing Size 16 sieve, with the following additional requirements:

Individual Sieve Size

Percent by Weight Retained on Sieve

30	26 to 36
50	18 to 28
100	11 to 21
Pan	25 to 35 (range shown is applicable when 60 to 100 percent of pan is retained on Size 200 sieve)

- O. Chemical Grout: Section 02415.
- P. Paver Tile Setting Bed:
1. Concrete: 3500 psi.
  2. Reinforcement: 4 x 4 - W4.0 x W4.0, Section 03200, furnish in sheets, not rolls
- Q. Elastomeric Concrete:
1. Elastomeric Concrete to consist of an aggregate and binder mixture proportioned by the manufacturer.
  2. Manufacturer qualifications: Manufacturer to have the following minimum qualifications:
    - a. Ten years experience in the manufacturing of elastomeric concrete materials.
    - b. Qualified personnel, factory trained and certified in the proper installation procedures, are to be available during construction.
  3. Manufacturers: The naming of certain manufacturers is intended to establish a standard of quality. Elastomeric Concrete from the following manufacturers is acceptable:
    - a. Delcrete Elastomeric Concrete by the DS Brown Company, PO Box 158, North Baltimore, OH 45872, telephone (419)257-3561.
    - b. Wabocrete by Watson Bowman Acme Corporation, 95 Pineview Drive, Amherst, NY 14228, telephone (716)691-7566.
  4. Equal Products: Other manufacturers or material suppliers who wish to propose their product as equal to this specification submit product information and a working sample along with independent physical test property verification, and product literature for review and approval.
- R. Waterstop: Section 03100.
- S. Chairs for Reinforcement: Plastic or stainless steel.
- T. Corrosion-inhibitor in concrete. The corrosion-inhibitor shall be calcium nitrite-based admixture DCI or approved equal. Use four (4) gallons per cubic yard of the corrosion inhibitor when the water-cement ratio is 0.40 or less and use three and a half gallons (3-1/2) per cubic yard when water-cement ratio is 0.38 or less. For precast prestressed parking structures/garages use the corrosion-inhibitor in cast-in-place concrete overlay topping over the double tees and the inverted tee beams on top level and for cast-in-place concrete in wash strips and wash areas on all levels.

## 2.02 SAMPLING:

- A. Sample concrete ingredients prior to use and have them tested by an approved laboratory in accordance with methods specified. Subsequently test materials as often as necessary to verify that materials conform to specified requirements and that quality of product is maintained.

- B. Make arrangements for the Engineer to witness sampling and testing. Submit record of test results.
- C. Ready-Mixed Concrete: ASTM C94.

### **2.03 GROUT MIXES:**

- A. Portland-cement grout:
  - 1. Prepare grout composed of portland cement, sand and water.
  - 2. Use portland-cement grout under bearing plates, in recesses, holes and surfaces under structural members and at other locations shown.
  - 3. Do not use staining ingredients in grout exposed to view.
  - 4. Formulation: Two parts sand and one-part cement measured by volume.
  - 5. Mix grout with sufficient water to permit placing and packing, approximately 45 minutes prior to use.
- B. Nonshrink grout: ASTM C1107.
- C. Shrinkage-compensating grout:
  - 1. Use shrinkage-compensating grout for setting structural members, anchor bolts, embedded items or items of equipment and machinery on hardened concrete.
  - 2. Prepare nonstaining shrinkage-compensating grout with portland cement, sand and aluminum powder and use in accordance with manufacturer's recommendations.
  - 3. Prepare shrinkage-compensating grout for use up to two inches thick as follows, measured by volume:
    - a. One-part portland cement, Type I or II.
    - b. One-part fine natural-sand aggregate, graded as specified.
    - c. One-part ferrous aggregate, graded as specified, combined with Type-A chemical admixture, oxidation agent and water in sufficient amount to permit placing and packing.
- D. Premixed shrinkage-compensating grout:
  - 1. In lieu of specified shrinkage-compensating grout, use premixed ready-to-use formulation when approved. Approval will be based on manufacturer's certification that:
    - a. Material will perform as specified.
    - b. Composition and proportioning of grout materials is essentially as specified for shrinkage-compensating.
    - c. Formulation has been used successfully in like applications for at least five years.
  - 2. Proportion ingredients in accordance with the manufacturer's recommendations.
- E. Mixing water:
  - 1. Proportion mixing water in accordance with grout manufacturer's recommendation or to produce flowable mixture without segregation or bleeding.
- F. Curing:
  - 1. After grout has attained initial set, keep damp for 24 hours minimum.

## **PART 3 - EXECUTION**

### **3.01 FIELD QUALITY CONTROL:**

- A. Classes of Concrete:

1. Classes of concrete are designated by numerals corresponding to their specified 28-day compressive strength in pounds per square inch as determined by ASTM C94.
2. Concrete classes used in this project are specified. Unless otherwise indicated, use Class 3500.
3. Each class of concrete may comprise one or more mixes determined by maximum size of aggregate, cement factor and types of admixtures used.
  - a. Portland cement may be used alone or mixed with either ground-iron blast-furnace slag or fly ash. Do not use fly ash in architectural concrete exposed to public view.
  - b. Maximum allowable ground-iron blast-furnace slag: 50 percent of the total weight of the portland cement and ground-iron blast-furnace slag mixture.
  - c. Maximum allowable fly ash: 20-percent of the total weight of the portland cement and fly-ash mixture.
4. Concrete with fly ash or ground-iron blast-furnace slag may be used at locations shown on the drawings.

B. Types of Concrete:

1. Types of concrete are designated as Concrete Other than Lightweight and Lightweight Structural Concrete.

C. Minimum Cement Factor:

1. Observe minimum cement factor for various classes of concrete other than lightweight, as follows:

Class of Concrete	Minimum Cement Factor Bags Per Cubic Yard Of Concrete
5,000	6.5
3,500 - 4,000	6.0
2,500 - 3,000	5.0

\* one bag of cement = 94lbs. of cement

2. If a mix of portland cement and ground-iron blast-furnace slag or portland cement and fly ash is used, the mix is the basis of determining the bags per cubic yard of concrete.

D. Air Entrainment:

1. Determine air content of concrete in accordance with ASTM C94.

E. Testing of Concrete:

1. General:
  - a. Provide the Engineer with molds and concrete, and cast specimens for testing. In addition, furnish necessary testing equipment and tools to perform sampling, slump tests and yield tests. Furnish boxes for shipping samples.
2. Perform strength tests by making not less than one set of standard cylindrical test specimens for each 100 cubic yards of concrete or any portion thereof for each structure.
  - a. For each work shift, when concrete is delivered, make at least one set of specimens. A set of test specimens consists of at least three standard cylinders from a batch.
  - b. Perform slump tests, unit weight and air content tests with no less frequency than that of strength-specimen sets.
3. Concrete strengths:

- a. Determine strengths from standard test specimens according to ASTM C31 and ASTM C172 and cured and tested in accordance with ASTM C39 by the testing laboratory. Core drilling and testing in accordance with ASTM C42. Consider the effects of corrosion-inhibiting admixture and other admixtures on the strength of the concrete, in the concrete mix design. The corrosion-inhibiting admixture and other admixtures must be present in the concrete used for the test of the proposed mix strength.
  - b. Compute and evaluate in accordance with ASTM C94.
- F. Variability of Constituents in Concrete:
- 1. Take representative samples of concrete mortar.
  - 2. Maximum allowable unit-weight variation of air-free mortar taken from consecutive batches as discharged from mixer:
    - a. Average of two mortar weights: 0.8-percent maximum.
    - b. Average of six mortar weights: 0.5-percent maximum.
  - 3. Maximum allowable weight variation of coarse aggregate per cubic foot of concrete taken from consecutive batches as discharged from mixer.
    - a. Average of two weights: Five-percent maximum.
- G. Batching Plant:
- 1. Arrangement:
    - a. Provide separate bins or compartments for each size or classification of aggregate and for bulk portland cement, ground-iron blast-furnace slag or fly ash.
  - 2. Compartments:
    - a. Provide compartments of ample size, so constructed that materials will be kept separated under working conditions. Equip batching plant so that flow of each material into its batcher is stopped automatically when designated weight has been reached.
    - b. Weigh aggregates in separate weight batches with individual scales or cumulatively in one batcher on one scale. Weigh bulk cement on separate scale in separate weight batcher. Weigh ground-iron blast-furnace slag or fly ash on the same scale in the same weight batcher containing the bulk cement. Weigh and record bulk cement first; then add to the bulk cement, weigh and record the ground-iron blast-furnace slag or fly ash. Weigh and record the cumulative bulk cement and ground-iron blast-furnace slag or the bulk cement and fly ash.
    - c. Water amount may be measured by weight or volume. If measured by weight, do not weigh cumulatively with other ingredients.
    - d. Interlock batching controls so that charging mechanism cannot be opened until scales have returned to zero. Satisfy these requirements by semi-automatic batching system as defined in the Concrete Plant Standards of the CPMB, with specified interlocking, or by automatic-batching system as defined in the Concrete Plant Standard.
    - e. Arrange plant so as to continuously facilitate inspection of operations. Provide facilities for obtaining representative samples of aggregate from each bin or compartment for test purposes.
    - f. Deliver materials from batching equipment within limits specified in ASTM C94.
    - g. Subject to approval, accomplish batching in accordance with ASTM C685, in lieu of weight batching, provided batching plant complies with requirements of CPMB Concrete Plant Standards.
  - 3. Water batcher and admixture dispensers:
    - a. Provide equipment for batching water and air-entraining or other admixtures at batching plant except in cases where mixing is to be performed at jobsite in paving mixers or in truck mixers.

- b. Provide water-measuring device capable of measuring mixing water within specified requirements for each batch. Provide mechanism for delivering water to mixers so that leakage does not occur when valves are closed.
  - c. Interlock filling and discharge valves for water batcher so that discharge valve cannot be opened before filling valve is fully closed.
  - d. Introduce admixtures in solution form.
  - e. Provide measuring devices for admixtures capable of ready adjustment to permit varying quantity of admixture to be batched. Interlock dispenser for admixtures with batching and discharging operations so that batching and discharging of mixture will be automatic.
  - f. If noninterlocked dispensers are permitted, check calibration of dispensers at directed intervals. Record results of such calibration for inspection by the Engineer.
4. Moisture control:
- a. Provide plant capable of ready adjustment to compensate for varying moisture contents of aggregate and to change weights of materials being batched. Provide approved electric moisture meter for measurement of moisture in fine aggregate. Calibrate as often as directed.
  - b. Moisture content of fine aggregate not to exceed eight percent. Arrange sensing element so that measurement is made near batcher.
5. Scales:
- a. Provide accurate measurement facilities for and control of each of the materials entering each batch of concrete. Provide accurate weighing equipment in accordance with NBS Handbook 44.
  - b. Include in each weighing unit a visual springless dial to indicate scale load at each stage of weighing operation or include beam scale with beam balance indicator to show scale in balance at zero load and at each beam setting, indicator to have undertravel and overtravel equal to at least five percent of capacity of beam.
  - c. Provide standard test weights and other auxiliary equipment necessary to verify operating performance of each scale or other measuring device.
  - d. Make periodic tests in the presence of the Engineer at directed intervals. Upon completion of each check test and before further use of indicating, recording and control devices, make adjustments, repairs or replacements as necessary to ensure satisfactory performance.
6. Recorders:
- a. Provide accurate recorder for producing digital printout of scale readings corresponding to each concrete ingredient of each concrete batch, including zero initial readings; indicate presence of each individual admixture by corresponding code in lieu of weight or volume record.
  - b. Record water in gallons where batched by volume. In addition, on each printout show date and time of batching, identification number identical to that of concrete delivery ticket and codes for mix design and for project section.
  - c. Prepare printout in duplicate and submit one copy with its corresponding concrete ticket at the time and site of concrete placement.
  - d. House each recorder in locked cabinet.
  - e. Place recorders in position convenient for observation by plant operator and the Engineer.
7. Protection:
- a. Protect weighing, indicating and control equipment against exposure to dust and weather; isolate against vibration or movement caused by other operating equipment.
8. Dry batching:
- a. When bulk cement and aggregates are hauled from central batching plant to mixers, place cement, ground-iron blast-furnace slag or fly ash for each

batch in an individual compartment which, during transit, will prevent cement from intermingling with aggregates and will prevent loss of cement.

- b. Provide bins of batch trucks with suitable covers to protect materials.
- c. Provide batch compartments of sufficient capacity to prevent loss in transit and to prevent spilling and intermingling of batches as compartments are being emptied.

H. Allowable Concrete Finish Tolerances:

- 1. Finish concrete elements to dimensions, elevations and positions shown within the tolerances specified for each:
  - a. Formed surfaces such as walls, roof soffits, columns, beams and girders: Plus-or-minus 1/4 inch.
  - b. Arches: Plus-or-minus 1/2 inch.
  - c. Bearing-assembly locations of aerial structure piers and abutments: Plus-or-minus 1/16 inch.
  - d. Traction-power substations, tie-breaker stations and ac-switchboard rooms: Plus zero or minus 1/4 inch.
  - e. Safety walks, vertical and horizontal: Plus-or-minus 1/2 inch.
  - f. Station platforms:
    - 1) Vertical: Plus-or-minus 1/4 inch.
    - 2) Horizontal, measured from centerline of track to edge of platform: Plus 1/4 inch or minus zero.
  - g. Invert slabs and floating slabs:
    - 1) Maximum deviation from profile grade: Plus zero or minus 1/2 inch.
    - 2) Maximum deviation from 10-foot steel straightedge: Plus-or-minus 1/8 inch, noncumulative.
    - 3) Verify adequacy of finish for draining by hosing area. Ponding or obstructions to flow toward invert drains constitute defects.
  - h. Invert under floating slabs:
    - 1) Maximum deviation from profile grade: Plus zero, minus 1/2 inch.
    - 2) Maximum deviation from 10-foot steel straightedge: Plus-or-minus 1/8 inch, noncumulative.

I. Water tightness Criteria:

- 1. Maximum allowable water leakage:
  - a. Permanent-support lining for circular and horseshoe tunnels, including joints:
    - 1) 0.14 gallons per minute per 250 linear feet.
    - 2) 0.07 gallons per minute in any 10 linear feet.
  - b. Single-box, cut-and-cover line structures, including joints:
    - 1) 0.12 gallons per minute per 250 linear feet.
    - 2) 0.06 gallons per minute in any 10 linear feet.
  - c. Double-box or cross-over, cut-and-cover line structures, including joints:
    - 1) 0.08 gallons per minute per 250 linear feet.
    - 2) 0.04 gallons per minute in any 10 linear feet.
  - d. Passenger stations, other public spaces, NATM tunnels and two-pass system tunnels where full wrap-around waterproofing is used: No leakage permitted.

**3.02 MATERIAL PREPARATION:**

A. Mixing Concrete:

- 1. Operations:
  - a. Provide concrete mixers that discharge concrete of uniform composition and consistency.

- b. Combine coarse aggregates of different gradation and identical sources, provided corresponding concrete mix has been approved. The use of alternate batches of gravel, crushed gravel or crushed stone of a single size is prohibited.
  - c. Adequacy of mixing will be determined by the Engineer by means of mixer performance tests in accordance with USBR Concrete Manual, Designation 26, Variability of Constituents in Concrete, in the appendix.
  - d. The Engineer may reduce size of batch to be mixed or increase mixing time when charging and mixing operations fail to produce concrete which conforms to specified requirements and which has uniform coloration and consistency.
  - e. Add water prior to, during and following mixer-charging operations. Do not overmix or add water to maintain consistency.
  - f. Use of concrete to which water in excess of amount permitted by approved design mix has been added to overcome conditions caused by excessive retention in mixer is prohibited.
2. Central-mixed concrete:
- a. Arrange mixers in centralized mixing plant so that mixing action in mixers can be conveniently observed by the Engineer and plant operator.
  - b. Do not load mixers in excess of rated capacity. Mix concrete ingredients in batch mixer for not less than period of time specified for various mixer capacities after each ingredient except full amount of water is in mixer. Reduce mixing time if thorough mixing as specified can be obtained in less time and if approved.
  - c. Mixing time:

Cubic-Yard Capacity of Mixer	Mixing Time
2 or less	1-1/2 minutes
3	2 minutes
4	2-1/2 minutes
More than 4	To be determined per ASTM C94 tests by the Engineer

- d. Equip each mixer with mechanically operated batch counter and timing and signaling device to indicate completion of mixing period.
3. Truck-mixed concrete: Use equipment and procedures that conform to the requirements of ASTM C94 and ACI 304, Chapter 5, with the following additional requirements:
- a. Introduce materials, including water and mixtures, into the mixing drum only at the central batching plant, or
  - b. Transport aggregates from the central plant to the jobsite in the mixing drum and add measured and recorded cement, admixtures and water into the drum prior to mixing at discharge point.
  - c. When ice is used, add it with the water and counted as part of the water-cement ratio.

- d. Place concrete within 90 minutes after cement is introduced into the mixing drum.
  - e. Accomplish initial mixing by 70 to 100 revolutions with drum rotating at the manufacturer's recommended speed. 30 revolutions at mixing speed will be required, if the addition of water is permitted. Do not exceed total of 300 mixing and agitating revolutions.
4. Temperature control:
- a. Use preparation methods capable of producing concrete with temperature 85F maximum and 55F minimum at time of placement.
  - b. Do not heat concrete ingredients to temperature higher than that necessary to keep temperature of mixed concrete as placed within specified temperatures.
  - c. Do not heat water in excess of 140F.
- B. Admixtures:
- 1. Introduce admixtures in solution form.
  - 2. Air-entraining admixture: Use for concrete exposed to weathering or in contact with rock or moist soil.
  - 3. Chemical admixtures:
    - a. Use water-reducing admixtures in concrete areas below grade in contact with rock, earth or fill.
    - b. Employ admixtures without interfering with specified air-content dosage of air-entrained concrete.
    - c. Except as otherwise specified or approved, use of water-reducing, set-retarding or set-accelerating admixtures is prohibited.
    - d. If introduction of certain admixtures to improve concrete strength is approved, do not reduce cement content below minimum amounts specified.
- C. Consistency:
- 1. For concrete to be compacted by approved mechanical vibrators, maintain slump range at point of delivery within the following limits:
    - a. Concrete pavement, pavement base, sidewalk and incidental construction: Two to three inches.
    - b. Unreinforced concrete other than pavements: One to three inches.
    - c. Reinforced concrete: Two to four inches.
    - d. Concrete placed by pumping and concrete for filling steel-shell piles: Four to five inches.
    - e. Do not use concrete if slump exceeds maximum by 1/2 inch or more.
- D. Lightweight Structural Concrete:
- 1. Prepare lightweight structural concrete with minimum cement content as follows:

Compressive Strength	Cement Content Bags Per Cubic Yard
2,000 psi	4 to 7
3,000 psi	5 to 8
4,000 psi	6 to 9
5,000 psi	7 to 10

- 2. Air-entrainment:
  - a. Use air-entraining admixture in lightweight structural concrete to provide not less than four nor more than six percent of entrained air.

3. Dry unit weight:
  - a. Prepare lightweight structural concrete to provide air-dry weight required by design but not less than 90 pounds per cubic foot.
4. Consistency:
  - a. Maintain slump range within two to four inches.

### **3.03 CONVEYING:**

- A. General:
  1. Provide equipment for conveying concrete from mixer with continuous flow of concrete to point of placement without segregation.
  2. Provide arrangement at discharge end of conveyor to prevent segregation.
  3. Design long conveyor runs to discharge concrete into hopper, without segregation, before it is deposited in forms.
  4. Ensure that pumps, pneumatic equipment, pipes, chutes and troughs are cleaned of dirt and concrete before use.
- B. Chutes and Troughs:
  1. Use only ferrous-metal-lined chutes and open troughs. Where steep slopes are unavoidable, equip chutes or troughs with baffles to minimize segregation of aggregates. Keep chutes or open troughs clean of hardened concrete by flushing with water after each use.
  2. Discharge water used for cleaning outside lines of structure. Lay out chutes or open troughs with slope one-foot vertical to two feet horizontal maximum and one-foot vertical to three feet horizontal minimum.
  3. Discharge chutes 20 feet or more in length into hopper before final distribution.
- C. Adjustable Length Pipes (Elephant Trunks):
  1. Use flexible pipes of ferrous metal, rubber or plastic, six inches minimum diameter so as to prevent segregation of concrete.
  2. Position chutes or flexible pipes so that concrete is delivered in continuous flow to points not more than five feet horizontally and five feet vertically from final location. In vicinity of expansion and contraction joints, reduce horizontal distance to three feet maximum.
  3. Clean flexible pipes and elephant trunks after each use.
- D. Buggies:
  1. Construct runways for buggies so they will not come into contact with or be supported by reinforcing steel of structure.
- E. Pumping and Pneumatic Conveying Equipment:
  1. Use pumping and pneumatic conveying equipment, designed to handle without segregation types, classes and volumes of concrete to be conveyed.
  2. Operate pump or pneumatic equipment so that continuous stream of concrete without air pockets is produced. Position discharge end of line as near final position of concrete as possible but in no case more than five feet away.
  3. At conclusion of placement, clean equipment. Discharge debris and flushing water outside of forms.

### **3.04 PLACEMENT:**

- A. General:
  1. Prior to placing concrete, remove debris and extraneous material from interior of forms.

2. Place first lift of concrete on wet surface. Consolidate by dragging vibrator along edges of joints. Make sure there is no free or standing water over the surface.
3. Place concrete continuously and as rapidly as possible after mixing. Do not use vibrators for shifting mass of fresh concrete.
4. Place concrete in layers of such thickness that no concrete will be deposited on concrete which has hardened sufficiently to cause formation of seams or planes of weakness. Cover each layer of concrete with fresh concrete within 45 minutes.
5. Do not place concrete which has attained initial set or concrete which has contained mix water for more than 90 minutes.
6. Remove temporary spreaders in forms when concrete has reached elevation which makes them unnecessary.
7. Place column concrete using adjustable-length flexible pipes or elephant trunks to avoid dropping concrete over five feet. In monolithic placements, do not deposit concrete in supported elements such as beams, girders and slabs until concrete previously deposited in columns or walls has completed its settlement shrinkage, but not to the point at which concrete in supporting members will not permit vibrator to sink into its mass of its own weight.
8. Placing will not be permitted when sun, heat, wind or limitations of facilities will prevent finishing and curing.
9. Concrete temperature at time of placement:
  - a. 55F, minimum.
  - b. 85F, maximum.
10. Unless approved, do not continue concreting when descending ambient air temperature falls lower than 40F.
11. Prior to placing fresh concrete against rock or previously placed concrete, take necessary steps, such as flushing with water, to ensure removal of foreign matter which would adversely affect bond.
12. Maintain wire fabric and other reinforcing in proper position on chairs during concrete placement.

B. Underwater Concrete Placement:

1. Place concrete carefully and continuously in compact mass by means of tremie or underwater bottom-dump bucket; do not disturb after depositing. Maintain still water at point of deposit. Use tight forms. In placing concrete, produce approximately horizontal surfaces.
2. Do not perform pumping within area until concrete has set at least 48 hours.
3. Tremie:
  - a. Provide tremie consisting of watertight tube, 10-inch minimum diameter, with hopper at top. Equip tube with device to close discharge end and prevent water from entering tube while charging tube with concrete.
  - b. Support tremie so as to permit free movement of discharge end over entire top surface of work and to permit rapid lowering when necessary to retard or stop flow of concrete.
  - c. Close discharge end at start of work to prevent water entering tube and maintain entirely sealed, except when concrete is being placed. Keep tremie tube full of concrete.
  - d. Maintain continuous flow until work is complete and resulting concrete seal is monolithic and homogenous. Control tremies so that concrete will be effectively compacted into horizontal layers not more than 12 inches thick.
  - e. Space tremies so as to avoid segregation.

C. Consolidation:

1. Consolidate concrete thoroughly as it is placed in order to secure a dense mass. Work concrete well around reinforcement, embedded items and into the corners of forms. Consolidate concrete in accordance with ACI 309.
2. Use internal vibrators unless external vibrators are approved.

3. Use vibrators capable of generating frequencies of not less than 7,000 impulses per minute. Verify that vibrators have power and amplitude factor so as to visibly affect mass of concrete of one-inch slump over radius of at least 18 inches. Prevent formation of laitance and accumulation of excessive water on surface of concrete as it is deposited. Remove excessive water by pumping or other approved means.
4. When consolidating concrete in haunches, girders, beams or slabs, ensure that vibrator penetrates and revibrates previously placed concrete in top of supporting members.
5. Do not use vibrators where internal vibration might cause damage to embedded items; in such cases spading is required.

### **3.05 CURING AND PROTECTING:**

- A. General:
  1. Protect freshly placed concrete from excessively hot or cold temperatures. Maintain without drying for period of time necessary for hydration of cement and proper hardening of concrete.
  2. Provide sufficient tarpaulins to cover completely or enclose forms and working areas prior to and during placing and finishing operations.
  3. Cure newly placed concrete continuously for seven days at ambient temperature in excess of 55F.
  4. Cure concrete in subway structures by normal curing method specified.
  5. During curing period keep steel and wood forms wet. If forms are removed during curing, use one of the following methods of curing immediately and continue for remainder of the curing period.
- B. Normal Curing and Protection:
  1. Use one of the following methods for flat surfaces, weather permitting:
    - a. Use ponding on horizontal surfaces providing surface is continuously submerged for required curing period.
    - b. Apply continuous sprinkling with nozzle or nozzles which, during first 24 hours, atomize flow of water providing a mist and not a spray. Do not apply moisture under pressure directly upon concrete; avoid flowing or washing on surfaces while susceptible to erosion.
    - c. Cover entire surface of concrete with double thickness burlap sheet, laid directly on concrete and kept continuously wet. Maintain in good condition.
    - d. Sprinkle concrete surface as specified for at least 18 hours and immediately cover with waterproof curing sheet, free from holes or tears. Hold in position so that entire surface of concrete is fully and continuously covered.
    - e. Do not damage burlap, waterproof sheet or concrete surfaces.
- C. Membrane-Forming Curing Compound:
  1. Use curing compound when approved for circumstances where application of moisture is impracticable and where such compounds will not jeopardize appearance of concrete. Except as otherwise specified, use Type-1 compound, uniformly applied over surface at thickness recommended by manufacturer. Thoroughly mix compound and apply within one hour after mixing.
  2. Where surfaces are subject to sunlight, apply Type-2 compound. Except for surfaces exposed to public view and architectural finished concrete.
  3. Do not apply wax-resin curing compounds to surfaces requiring bond for additional concrete or where bonded surface coating such as paint, tile, dampproofing, waterproofing or roofing is to be applied.
    - a. Do not apply curing compound to floors to be chemically sealed.

4. Warm or stir curing compound if necessary for satisfactory application in accordance with manufacturer's recommendations. If film of compound is damaged before expiration of curing period, repair immediately with additional compound.
  5. Inside surfaces of tunnels, cut-and-cover boxes and other surfaces specifically approved may be cured with Type-1 membrane curing compound.
  6. Finish surfaces prior to application of curing compound. Do not use curing compound on construction joints.
  7. Apply curing compound in two coats. Apply first coat immediately after stripping of forms and acceptance of concrete finish.
  8. If surface is dry, thoroughly wet concrete with water and apply curing compound just as surface film of water disappears. Apply second coat after first coat has set.
  9. Protect coating against damage for at least 10 days after application. If damage occurs, apply additional coating.
  10. If use of curing compound results in streaked or blotchy appearance, cease operations and use other method of curing until cause of defective appearance is corrected.
- D. Floor Treatment:
1. In accordance with recommendations of manufacturer of floor hardener, apply floor curing compound and curing sheet to surfaces to receive floor hardener.
  2. Where such surfaces are subject to sunlight, protect them by tenting white opaque, polyethylene waterproof sheet.
- E. Protection of Rod Reinforcement:
1. After forms are removed, coat rod reinforcement and dowels extending beyond concrete surfaces with application of neat cement paste.
  2. Remove hardened cement paste and resultant debris immediately prior to extension of reinforcement or installation of formwork.

### **3.06 COLD WEATHER CONCRETING:**

- A. Do not place concrete when ambient temperature is less than 55 ° F and falling. Do not place concrete unless the form temperature at the time of placement is at least 40 ° F.
- B. When ambient temperature is 40 ° F and falling, carry out one of the following procedures to protect placed concrete:
1. Heating:
    - a. Enclose forms or structures and heat to maintain concrete and air within enclosure at not less than 55 ° F for seven days after placement.
    - b. Maintain relative humidity at not less than 40 percent during curing period when heat is applied to enclosures. Arrange stoves, salamanders or heaters so as to provide uniform distribution of heat. Vent combustion gases to outside air. Do not let hot air blow across concrete surfaces.
    - c. After seven-day curing period, reduce temperature within enclosure gradually at maximum rate of 20 ° F per day until outside temperature has been reached.
    - d. Provide continuous and adequate fire protection and watchmen when heating units are in operation.
  2. Form insulation:
    - a. Insulate forms with blanket insulation of approved type and thickness to maintain concrete at 55 ° F minimum for seven days.
    - b. Protect top of placed concrete by tarpaulins or other approved waterproof material over insulation.

- C. Do not allow concrete to freeze in a saturated condition prior to achieving a strength of 4000 psi.

### **3.07 HOT WEATHER CONCRETING:**

- A. When temperature in forms is 75F or above, carry out the following procedures to protect placed concrete:
  - 1. Protect concrete from direct sunlight.
  - 2. Keep forms moist by means of cool-water sprinkling or application of wet burlap or cotton mats.
  - 3. At 90F or above cool aggregates with water spray hoses.
  - 4. Cool truck barrels with water spray system.

### **3.08 JOINTS:**

- A. General:
  - 1. Unless otherwise shown make construction joints bonded joints by roughening surface to expose aggregates. Clean and roughen surface by wet sandblasting, by cutting with high-pressure water jet with a minimum pressure of 2,000 psi or by other approved means. Perform cleaning after concrete has hardened to prevent raveling of surface.
  - 2. Exercise caution in cleaning concrete to prevent damage to waterstops.
  - 3. Treat overlays on slabs the same as for rock or other bonded joint.
  - 4. Place construction joints at locations shown, or at locations approved by the Engineer.
- B. Horizontal Construction Joints:
  - 1. Joints within 18 inches of tops of faces are prohibited.
  - 2. Trowel top surface of concrete adjacent to forms smooth to minimize visible joints on exposed faces. Remove laitance and other objectionable materials from joint surface to expose sound concrete as soon as concrete is firm enough to retain its form.
  - 3. Immediately after placement of concrete, remove accumulations splashed on exposed reinforcement and surfaces of adjacent forms before concrete attains initial set.
- C. Other Joints:
  - 1. Place concrete for rock tunnels with vertical contraction joints, with vertical or sloping construction joints or continuously without joints.
  - 2. Install forms for vertical joints. Remove forms as soon as concrete has attained sufficient strength to be self-supporting.
- D. Waterstops:
  - 1. Provide waterstops per Section 03100, Article 3.7.
  - 2. Rework or replace concrete where waterstop has moved unacceptably.
  - 3. Support water stop in exact position, do not sink water stops in fresh concrete.

### **3.09 CONCRETE FINISHING:**

- A. When forms are removed, do not remedy voids, stone pockets and other defects until the Engineer has inspected them and given directions.
- B. Finish concrete surfaces as shown and as follows:
  - 1. Number-1 Form Finish:

- a. Immediately following form removal, remove fins and irregular projections from surfaces exposed to view or those that will receive waterproofing.
  - b. Prepare pointing mortar not more than 30 minutes prior to use.
  - c. Cure mortar patches as specified under curing and protection.
  - d. Leave contraction joints and articulated joints in completed work carefully tooled and free of mortar and concrete.
  - e. Leave joint filler exposed for its full length with clean and true edges.
  - f. Apply this finish to structures, unless otherwise shown.
2. Number-2 Wet-Rubbed Finish:
    - a. Start rubbing of concrete after removal of forms and as soon as its condition will permit. Keep concrete thoroughly saturated with water before starting this work.
    - b. Allow sufficient time to elapse before wetting down to allow pointing mortar to thoroughly set. Rub surfaces with medium-coarse carborundum stone.
    - c. Continue rubbing until form marks, projections and irregularities have been removed, voids are filled and uniform surface is obtained.
    - d. Leave paste produced by rubbing in place. Obtain final finish by rubbing with fine carborundum stone and water after concrete above surface being treated has been cast. Continue rubbing until entire surface is of smooth texture and uniform color. After final rubbing is completed and surface has dried, rub with burlap to remove loose powder and objectionable marks.
  3. Number-3 Broomed Finish:
    - a. Where floors and other areas are shown to have rough finish, strike-off surface with screeds and wood floats at elevation shown.
    - b. Before concrete has achieved initial set, broom transversely to flow of traffic with stiff, medium-bristle broom especially made for intended purpose to develop corrugations not more than 1/8-inch deep.
  4. Number-4 Steel-Troweled Finish:
    - a. Where floors are shown to have a steel-troweled finish, screed concrete to established grades and compact with wood or power-driven disc float.
    - b. After surface has hardened sufficiently, finish with steel trowel to dense hard finish, free of trowel marks.
    - c. Do not use dry cement or mixture of dry cement and sand to absorb water.
  5. Number-5 Wood-Float Finish:
    - a. Screed inverts of subway structure, floors not specified or shown to be finished otherwise, areas below floating slabs and areas to receive dampproofing, waterproofing or roofing to a true and uniform surface conforming to shape and elevations shown.
    - b. Follow with wood-float finish to tolerances specified.
    - c. On slabs and floors, where drainage is shown, maintain accurate slopes for drainage.
    - d. Protect floors and slabs until final acceptance.
  6. Number-6 Sandblast-Sealer Finish:
    - a. Where concrete surfaces are shown to receive sandblast finish and a sealer prepare sample using sandblast finish on file in the Engineer's office as criterion.
    - b. Prepare samples with degree of sandblasting which will produce uniform texture on surface of concrete. Blast to achieve smooth, sanded surface approximately equivalent to 100-120 grit sandpaper finish.
    - c. Sandblasted surfaces will be inspected before sealing and compared with approved samples.
    - d. Apply concrete surface sealer to sandblast finish in accordance with approved procedures.
  7. Number-7 Natural-Board Finish:
    - a. After stripping forms, cut back form ties as specified. Touch-up holes created by form ties and damaged or defective finish using grout closely

matching surrounding concrete. Accomplish grouting and repairs as specified. Knock-off heavy elongated fins, but do not rub down.

8. Number-8 Abrasive-Aggregate Finish:
    - a. After screeding and floating as for Number-4 Finish, apply abrasive aggregate at rate of not less than 0.6 pound per square foot.
    - b. Sprinkle evenly in two applications using one half the amount for each application. Apply second half at right angle to first.
    - c. Follow with wood float; lightly tamp or roll surface to embed aggregate flush with concrete surface.
    - d. Lightly steel trowel to smooth, even finish.
    - e. After curing, rub surface using abrasive brick with water to slightly expose abrasive aggregate.
- C. Do not sprinkle water or cement on surfaces to be trowel finished.

### 3.10 FLOOR TREATMENT:

- A. Sealer:
  1. Water cure floor surfaces to be sealed for 28 days minimum and ensure that they are completely dry before treatment.
  2. Complete overhead work before sealer is applied.
  3. Apply liquid floor sealer in three separate coats as recommended by the manufacturer using maximum quantity recommended. Allow to dry between applications.
- B. Floor-Hardener System:
  1. Areas of application: Concrete floor surfaces as shown.
  2. Preparation:
    - a. Strike concrete to established grade using wooden strike-off bar. Further level and consolidate concrete with wood bull float or wood darby immediately following strike-off. Complete before free moisture rises to surface.
    - b. Begin floating adjacent to columns, forms and walls where concrete is most likely to stiffen first.
  3. Application:
    - a. Apply at uniform rate of 1.8 to 2.2 pounds of hardener per square foot of floor surface.
    - b. Apply first shake to floated concrete adjacent to forms, columns, and walls where moisture will be lost first. Apply 2/3 of specified total shake immediately following floating of total area as follows:
      - 1) Distribute evenly.
      - 2) Throwing shake is prohibited.
      - 3) Perform hand floating with wood floats. Magnesium floats are prohibited.
    - c. Use finishing machines with float blades as soon as shake has absorbed moisture as evidenced by darkening of surface. Do not allow float blades to dig into surface. Float sufficiently to bring moisture from base slab through shake.
    - d. Immediately after floating first shake, apply remaining 1/3 of total specified shake in the same manner and machine float as specified. Plan operations to avoid necessity of sprinkling water on surface.
    - e. As surface stiffens as evidenced by loss of sheen, finish by hand steel trowel removing marks and pinholes; leave surface in uniform condition with relatively smooth but nonslip surface.
  4. Field service:

- a. During installation, provide services of qualified representative of manufacturer to aid in proper use of product. Notify manufacturer three days minimum prior to initial application of product.
- 5. Quality control:
  - a. Prior to installation, submit for approval detailed quality-control plan describing method of application of floor hardener and listing items to be checked to ensure that materials are placed at proper time and in proper manner to achieve optimum durability of finished floor surface. Prior to submittal, have quality-control plan authenticated by qualified representative of material manufacturer indicating manufacturer's approval.
  - b. Submit quality-control reports authenticated by manufacturer's representative verifying that installation has been made in accordance with approved quality-control plan.

### **3.11 DEFECTIVE CONCRETE:**

- A. Concrete will be considered defective unless it is structurally sound, watertight, properly finished and within specified tolerances.
- B. Concrete in place that is deemed structurally defective will be checked by the Engineer by drilled core specimens. If testing of core specimens shows that strength is less than 85 percent of specified strength, costs incurred in taking and testing of core specimens will be borne by the Contractor.
- C. Replace, strengthen or correct defective concrete as directed.

### **3.12 PROTECTION FROM AND REMOVAL OF STAINS:**

- A. Protect concrete structure from rust staining by structural-steel members or from other substances during the work.
- B. If staining should occur, remove stains and restore concrete to its original color.

### **3.13 DAMAGED WORK:**

- A. Before final acceptance of the work, neatly repair damaged surfaces, corners of concrete and concrete finish.
- B. Where surface repairs are permitted, finish damaged areas to smooth, dense watertight condition.
- C. Replace concrete that is not satisfactorily repaired.

### **3.14 CORRECTIVE WORK:**

- A. Submit corrective action patching procedure.
- B. If correction of defects is approved, remove defective concrete; key area to be repaired, soak surface with water and patch with approved materials. Patch architectural concrete so as to match existing. Use bonding agents applied to the substrate or mixed with patching material only as approved by the Engineer.
- C. Clean surface cavities produced by form ties, other holes, honeycomb spots, broken corners or edges and other defects. Saturate with water and point with mortar paste consisting of

cement and fine aggregate mixed in proportions to give same appearance as original concrete.

- D. Prepare pointing mortar not more than 30 minutes prior to use. Cure mortar patches properly. Carefully tool contraction and articulated joints in completed work and keep them free of concrete. Where necessary, leave joint filler exposed for its full length with clean and true edges.
- E. Tolerance deviations and other surface defects may also be corrected, if approved, by grinding high areas and swales. Leaks in station electrical rooms, TPSS and TBS shall be epoxy injected.
- F. Where necessary or when directed, repair leakage in excess of specified maximum allowable, by means of contact grouting, chemical grouting or other approved means.
- G. Where corrective work is unsatisfactory, completely remove such work and replace with new work complying with specified requirements.

### **3.15 EPOXY MORTAR REPAIRS:**

- A. Surface Preparation:
  - 1. Remove defective concrete with chipping hammers or other approved equipment. To prevent removing extra material and causing cracks, saw-cut concrete area to be removed into maximum six-inch square checkerboard pattern 4-1/2 inches deep.
  - 2. Prepare exposed concrete surface by sandblasting clean and allowing to dry thoroughly. Surface drying may be accomplished by air jet. Ensure that compressed air used in cleaning and drying is free from oil or other contaminating materials.
  - 3. Maintain concrete surface in sufficient depth at temperature of 65F minimum during first four hours after placement of epoxy bond coat. Preheating may be done with radiant heaters or other approved means. Do not preheat concrete in excess of 200F with final surface temperature below 105F at time of placing epoxy materials.
- B. Application of Epoxy Bonding Agents:
  - 1. Prepare epoxy bonding agent in accordance with manufacturer's recommendations.
  - 2. Apply epoxy bonding agent to prepared dry concrete surface at coverage of 80 square feet per gallon maximum or as recommended by manufacturer
  - 3. Epoxy bonding agent may be applied by any convenient and safe method which will yield effective coverage, such as squeegees, brushes or rollers.
  - 4. During application of epoxy bonding agent, ensure that material is confined to area being bonded; avoid contamination of adjacent surfaces. Extend epoxy bond coat slightly beyond edges of repair area.
- C. Application of Epoxy Mortar:
  - 1. Mix epoxy components in accordance with manufacturer's recommendations.
  - 2. Proportion: 5-1/2 parts sand by weight to one-part epoxy.
  - 3. Mix components with slow-speed mechanical device.
  - 4. Prepare mortar in small batches so that each batch can be completely mixed and placed within approximately 30 minutes.
  - 5. Do not add thinners or dilutants to mortar mixture.
  - 6. Immediately after application of epoxy bonding agent, place, tamp, flatten and smooth epoxy mortar.
  - 7. Work mortar to grade.
  - 8. Steel-trowel finish. Trowels may be heated to facilitate finishing.
- D. Curing:

1. Cure epoxy mortar repairs immediately after completion at 60F minimum until mortar is hard.
2. Initiate post-curing of four hours minimum at surface temperature of 90F minimum, 110F maximum.
3. Heat may be applied by using portable propane heaters, infrared heaters or other approved sources positioned to attain necessary surface temperature.
4. Do not subject epoxy-bonded epoxy mortar to moisture until after specified post-curing has been completed.

**3.16 CONCRETE OVERLAYS AND TILE SETTING BEDS:**

- A. General:
1. Water blast (3,000 - 5,000 psi) or sand blast the substrate.
  2. Keep slabs continuously wet for 24 hours prior to concrete placement. Substrate to be air blown just prior to concrete placement.
  3. Place concrete in two pours of equal thickness. Place welded-wire-fabric reinforcement on first pour and then place second pour.
  4. Use a vibratory screed on overlays.
  5. Float slab and apply light broom finish. Cure slabs with water.
  6. Remove laitance by methods in number one above if the overlay requires a bonding surface for tile or other treatments.
  7. Continuously moist cure of overlay( setting bed) for seven(7) days.

**END OF SECTION**

## SECTION 03331

### CAST-IN-PLACE ARCHITECTURAL CONCRETE

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This Section specifies cast-in-place architectural concrete, including form work reinforcement accessories, concrete materials, concrete mix design, placement procedures, and finishes.
- B. Related Work Specified Elsewhere:
  - 1. Concrete Formwork: Section 03100 .
  - 2. Concrete Reinforcement: Section 03200.
  - 3. Cast-in-Place Structural Concrete: Section 03300.
  - 4. Seals and Sealants: Section 07900.

##### 1.02 DEFINITION:

- A. Cast-in-Place Architectural Concrete: Concrete that is exposed to view on surfaces of the completed structure or building and that requires special concrete materials, formwork, placement, or finishes to obtain specified architectural appearance.
- B. Design Reference Sample: Sample designated by The Engineer in the Contract Documents that reflects acceptable surface quality and appearance of cast-in-place architectural concrete.
- C. Reveal: Projection of the coarse aggregate from the matrix after exposure.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the Special Conditions and with the additional requirements as specified for each:
  - 1. Product Data: For each type of manufactured material and product indicated.
  - 2. Design Mixes: For each concrete mix. Include alternate mix designs when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
  - 3. Shop Drawings: Show formwork construction including form-facing joints, rustications, construction and contraction joints, form joint-sealant details, form tie location and patterns, inserts and embedments, cutouts, cleanout panels, and other items that visually affect cast-in-place architectural concrete.
  - 4. Samples: For each of the following materials
    - a. Form-facing panel.
    - b. Form-release agent.
    - c. Form ties.
    - d. Form liners.
    - e. Cement.
    - f. Coarse- and fine-aggregate gradations.
    - g. Chamfers and rustications.
    - h. Curing compound.
    - i. Coloring admixtures.
  - 5. Samples for Verification: Architectural concrete samples, cast vertically, approximately 18 by 18 by 2 inches, of finishes, colors, and textures to match the design reference sample. Include Sample sets showing the full range of variations expected in these characteristics.

6. Material Test Reports: From a qualified testing agency indicating and interpreting test results of the following for compliance with requirements indicated, based on comprehensive testing of current materials:
7. Material Certificates: Signed by manufacturers certifying that each of the following materials complies with requirements:
  - a. Cementitious materials and aggregates.
  - b. Admixtures.
  - c. Curing compounds.
8. Placement Schedule: Submit concrete placement schedule before start of architectural concrete placement operations. Include location of all joints including construction joints.

#### **1.04 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
  1. ASTM C 33, C 94, C 144, C 150, C 171, C 260, C 309, C 494, C 618, C 881, C920, C 979, C989, C 1077, C 1059, E 329, E 548, M 182
  2. ACI CP-1,117, 301, 303, 303.1, 309R.
  3. AAMA 810.1.
  4. AASHTO M 182.
- B. Installer Qualifications: An experienced cast-in-place architectural concrete contractor who has specialized in installing cast-in-place architectural concrete similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.
- C. Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.
- D. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, qualified according to ASTM C 1077 and ASTM E 329 to conduct the testing indicated, as documented according to ASTM E 548.
  1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program recognized by ASTM C 1077.
- E. Source Limitations for Cast-in-Place Architectural Concrete: Obtain each color, size, type, and variety of concrete material and concrete mix from one manufacturer with resources to provide cast-in-place architectural concrete of consistent quality in appearance and physical properties.
- F. ACI Standards: Comply with ACI 303.1, "Specification for Cast-in-Place Architectural Concrete"; ACI 301, "Specification for Structural Concrete"; and ACI 117, "Specifications for Tolerances for Concrete Construction and Materials," unless more stringent provisions are indicated.
- G. Sample Panels: Before casting architectural concrete, produce sample panels to demonstrate the approved range of selections made under sample Submittals. Produce a minimum of 3 sets of full-scale sample panels, cast vertically, approximately 48 by 48 by 6 inches minimum, to demonstrate the expected range of finish, color, and texture variations.
  1. Locate panels as indicated or, if not indicated, as directed by the Engineer.
  2. Demonstrate methods of curing aggregate exposure, sealers, and coatings, as applicable.
  3. In presence of The Engineer, damage part of an exposed-face surface for each finish, color, and texture, and demonstrate materials and techniques proposed for

- 4. repair of tie holes and surface blemishes to match adjacent undamaged surface
  - 4. Maintain sample panels during construction in an undisturbed condition as a standard for judging the completed Work.
  - 5. Demolish and remove sample panels when directed.
- H. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Meetings."

## **PART 2 - PRODUCTS**

### **2.01 FORM-FACING MATERIALS:**

- A. General: Comply with Section 03300 for formwork and other form-facing material requirements.
- B. Form-Facing Panels for As-Cast Finishes: Steel, glass-fiber-reinforced plastic, or other approved nonabsorptive panel materials that will provide continuous, true, and smooth architectural concrete surfaces. Furnish in largest practicable sizes to minimize number of joints.
- C. Form-Facing Panels for As-Cast Finishes: Exterior-grade plywood panels, nonabsorptive, that will provide continuous, true, and smooth architectural concrete surfaces, high-density overlay, Class 1, or better.
- D. Forms for Cylindrical Columns, Pedestals, and Supports: Metal, glass-fiber-reinforced plastic, paper, or fiber tubes that will provide surfaces with gradual or abrupt irregularities not exceeding specified formwork surface class. Provide units with sufficient wall thickness to resist plastic concrete loads without detrimental deformation.
- E. Pan-Type Forms: Glass-fiber-reinforced plastic or formed steel, stiffened to resist plastic concrete loads without detrimental deformation.
- F. Form Liners: Units of face design, texture, arrangement, and configuration indicated or to match design reference sample. Furnish with manufacturer's recommended liquid-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent surface treatments of concrete.
- G. Rustication Strips: Metal, rigid plastic, or dressed wood with sides beveled and back kerfed; nonstaining.
- H. Chamfer Strips: Metal, rigid plastic, elastomeric rubber, or dressed wood, 3/4 by 3/4 inch, minimum; nonstaining.
- I. Form Joint Tape: Compressible foam tape, pressure sensitive, AAMA 810.1, minimum 1/4 inch thick.
- J. Form Joint Sealant: Elastomeric sealant complying with ASTM C 920, Type M or S, Grade NS, that adheres to form joint substrates.
- K. Sealer: Penetrating, clear, polyurethane wood form sealer formulated to reduce absorption of bleed water and prevent migration from wood of set-retarding chemicals.
- L. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect architectural concrete surfaces and will not impair subsequent treatments of those surfaces.
  - 1. Formulate form-release agent with rust inhibitor for steel form-facing materials.

- M. Surface Retarder: Chemical liquid set retarder, for application on form-facing materials, capable of temporarily delaying final hardening of newly placed concrete surface to depth of reveal specified.
- N. Form Ties: Factory-fabricated, glass-fiber-reinforced plastic, internally disconnecting or removable ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.
  - 1. Furnish ties with tapered tie cone spreaders that, when removed, will leave holes not larger than 3/4 inches in diameter on concrete surface.
  - 2. Furnish internally disconnecting ties that will leave no corrodible metal closer than 1-1/2 inches, plus reveal projection of exposed aggregate, from the plane of architectural concrete surface.
  - 3. Heavy-duty forms engineered to resist the concrete without ties, to avoid difficulty in matching concrete color and patching form tie holes, may be submitted for approval by the engineer. This procedure is applicable only for the architectural concrete arches indicated.
  - 4. Furnish ties with integral water-barrier plates to walls indicated to receive dampproofing or waterproofing.

## **2.02 REINFORCEMENT ACCESSORIES:**

- A. Comply with Section 03200 and 3300 for steel reinforcement and other accessory requirements.

## **2.03 CONCRETE MATERIALS:**

- A. Portland Cement: ASTM C 150, Type I, II, or III, white color, use Type I unless otherwise approved in writing by the engineer, single source for entire Project.
  - 1. Alkali content not to exceed 0.6 percent.
  - 2. Fly Ash: ASTM C 618, Class C or F.
  - 3. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.
- B. Normal-Weight Coarse Aggregate: ASTM C 33, single source for entire Project as follows:
  - 1. Weathering Region and Class shall be 5S (severe).
  - 2. Nominal Maximum Aggregate Size: 3/4 inch, uniformly graded.
- C. Normal Weight Fine Aggregate: ASTM C144, natural sand from single source.
- D. Water: Potable, complying with ASTM C94 except free of wash water from mixer cleanout operations.
- E. Chemical Admixtures: Certified by manufacturer to contain not more than 0.1 percent water-soluble chloride ions by mass, compatible with other admixtures and cementitious materials. Admixtures containing calcium chloride are prohibited.
  - 1. Air-Entraining Admixture: ASTM C 260.
  - 2. Water-Reducing Admixture: ASTM C 494, Type A.
  - 3. High-Range, Water-Reducing Admixture: ASTM C 494, Type F.
  - 4. Water-Reducing and Accelerating Admixture: ASTM C 494, Type E.
  - 5. Water-Reducing and Retarding Admixture: ASTM C 494, Type D.
- F. Coloring Admixture: ASTM C 979, synthetic mineral-oxide pigments or colored water-reducing admixtures, free of carbon black; color stable, nonfading, and resistant to lime and other alkalis.
  - 1. Color: As necessary or if necessary to match color of sample provided.

## **2.04 CURING MATERIALS:**

- A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, washed to prevent concrete staining, weighing approximately 9 oz./sq. yd. when dry.
- B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.
- C. Clear, Liquid Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B.
  - 1. For integrally colored concrete, curing compound shall be pigmented type approved by coloring admixture manufacturer.
  - 2. For concrete indicated to be sealed, curing compound shall be compatible with sealer.

#### **2.05 REPAIR MATERIALS:**

- A. Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.
- B. Epoxy-Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class and grade to suit requirements, and as follows:
  - 1. Types IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.

#### **2.06 CONCRETE MIXES:**

- A. Prepare design mixes for each type and strength of cast-in-place architectural concrete determined by either laboratory trial mix or field test data bases. Proportion concrete according to ACI 211.1 and ACI 301.
- B. Use a qualified independent testing agency for preparing and reporting proposed concrete mix designs for the laboratory trial mix basis.
- C. Proportion concrete mix as follows:
  - 1. Compressive Strength (28 Days): 4000 psi.
  - 2. Maximum Water-Cementitious Materials Ratio: 0.46.
  - 3. Maximum Slump: 4 inches.
- D. Cementitious Materials: For cast-in-place architectural concrete exposed to deicers, limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 requirements.
- E. Air Content: Add air-entraining admixture at manufacturer's prescribed rate to result in architectural concrete at point of placement having an air content of 6 percent within a tolerance of plus 1 percent or minus 1.5 percent. Delete below if integrally colored concrete is not required.
- F. Coloring Admixture: Add coloring admixture to architectural concrete mix according to manufacturer's written instructions.

#### **2.07 CONCRETE MIXING:**

- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver cast-in-place architectural concrete according to ASTM C 94, and furnish batch ticket information.
- B. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 90 to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

## **PART 3 - EXECUTION**

### **3.01 FORMWORK:**

- A. General: Comply with Section 03100 Concrete Formwork for formwork and embedded items.
- B. Comply with ACI 303.1 limits on form-facing panel deflection.
- C. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast-in-place surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical. Kerf wood rustications, keyways, reglets, recesses, and the like, for easy removal.
  - 1. Do not use rust-stained, steel, form-facing material.
- D. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.
- E. Chamfer exterior corners and edges of cast-in-place architectural concrete.
- F. Coat contact surfaces of wood rustications and chamfer strips with sealer before placing reinforcement.
- G. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.
- H. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.
- I. Seal form joints and penetrations at form ties with form joint tape or form joint sealant to prevent mortar leaks
- J. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.
- K. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

### **3.02 REINFORCEMENT AND INSERTS:**

- A. General: Comply with Section 03200 Concrete Reinforcement for fabricating and installing steel reinforcement.
- B. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.

### **3.03 REMOVING AND REUSING FORMS:**

- A. Formwork, for sides of beams, walls, columns, and similar parts of the Work, that does not support weight of concrete may be removed after cumulatively curing at not less than 50 deg F for 24 hours after placing concrete, provided concrete is hard enough to not be damaged by form-removal operations and provided curing and protection operations are maintained.
- B. Leave formwork, for beam soffits, joists, slabs, and other structural elements, that supports weight of concrete in place until concrete has achieved at least 70 percent of 28-day design

compressive strength. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.

- C. Clean and repair surfaces of forms to be reused in the Work. Do not use split, frayed, delaminated, or otherwise damaged form-facing material. Apply new form-release agent.
- D. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for architectural concrete surfaces.

### **3.04 JOINTS:**

- A. Construction Joints: Install construction joints true to line with faces perpendicular to surface plane of cast-in-place architectural concrete so strength and appearance of concrete are not impaired, at locations indicated or as approved by the Engineer.
  - 1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints, unless otherwise indicated.
  - 2. Use bulkhead forms with keys of plywood, wood, or expanded galvanized steel sheet, unless otherwise indicated. Embed keys at least 1-1/2 inches into concrete. Align construction joint within rustications attached to form-facing material.
  - 3. Locate joints for beams, slabs, joists, and girders in the middle third of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
  - 4. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
  - 5. Space vertical joints in walls as indicated. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.
  - 6. Use epoxy-bonding adhesive at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
- B. Contraction Joints: Form weakened-plane contraction joints true to line with faces perpendicular to surface plane of cast-in-place architectural concrete so strength and appearance of concrete are not impaired, at locations indicated or as approved by The Engineer.

### **3.05 CONCRETE PLACEMENT:**

- A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.
- B. Do not add water to concrete during delivery, at Project site, or during placement, unless approved by The Engineer.
- C. Deposit concrete continuously between construction joints. Deposit concrete to avoid segregation.
- D. Deposit concrete in forms in horizontal layers no deeper than 24 inches and in a manner to avoid inclined construction joints. Place each layer while preceding layer is still plastic, to avoid cold joints.
  - 1. Consolidate placed concrete with mechanical vibrating equipment. Use equipment and procedures for consolidating concrete recommended by ACI 309R.
  - 2. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations no farther than the visible effectiveness of the vibrator.
- E. Cold-Weather Placement: Section 03300.

F. Hot-Weather Placement: Section 03300.

**3.06 FINISHES, GENERAL:**

- A. Architectural Concrete Finish: Match The Engineer's design reference sample, identified and described as indicated.
- B. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces.
  - 1. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces, unless otherwise indicated.
- C. Maintain uniformity of special finishes over construction joints, unless otherwise indicated.

**3.07 AS-CAST FORMED FINISHES:**

- A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defective areas repaired and patched. Remove fins and other projections exceeding ACI 347R limits for class of surface specified.
- B. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and defective areas. Remove fins and other projections exceeding 1/8 inch in height.
- C. Sand Blast-Sealer Finish: Section 03300.

**3.08 CONCRETE CURING:**

- A. Protect freshly placed concrete from premature drying and excessive cold or hot temperatures according to ACI 301.
- B. Begin curing immediately after removing forms from concrete. Cure by one or a combination of the following methods that will not mottle, discolor, or stain concrete:
  - 1. Moisture Curing: Keep exposed surfaces of cast-in-place architectural concrete continuously moist for not less than seven days with the following materials:
    - a. Water.
    - b. Continuous water-fog spray.
    - c. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.
  - 2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period; use cover material and waterproof tape.
  - 3. Curing Compound: Mist concrete surfaces with water. Apply curing compound uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

**3.09 FIELD QUALITY CONTROL:**

- A. General: Comply with Section 03300 for field quality-control requirements

### **3.10 REPAIRS, PROTECTION, AND CLEANING:**

- A. Repair and cure damaged finished surfaces of cast-in-place architectural concrete when approved by The Engineer. Match repairs to color, texture, and uniformity of surrounding surfaces and to repairs on approved mockups.
  - 1. Remove and replace cast-in-place architectural concrete that cannot be repaired and cured to The Engineer's approval.
- B. Protect corners, edges, and surfaces of cast-in-place architectural concrete from damage; use guards and barricades.
- C. Protect cast-in-place architectural concrete from staining, laitance, and contamination during remainder of construction period.
- D. Clean cast-in-place architectural concrete surfaces after finish treatment to remove stains, markings, dust, and debris.
- E. Wash and rinse surfaces according to concrete finish applicator's written recommendations. Protect other Work from staining or damage due to cleaning operations.
  - 1. Do not use cleaning materials or processes that could change the appearance of cast-in-place architectural concrete finishes.

**END OF SECTION**

## SECTION 03370

### SHOTCRETE

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing shotcrete in permanent lining work.
- B. Related Work Specified Elsewhere:
  - 1. Rock reinforcement: Section 02420.
  - 2. Chemical grout: Section 02431.
  - 3. Concrete: Section 03300.
- C. Definitions:
  - 1. Shotcrete: Portland-cement concrete applied from a nozzle by compressed air and containing, if necessary, admixtures to provide quick set, high early-strength and satisfactory adhesion.
- D. Shotcrete Test Strengths:
  - 1. Specified testing strengths have been modified by length to diameter ratio (L/DR) adjustments and coring correction factors that will achieve design strength of 5,000 psi.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ASTM: C31, C33, C39, C42, C150, C192, C266, C494.
- B. Qualifications of Applicator:
  - 1. Have work performed by firm regularly engaged in shotcreting.
  - 2. Employ qualified nozzle operators who have had previous experience or training in application of shotcrete on at least two projects of comparable nature. Perform work under immediate supervision of foreman with at least three years experience. Have each nozzle operator demonstrate for approval, acceptable proficiency in uniformity of application of shotcrete to vertical and overhead test panels before beginning production work.
- C. Uniformity of Materials:
  - 1. In applied production work, use same cement, aggregate and water used in approved test areas and test units. Minor adjustment permitted subject to prior approval. Maintain specified strengths.
- D. Mix Design and Testing Prior to Production:
  - 1. Develop shotcrete mix by laboratory compatibility tests and field trials as specified at least 60 days prior to the actual application of shotcrete.
  - 2. Perform compatibility tests to determine cements and additives to be used in field trial mixes. Determine initial and final set for additive concentrations of varying percentages of cement content by weight contemplated for use in the work.
  - 3. Make laboratory and field trial mixes with ingredients identical to those proposed for use in the work.

4. To ascertain compatibility of ingredients and optimum proportions, develop shotcrete mix having strength and characteristics necessary for actual application.
  5. Accelerating admixture:
    - a. Use approved accelerating admixture to develop quick set as follows:
      - 1) Time of initial setting: Three minutes maximum.
      - 2) Time for final setting: 12 minutes maximum.
    - b. Determine time of setting in accordance with ASTM C266 with the following additional requirements:
      - 1) Add accelerator to 50 grams of cement in preparation of paste, together with water to produce water-cement ratio in varying percentages expected to be used in actual shotcrete application.
      - 2) Use minimum possible time interval to attain proper mixing without disturbing initial set of paste.
      - 3) Additional modifications to accommodate quick-set accelerators: As approved.
  6. Standard concrete-cylinder testing:
    - a. Choose materials and proportions so that three cast cylinders six inches by 12 inches made with no additive will achieve average minimum strength at 28 days of 7,000 psi. Cast cylinders in accordance with ASTM C192 and test in accordance with ASTM C39. Cast and test three cylinders minimum for each combination of materials proposed.
  7. Field trial:
    - a. After completion and approval of laboratory tests, make field trials using selected mixes to accommodate capability of equipment, workmanship and material under field conditions prior to actual application of shotcrete.
    - b. Make field application of each mix selected for field trial on at least three horizontal overhead and three vertical test panels to simulate construction conditions.
    - c. Shoot test panels measuring not less than 18 inches square by six inches.
    - d. Cure test panels in accordance with ASTM C31.
    - e. Within 24 hours after shooting, obtain from each panel and submit a minimum of seven full-depth cores each three inches in diameter.
    - f. Average three cores from each panel to comprise one test.
    - g. Perform field-trial work in the presence of the Engineer.
    - h. The Engineer will cut specimens to length equal to diameter and test specimens in accordance with ASTM C42 except as otherwise specified. Soaking of specimens prior to testing is prohibited. The Engineer will make no L/DR correction in reporting results.
    - i. Achieve strengths as follows:
      - 1) Average strength of six tests, three overhead and three vertical, at 24 hours: 2,000-psi minimum.
      - 2) Average strength of six tests, three overhead and three vertical, at 28 days: 5,540-psi minimum.
  8. Proportions:
    - a. Proportion shotcrete mixes equivalent to those of a concrete mix having between 6.5 and 8.5 bags of cement per cubic yard.
- E. Testing:
1. Before proceeding with the work in accordance with manufacturer's published instructions, completely seal by the methods and materials to be used in the work the following:
    - a. Circular or single-horseshoe tunnels: 25-foot section of area of tunnel roof described by arch of approximately 45 degrees on each side of tunnel's vertical centerline, extending to one-foot minimum beyond outside face of third-rail cover and on opposite side of track to one-foot beyond outside face of track rail.

- b. Station vaults: 10-foot section of station-roof area described by arch of approximately 75 degrees on each side of station vault's vertical centerline, extending to one-foot minimum beyond back face of station's precast-concrete liner panels.
- c. Crossover vaults: 10-foot section of area of crossover roof described by arch of approximately 67 degrees on each side of crossover's vertical centerline extending to one-foot minimum beyond outside face of third-rail cover on one side and on opposite side of track to one-foot beyond outside face of track rail.

#### **1.02 SUBMITTALS:**

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Samples:
    - a. On completion of field trial, submit 42 test specimens of each trial mix, seven from each test panel, proposed for use in the work together with relevant data which demonstrate conformance with specified requirements. These specimens will be tested by the Engineer to verify such conformance.
  - 2. Certification:
    - a. Mill or manufacturer's certificates with mix design verifying that materials meet specified requirements.
    - b. Certified test reports without adjustment for type or size of specimen.
    - c. Personnel documentation as required under Quality Assurance article above.
  - 3. Documentation:
    - a. Prior to making laboratory compatibility tests, submit detailed plan showing methods and proportions to be used in such tests. The Engineer may inspect tests and materials at any time.

#### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Store and handle basic materials in accordance with Section 03300.

#### **1.05 JOB CONDITIONS:**

- A. Alkali hydroxides and other chemicals contained in shotcrete admixtures are moderately toxic and can cause skin and respiratory irritation unless adequate safety measures are taken.

### **PART 2 - PRODUCTS**

#### **2.01 MATERIALS:**

- A. Portland Cement: ASTM C150 Type I or Type III. If Type II is specified, Type I or III may still be used provided tricalcium aluminate is less than eight percent.
  - 1. Alkali content not to exceed 0.6 percent.
- B. Aggregate: Section 03300, with following additional requirements:
  - 1. Uniformly well-graded and not exhibiting extremes of gradation, in accordance with ASTM C33.
  - 2. Specific gravity: 2.55 minimum.
  - 3. Maximum aggregate size: No. 67.
- C. Water: Section 03300.

- D. Admixtures: ASTM C494, Type C, with the following additional requirements:
  - 1. Containing no water-soluble chlorides or materials corrosive to steel nor those which can cause other detrimental effects such as cracking or spalling.
  - 2. In accordance with reference standard or documented history of demonstrable satisfactory performance in mix of similar proportions.
  - 3. Chemical Grout: Section 02431. Use soil-solidification agent only when shotcrete is to be in contact with earth.

## **PART 3 - EXECUTION**

### **3.01 FIELD QUALITY CONTROL:**

- A. Testing During Construction:
  - 1. Furnish three-inch diameter core test specimens with minimum length of six inches, three for each 50 cubic yards of material used in Stage-II and Stage-III shotcrete.
  - 2. Take cores from completed work at locations and on date directed.
  - 3. The Engineer will cut test cores to length equal to diameter and test cores in accordance with ASTM C42 and as specified. The Engineer will make no L/DR correction in reporting the results.
  - 4. Test specimens shall be cured/conditioned wet or dry, depending on wet/dry condition shotcrete will be under load.
  - 5. After application of the first 500 cubic yards of shotcrete, the Engineer may call for test specimens at the reduced rate of three per 100 cubic yards of material.
  - 6. Additional specimens will be required upon failure of original cores. Should additional specimens show acceptable strength, the work will be accepted. If additional specimens show unacceptable strength, the work will be rejected. Furnish additional specimens as directed.
  - 7. Plug voids caused by coring operation with material equal to shotcrete in-place and workmanship to ensure continuity of lining with respect to watertightness, strength and appearance.
  - 8. Shotcrete strengths determined by testing during construction:
    - a. Average strength of three cores from one area: 4,670-psi minimum when tested at 28 days.
    - b. Minimum strength of a single core: 4,120 psi at 28 days.
- B. Watertightness Criteria:
  - 1. Permanent-support lining for circular or single-horseshoe tunnels:
    - a. Maximum-allowable water leakage:
      - 1) 0.14 gallon-per-minute per 250 linear feet.
      - 2) 0.07 gallon-per-minute in any 10 linear feet.
  - 2. Permanent-support lining for station vaults or crossover vaults:
    - a. Prior to application of Stage-III shotcrete:
      - 1) Control water flow by appropriate approved methods.
    - b. Maximum allowable water leakage after application of Stage-III shotcrete:
      - 1) 0.08 gallon-per-minute per 250 linear feet.
      - 2) 0.04 gallon-per-minute in any 10 linear feet.

### **3.02 PROPORTIONING AND MIXING:**

- A. Have aggregate and cement proportioned by an approved batching plant based on weight or volume and in accordance with the applicable requirements of Section 03300.
- B. For dry-mix process, maintain moisture content of combined aggregate in range of three to six percent of oven-dry weight of aggregate at time of mixing with cement.

- C. Use mixed material within one-hour after adding cement.
- D. Accurately proportion and thoroughly mix additive with other ingredients.

### **3.03 SHOTCRETE APPLICATION:**

- A. Remove loose material, mud and other foreign matter from new and previously shotcreted surfaces that are to receive shotcrete.
- B. After cleaning, keep surfaces moist until shotcrete is applied.
- C. Hold nozzle at predetermined distance and position so that stream of flowing material is applied as nearly as possible at right angles to surface to be covered.
- D. Maintain steady nozzle motion as layer is built up to thickness shown or specified.
- E. Apply shotcrete of uniform consistency to maximize binding, cohesion and density, to minimize rebound and segregation and to prevent sagging of applied shotcrete.
- F. Acceptable shotcrete consists of dense, uniform concrete without segregation or discernible weakness of bond between layers accomplished without reuse of rebound.
- G. Do not apply shotcrete to frozen surfaces.

### **3.04 SEQUENCE OF OPERATIONS:**

- A. Apply shotcrete lining in three stages.
- B. Stage I:
  - 1. Apply first shotcrete layer to surface of excavation exposed by blasting. Complete operation within three hours.
  - 2. Install rock bolts, steel-rib supports and their assemblies after Stage-I shotcrete application.
- C. Stage II: Apply shotcrete to provide continuous blocking of steel-rib supports within specified distance from heading.
- D. Stage III: Apply shotcrete to surfaces to total thickness shown within specified distance from heading.
- E. Cure final shotcrete layer for seven days in accordance with Section 03300. Remove laitance, loose material and rebound. Sound surface layer with hammer to verify absence of voids, rebound pockets, aggregate pockets and unbonded areas.

### **3.05 CONTROL OF WATER:**

- A. Prior to Stage-II shotcrete application, control water flows and seepage to comply with specified watertightness criteria. Control water by appropriate approved methods.
- B. To eliminate water penetration, completely seal areas as specified for quality assurance using approved methods and materials.

### **3.06 DEFECTIVE SHOTCRETE:**

- A. All shotcrete which lacks uniformity or exhibits segregation, low strength, honeycombing or laminations will be regarded as defective. Stage-II and III shotcrete will be considered defective unless it is crack-free and watertight.
- B. Remove and replace or otherwise correct all defective shotcrete as directed.

**END OF SECTION**

## SECTION 03400

### STRUCTURAL PRECAST CONCRETE

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies precast-concrete work.
- B. Related Work Specified Elsewhere:
  - 1. Concrete formwork: Section 03100.
  - 2. Concrete reinforcement: Section 03200.
  - 3. Cast-in-place structural concrete: Section 03300.
  - 4. Prestressed concrete: Section 03415.
  - 5. Flashing and reglets: Section 07600.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ACI: 503.
  - 3. ASTM: A666, C143, C50, C881, C1107.
  - 4. PCI: MNL 116, Plant Certification Program.
- B. Manufacturer's Qualifications: Use only a precast concrete manufacturing plant (or site) certified by PCI Plant Certification Program.
  - 1. Certification is required at time of bidding and throughout construction time.
  - 2. Furnish certification in the following product groups and categories: A1, C1, plus additional certification as appropriate to the visibility and use of precast units required.
  - 3. Furnish name, qualifications and evidence of recent experience on work comparable to that specified.
  - 4. Do not commence work until fabricator has been approved.
- C. Test Units:
  - 1. Prior to production runs of precast elements, cast at least two full-size test units as specified.
  - 2. Color, texture, finish and workmanship subject to approval.
- D. Uniformity of Materials:
  - 1. To minimize irregularities in color and texture, use same cement, aggregate and water in delivered production units as that used in approved samples and test units.
- E. Repair of Defective Concrete: Effect epoxy-mortar repairs in accordance with ACI 503.4-.7, except as otherwise specified.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Have drawings and calculations certified by a registered professional engineer who is licensed to practice in the jurisdiction where the work is to be performed and is experienced in the work of this section.

- b. Include details of form fabrication, profiles, joints, reinforcing steel, clips, anchors, inserts, reglets, lifting devices, connection to other work and placement and erection sequence.
  - c. Submit prior to fabrication of units and ordering material.
- 2. Samples:
  - a. Panels representing color, texture and general finish of test units and production panels, each 12 inches square by 1-1/2 inches: Two. Submit prior to fabrication.
  - b. Gasket and flashing materials proposed for use, each 12 inches long: Two.
- 3. Certification:
  - a. Certificates from concrete supplier as specified in Section 03300.
  - b. Certification or published listing of manufacturer per Quality Assurance paragraph above.
- 4. Documentation:
  - a. Prior to installation of units, submit schedule indicating sequence of installation, joints, support and bracing system and anchoring system.
  - b. Design mix. Submit prior to use for test units.
  - c. Delivery tickets from concrete supplier in lieu of certification as specified in Section 03300.
- 5. Quality Control Plan: Provide production quality control in accordance with the requirements of PCI MNL 116.

**1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Store and handle basic materials in accordance with Section 03300.
- B. After completion of fabrication and curing, transport and store units.
- C. Avoid damaging of surfaces, edges and corners and creating of stresses within units.
- D. Keep units under cover and protected until installed.

**PART 2 - PRODUCTS**

**2.01 MATERIALS:**

- A. Concrete: Section 03300, Class 5000 unless otherwise shown; slump of 3-1/2 inches plus-or-minus 1/2 inch as determined by ASTM C143.
  - 1. Color matching sample on file with the Engineer.
- B. Formwork:
  - 1. One of the following in accordance with Section 03100.
    - a. Fibrous-glass-reinforced plastic forms.
    - b. Steel forms.
    - c. Epoxy-coated concrete forms.
  - 2. Use largest sizes possible to produce units without visible joints.
- C. Reinforcement: Section 03200, welded-wire fabric to be galvanized.
- D. Gaskets:
  - 1. ASTM C509, preformed, expanded closed-cell neoprene sponge, acid-resistant, nonstaining, inert to temperature changes, sized to provide constant compression in joint and in pieces as long as practicable to minimize field splices.
  - 2. Gasket cement: Type recommended by gasket manufacturer.

- E. Anchors, Dowels and Accessories Cast Into Precast Units: Steel, hot-dip galvanized.
- F. Joint Connections: Stainless steel, ASTM A666.
- G. Surface Sealer:
  - 1. Methyl-methacrylate-based water repellent.
  - 2. Compliant with Federal and local VOC limitations.
  - 3. Nonpeeling, low viscosity and surface penetrating.
  - 4. Water-repellent, performing as a warranted barrier to moisture penetration for minimum of five years under exterior exposure.
  - 5. Colorless, nonyellowing, nonglossy, not affecting color, texture or surface of concrete for life of material.
- H. Sandblasting Sand: One-size silica sand equivalent to Ottawa Sand Grade, graded to pass Size 20 sieve and retained on Size 30 sieve.
- I. Non-shrink Grout: Premixed, nonmetallic, noncorrosive, nonstaining grout containing selected silica sands, portland cement, shrinkage-compensating agents, plasticizing and water-reducing agents, complying with ASTM C1107, with fluid consistency and a 30-minute working time.
- J. Epoxy Adhesive: Non-sagging. Consist of epoxy resin bonding material and a hardener. Epoxy shall conform to ASTM C881

### **PART 3 - EXECUTION**

#### **3.01 FABRICATION OF TEST UNITS:**

- A. In order to determine materials, proportions and techniques which will result in required color, texture, finish and strength and which will be used in precast concrete production, cast at least two full-size test units, using forms, concrete mix proportions, admixtures and methods proposed for production work.
- B. Design mix to conform to Section 03300 and submit for approval prior to use in test units.
- C. Cast test units as directed to simulate production run, incorporating reinforcing and embedded items as shown.
- D. Maintain complete records of proportions, mixing, consolidation and curing procedures during casting.
- E. Prepare a set of at least four test cylinders during casting of each test unit for compressive tests as specified in Section 03300.
- F. If approved, precast-concrete elements may be cured by accelerated method such as steam treatment. The Engineer may direct that test cylinders be cured in accordance with curing process selected in order to determine satisfactory period of hardening of concrete in the units.
- G. Sandblasting and Sealing:
  - 1. After curing and when so directed, sandblast test units to determine conditions for achieving required texture of concrete surface. Use specified silica sand.
  - 2. Determine required surface texture by varying blasting pressure, size of nozzle, duration of blasting and distance between nozzle and surface. Maintain complete records of sandblasting.

3. After sandblasting test units, seal surface with application of sealing compound as specified.
  4. Prior to application of sealer, thoroughly clean surface by application of water or air. Apply sealer as recommended by manufacturer.
  5. Keep complete record of each sealer application.
  6. Utilize approved procedures and materials on the basis of test applications specified for sandblasting and sealing of surfaces of precast-concrete work.
- H. After test units are approved, fabricate units using mix, ingredients, sandblasting technique and sealer formulation used to prepare test units.
- I. If strength, color, texture, finish or workmanship of test units is rejected, cast additional units until units meet requirements and approval is obtained.

**3.02 FABRICATION OF PRODUCTION UNITS:**

- A. Fabricate units in number and sizes shown and specified to match approved test units.
- B. Deliver units to site in compliance with erection schedule.

**3.03 DEFECTIVE AND DAMAGED CONCRETE UNITS:**

- A. Do not install units with surface imperfections such as air bubbles, joint lines, warpage, stains, uneven matrix plane or uneven exposure of aggregate or units which are warped, cracked, broken, spalled, stained or otherwise defective.

**3.04 ERECTION:**

- A. Lift, support and erect precast members so as to prevent damage or overstressing. Handle precast members by means of lifting inserts, loops or other approved means.
- B. After erection remove lifting loops, bend them over or cut them flush with the surface of the concrete. If insert material may cause stains to surfaces exposed to view, inset cut and patch concrete.
- C. Set members in position properly leveled, aligned and braced as shown.
- D. Install members so that their erected position does not differ from position shown on approved shop drawings by more than allowable tolerances.
- E. Bring defects detected after erection to the attention of the Engineer who will conduct inspection. Where in his opinion structural adequacy is impaired, replace member.

**END OF SECTION**

## SECTION 03415

### PRESTRESSED CONCRETE

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies prestressed concrete work.
- B. Related Work Specified Elsewhere:
  - 1. Concrete formwork: Section 03100.
  - 2. Concrete reinforcement: Section 03200.
  - 3. Cast-in-place structural concrete: Section 03300.
  - 4. Precast concrete: Section 03400.
- C. Definitions:
  - 1. Site or job site: Location where members are to be manufactured.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. PCI: MNL 116, Plant Certification Program.
  - 3. ASTM: A416, A421, A722, C109, C404, C618.
- B. Fabricator Qualifications: Use only a prestressed concrete manufacturing plant (or site) certified by PCI Plant Certification Program.
  - 1. Certification is required at time of bidding and throughout construction time.
  - 2. Furnish certification in the following product groups and categories: A1, C1, plus additional certification as appropriate to the visibility and use of prestressed units required.
  - 3. Furnish name, qualifications and evidence of recent experience on work comparable to that specified.
  - 4. Do not commence work until fabricator has been approved.
- C. Installer qualifications: Use only an experienced installer who has completed prestressed concrete work similar in material, design and extent to that indicated for this Project and with a record of successful in-service performance.
- D. Allowable Tolerances:
  - 1. Fabricate prestressed-concrete members in accordance with dimensional tolerances indicated in referenced PCI standard.
- E. Sampling and Testing:
  - 1. Concrete:
    - a. Perform sampling, testing and frequency of testing in accordance with Section 03300, except as otherwise specified.
    - b. Mold three sets of at least two cylinders for each casting bed each day it is used or for each 100 cubic yards of concrete or fraction thereof for each prestressed-concrete structure. In any case, have at least six cylinders cast for each group of members cast from each batch.
    - c. Cure cylinders for stress transfer in same environment as members or structures they represent.

- d. Test one set for compressive strength at stress transfer and one set on twenty-eighth day.
  - e. Have tests performed by approved independent testing agency.
  - f. The Engineer may test concrete at any time during fabrication operations.
  - g. For major members carrying rapid transit loads or underpinning loads or as directed, perform sampling and testing in accordance with ASTM A416 and ASTM A421.
2. Tendons:
- a. Furnish samples for testing from each size and each heat of prestressing bars, from each manufactured reel of prestressing-steel strand, from each coil of prestressing wire and from each lot of anchorage assemblies and bar couplers to be used. With each sample of prestressing-steel wires, bars or strands furnished for testing, submit certificate stating manufacturer's minimum guaranteed ultimate tensile strength of sample furnished. Prior to installation submit certified test results from each manufacturer for each type of low-relaxation steel.
  - b. Furnish testing materials and equipment.
  - c. Assign individual lot number to bars of each size from each mill heat, wire from each coil, and strand from each manufactured reel to be shipped to site and tag so that each lot can be accurately identified at job site. Likewise, identify each lot of anchorage assemblies and bar couplers to be installed.
  - d. Unidentified prestressing steel, anchorage assemblies or bar couplers received at site will be rejected.
  - e. Submit the following samples of materials and tendons, selected by the Engineer from prestressing steel at plant or jobsite:
    - 1) For wire, strand or bars: One sample of each size from each heat or reel.
    - 2) If prestressing tendon is to be prefabricated, one completely fabricated prestressing tendon five feet in length for each size of tendon, including anchorage assemblies. If the prestressing tendon is to be assembled at jobsite, sufficient wire or strand and end fittings to make up one complete prestressing tendon five feet in length for each size of tendon, including anchorage assemblies.
    - 3) If prestressed tendon is a bar, one five-foot length complete with one end anchorage; if couplers are to be used with the bar, two four-foot lengths of bar equipped with one coupler and fabricated to fit coupler.
  - f. For prefabricated tendons, notify the Engineer at least 10 working days prior to commencing installation of end fittings or heading of wires. The Engineer will inspect end-fitting installations and wire headings while such fabrication is in progress at the plant and will arrange for testing of material to be shipped to the site.
  - g. Do not ship prefabricated tendons to the site until they are released by the Engineer. Tag each tendon before shipment as specified.
  - h. Material released by the Engineer will be rejected if subsequently damaged or found defective.

### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Have drawings and calculations for prestressed products certified by a registered professional engineer who is licensed to practice in the

- jurisdiction where the work is to be performed and who is experienced in the work of this section.
- b. Include the following:
    - 1) Description of equipment to be used and procedure for constructing prestressed-concrete members.
    - 2) Ductwork and method of holding ducts in position, tendon or bar sizes, splicing of bars, unit weights, materials and stress grade, jack clearances and procedures, stressing sequence, initial-tensioning forces, pressure gauge or load cell for determining loads, calculated friction and elastic-shortening losses and tendon or bar elongation, anchorage details and anchorage-slippage losses, bonding and grouting procedures, mild-steel placement, provisions for camber and clearances and concrete dimensions.
    - 3) Details of procedures for yard and site, handling, transporting, storing and erecting. If necessary, furnish design calculations. Show embedded items including, but not limited to, inserts, anchors, couplings, fittings, vent-hole openings and anchorage pockets. Show method of tendon support for post-tensioned systems during tendon-placing operations.
    - 4) Complete details and substantiating calculations of method and materials proposed for use in prestressing operations, including additions or rearrangement of reinforcing steel from that shown. Calculate, detail and show individual tendon layout and anchorage arrangement to satisfy design requirements and to avoid interferences. Coordinate with embedded items. Changes or rearrangement of details shown permitted only with approval. Ensure that spacing of tendon is sufficient for full encasement of each tendon in concrete. Plan sequence of installation to minimize fitting problem of various components embedded in prestressed member. Show camber computations.
    - 5) Stress/strain curve of tendons and bars. Show amount of slip normally expected in seating anchorage devices as opposed to that assumed in design calculations. Show friction-wobble coefficient and friction-curvature coefficient expected from tendons and bars and duct material. Show complete stress diagram for each tendon size or type.
    - 6) Bills of materials, erection diagrams and details of connections to other work.
    - 7) Details and design calculations for size and thickness of anchor plates and corresponding reinforcement necessary for each system to guarantee safe transfer of forces into end block. Show amount, size and arrangement of such reinforcement to be installed at anchorage zones and along path of tendons to prevent bursting and splitting concrete members when subjected to prestressing forces. Special Anchorage Devices, as defined by the AASHTO Guide Specifications for Design and Construction of Segmental Concrete Bridges, shall be approved based on the results of testing representing actual jobsite conditions.
2. Working Drawings:
    - a. Complete working drawings and necessary calculations for formwork and falsework.
    - b. Include compensation for deflection as necessary to construct structure to lines and grades shown.
    - c. Consider loads, forces and stresses to be imposed during casting and post-tensioning elements of structure.

3. Samples: As previously specified.
4. Certification:
  - a. Tendons:
    - 1) Certificates for each five reels or coils or fraction thereof.
    - 2) Submit certificates prior to delivery of tendons to jobsite.
    - 3) Applicable certificates to accompany each shipment of tendons.
  - b. Hydraulic jacks:
    - 1) Certified calibration curves for each hydraulic jack.
  - c. Certified test reports:
    - 1) Concrete tests.
    - 2) Tendons: For each size of strand to be used in the work, submit test certificates showing physical, chemical and stress/strain test properties including modulus of elasticity and stating guaranteed minimum ultimate tensile and yield strength.

5. Documentation:
  - a. Specified calculations.
  - b. Records of tendon elongation promptly upon completion of post-tensioning of each member.

- B. Quality Control Plan: Provide production quality control in accordance with the requirements of PCI MNL 116.

#### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Prestressing Steel:
  1. Protect prestressing steel against physical damage and rust or other results of corrosion at all times from manufacture to grouting or encasing in concrete. Physically damaged prestressing steel will be rejected. Rust or other corrosion will be cause for rejection.
  2. Package prestressing steel in containers or shipping forms for protection against physical damage and corrosion during shipping and storage. Place corrosion inhibitor and rust preventive in package or form or use corrosion-inhibiting carrier-type packaging material. If approved, apply corrosion inhibitor directly to steel.
  3. Use corrosion inhibitor which has no deleterious effect on steel, concrete or bond strength of steel to concrete.
  4. Replace or restore to original condition damaged packaging or forms.
  5. Clearly mark shipping package or form with statement that package contains high-strength prestressing steel, and caution that care be used in handling. Show type, kind, amount and placement date of corrosion inhibitor used. Include safety recommendations and instructions for use.
  6. When prestressing steel for post-tensioning is installed in members prior to placing and curing concrete, provide protection against rust or other corrosion, until grouted, by means of corrosion inhibitor placed in ducts or applied to steel in duct.
  7. Do not stress tendons until 28 day compressive strength is verified.
- B. Members:
  1. Handle, store and transport completed members and member components so as to prevent damage.
  2. Maintain beams in upright position.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS:**

- A. Concrete:
  - 1. Section 03300: Class 5000, unless otherwise specified.
- B. Grout:
  - 1. Materials for grout: Section 03300 and ASTM C404. Pozzolans, if used: ASTM C618.
- C. Formwork and Accessories: Section 03100.
- D. Reinforcing Steel: Section 03200.
- E. Tendons, Anchorage, Couplers and Ducts:
  - 1. Pretensioning tendons:
    - a. Steel strand: ASTM A416, Grade 270, regular or low-relaxation.
    - b. Strand similar to specified steel strand but with different number of wires per strand: As approved.
    - c. Steel wire: ASTM A421.
  - 2. Post-tensioning tendons:
    - a. Strand as specified or shown for pre-tensioning either in single-strand units or in multiple-parallel-strand units, with wedge-type anchorages.
    - b. Button heads to be cold-formed symmetrically about axes of wires so that butt develops minimum guaranteed ultimate tensile strength of wire. Use of cold-forming process that causes indentations in wire is prohibited.
    - c. Prestressing bars:
      - 1) Fabricated and processed in accordance with ASTM A722 and as specified.
      - 2) High-tensile-strength hot-rolled alloy steel, individually cold-stretched and thermally stress-relieved to ensure uniform stress/strain characteristics and to obtain yield strength not less than 85 percent of required minimum guaranteed ultimate tensile strength.
      - 3) In accordance with the following minimum requirements:
      - 4)

Properties	Regular Grade	Special Grade
a) Ultimate tensile strength	150,000 psi	160,000 psi
b) Modulus of elasticity at 70 percent of manufacturer's minimum guaranteed ultimate strength	29x10 <sup>6</sup> psi	30x10 <sup>6</sup> psi

- 5) High-strength, thermally stress-relieved, large steel cables with socketed ends fitted with anchorage nuts on peripheries of sockets and meeting required breaking strength, yield strength, elongation, composition and other pertinent requirements may be used if approved. Oil-tempered wires are prohibited.
- 3. Unbonded tendons are prohibited unless approved.

4. Anchorages and couplers:
    - a. Steel anchorages and couplers as approved if compatible with particular installation. Anchorage devices to hold prestressing steel at load-producing stress of not less than 95 percent of specified minimum ultimate tensile strength of prestressing steel. Anchorages with cut threads or notches are prohibited on prestressing steel. Fabricate stressing anchorages to provide adjustable-seating loss. Ensure that each anchorage is capable of lift-off, de-tensioning and re-tensioning tendon at any time prior to grouting.
  5. Ducts:
    - a. Galvanized ferrous metal.
    - b. Strong enough to retain shape and resist damage during construction.
    - c. Capable of preventing entrance of cement paste and water from concrete.
    - d. Incapable of causing electrolytic action or deterioration in concrete.
    - e. When grouting is necessary, ensure that:
      - 1) Inside diameter of duct is at least 1/4-inch larger than bar or strand tendons or, in the case of parallel-wire cable tendons, that inside area of duct is at least 100-percent larger than area of tendon.
      - 2) Ducts have grout holes at each end and at high points.
      - 3) Ducts have drain holes at low points.
    - f. Grout and vent-hole connections to duct made with metallic structural fasteners. Connections to be mortar-tight, taped as necessary. Provide grout holes with means to inject grout. Provide positive shutoff valves.
- F. Corrosion Inhibitor: Water-soluble oil; VISCONORUST 84-18, Viscosity Oil Company, or equal.

### **PART 3 - EXECUTION**

#### **3.01 CONCRETE:**

- A. Mixing and Placing:
  1. Mix concrete in accordance with the requirements of Section 03300, with the following additional requirements:
    - a. Do not use admixtures containing chlorides, fluorides or nitrates.
    - b. Use more than one admixture only if compatible with each other. If used, add separately during batching sequence.
  2. Placement of concrete: Section 03300.
- B. Sampling and Testing:
  1. Perform sampling and testing as specified.
- C. Concrete Protection for Reinforcement: Section 03200
- D. Compaction of Concrete:
  1. Compact concrete by means of internal, external or surface vibrators as approved and as follows:
    - a. Use internal vibrators on sections that are sufficiently large to admit them.
    - b. Use external vibrators on smaller sections and sections produced by extrusion or slip-form method.
    - c. Surface or screed vibrators may be used for flat slabs.
  2. Use vibrators having operating frequencies of at least 7,000 impulses per minute and higher frequencies if approved. Use vibrators only for compacting, not for moving concrete along forms.
- E. Patching:

1. Thoroughly clean and hammerpack holes left by tie rods, strand hold-down devices or other temporary inserts with stiff dry mortar made with same type of sand and cement used in concrete. In areas of tensile stress, bond hole patches with approved epoxy resin.
2. Members with honeycombs of such depth as to expose tendons will be examined by the Engineer for structural adequacy. Where in the Engineer's opinion impairment of structural adequacy is apparent, member will be rejected.
3. Where honeycombed areas are to be repaired, remove loose material and cut area back until coarse aggregate breaks under chipping; coat area with layer of epoxy bonding agent and patch with grout matching existing concrete color and strength. Obtain approval of proposed method and materials.

F. Curing: Section 03300.

G. Finishes:

1. Types of concrete finishing: As shown and specified.

### **3.02 FORMS:**

- A. Ensure that joints are smooth and tight to prevent leakage of mortar. Maintain accurate alignment of forms during casting operations. Check form alignment and grade for each casting.
- B. Make provisions in form-anchorage system for anticipated differential movement of beds and forms during casting and curing operations. In details of forms, ties, inserts, bulkheads and other accessories, detail forms and anchor them so that differential movement cannot occur or loosen them so that movement can occur without damage to member or forms. Ensure that bearing devices supporting prestressed members are free to rotate and that expansion bearings are free to translate during post-tensioning operation.
- C. Clean beds and forms thoroughly before casting. Do not allow coatings used for bond breakers to accumulate in bottoms of forms. For members to be cured by artificial heat, provide for ventilation of void forms.
- D. In areas subject to freezing and thawing, make provisions for draining voids.
- E. Treat surfaces in contact with concrete with effective bond breaker.
- F. Prevent contamination of tendons by bond breaker, mud, grease or other detrimental substances.
- G. Provide bolting fittings and welding plates for embedment in prestressed members to allow later attachment of conduits, pipes, boxes and similar items.

### **3.03 JACKS:**

- A. Equip each jack used to stress tendons with pressure gauge or load cell to determine jacking stress.
- B. If pressure gauge is used, provide accurate, easily readable dial at least six inches in diameter. Calibrate each jack and its gauge as a unit with cylinder extension in approximate position in which it will be at final jacking force. Provide certified calibration chart as specified.

- C. If inconsistencies occur between measured elongation and jack gauge reading, recalibrate gauge. If further discrepancies occur, determine cause and report to the Engineer. Agreement within seven percent will be satisfactory.
- D. If load cell is used, calibrate and provide with indicator by means of which prestressing force in tendon may be determined. Ensure that range of load cell is such that lower 10 percent of manufacturer's-rated capacity will not be used in determining jacking stress.

**3.04 TENDONS:**

- A. Placement and Tensioning of Tendons for Prestressing:
  - 1. Prior to stringing tendons, inspect bottom of forms for cleanliness and accuracy of alignment.
  - 2. String tendons singly or in multiples.
  - 3. Splicing of wires or strands is prohibited.
  - 4. Cut length of each tendon between tendon vise and coil or reel.
  - 5. Do not string tendons incorporating points previously gripped by tendon vises or wedges within lengths to be stressed. Do not use notched, nicked, pitted, rusted or otherwise damaged tendons.
  - 6. Provide tendon vises or wedges capable of anchoring stressing loads positively with a minimum of differential slippage. Have vises or wedges cleaned, lubricated and inspected between each use.
  - 7. Discard grips which become visibly worn or distorted or which allow excessive slippage. Furnish full set of cleaned and inspected tendon vises or wedges before commencing each stressing operation. Ensure that vises and wedges are free of rust and physical damage.
  - 8. Position tendons to conform to tensioning detail dimensions shown. Prevent sagging and kinking of tendons. Support tendons as necessary to maintain proper position and prevent vertical movement during pouring of concrete. Permissible deviations from profile shown on approved shop drawings as follows:

Depth of Member	Permissible Deviation
a) Less than 10 inches	Plus-or-minus 1/8 inch
b) Ten inches or more	Plus-or-minus 1/4 inch

- 9. After straight wire tendons have been positioned, apply initial force to each tendon to eliminate slack and to provide uniform initial-stress condition in all tendons prior to final stressing. Initial force may be applied only by pressure jacks equipped with proper gauging system for measuring initial force.
- 10. Do not weld or make grounds for welding equipment on forms or on steel in member after prestressing steel has been installed.
- 11. Maintain records of elongation of each tendon and tension applied to each tendon.
- 12. Use load cells to calibrate load-measuring devices and to check initial force on at least 10 percent of tendons.
- 13. Regardless of method used, measure initial load within tolerance of plus-or-minus 50 pounds or two percent, whichever is larger.
- 14. Do not use elongation measurements as measure of initial stress.
- 15. Perform final stressing as shown on approved shop drawings.
- 16. If prestressing bars less than 30 feet long are used, measure elongation by means of dial indicators.

- B. Tendon Vises for Pretensioning:
1. Use tendon vises for pretensioning capable of anchoring tendon positively without slippage after seating.
  2. Have steel cases for tendon vises proof-tested by manufacturer to at least 95 percent of guaranteed minimum tensile stress of prestressing steel.
  3. Maintain chucks in serviceable condition. Discard chucks that become visibly worn or show evidence of allowing post-seating slippage of tendon.
- C. Post-Tensioning:
1. Perform sequence and staging of post-tensioning in accordance with approved shop drawings. Perform special techniques, such as overjacking with following reduction of load or jacking from both ends of the tendon, in accordance with approved shop drawings.
  2. Stress post-tensioned prestressing steel by means of hydraulic jacks equipped with accurately calibrated, easily readable hydraulic pressure gauges or load cells to permit reading stress in prestressing steel throughout stressing operation.
  3. Keep records of tension and elongation of each tendon at all stages and submit records as specified. Make readings of elongations to within plus-or-minus 1/32 inch when dial indicators are used, reading accuracy to be accordingly higher.
  4. At the time of stressing first member of each type, check stresses in individual tendons and verify calculated frictional losses and seating losses to establish post-tensioning procedure and ensure uniform results.
  5. Recheck may be directed if it appears that stress shown is not being obtained.
  6. If the measured elongation is within seven percent, and the jacking force as measured by the pressure gauge is within five percent of theoretical, tendons may be cut and sealed for grouting. If an elongation or force is outside of these limits, obtain written approval before cutting and capping post-tensioned anchorage.
  7. If friction losses in post-tensioned tendon exceed calculated friction losses shown, relieve tendons of stress, lubricate with water-soluble oil or graphite spray and retension.
  8. Anchor prestressing steel at initial stresses (transfer) calculated to result in final force shown. Initial stress not to exceed 70 percent of minimum ultimate tensile strength of prestressing steel at any point of tendon.
  9. During jacking of prestressing steel, do not exceed 80 percent of the minimum guaranteed ultimate tensile strength of tendon.
  10. Make accurate measurements of anchorage slippage losses at time of anchoring first tendon of each type of member and compare with assumed slippage losses. In case of deviation, de-tension tendon; repeat tensioning in accordance with special approved procedure or by shimming as necessary for particular system.
  11. When necessary and approved, make adjustments to post-tensioning procedure to obtain required stresses.
  12. Submit for approval proposed remedy for inconsistencies which occur between measured elongation and jack-gauge readings and which cannot be corrected by specified recalibration of gauge nor by lubrication of tendons. Replace tendon, if necessary.
  13. Immediately after concreting, check ducts for obstructions by drawing cleaning device through them, by blowing through or by movement of tendon. Immediately prior to installation of tendons in ducts, demonstrate that ducts are free of water, debris and other obstructions.

### 3.05 GROUTING:

- A. Immediately prior to grouting, clean ducts of foreign materials and remove corrosion inhibitor by thoroughly flushing duct with water and dry by blowing. Unless prestressing steel is

adequately protected from corrosion, complete grouting operation within 28 days after concrete is placed around ducts but not later than 10 days after stressing.

- B. Mix grout as recommended by manufacturer, as tested and approved or for 1-1/2 minutes in high-speed mechanical mixer; pass through strainer into pumping equipment which has provision for recirculation. Begin pumping grout as soon as possible after mixing. Pumping may be continued as long as grout retains proper consistency.
- C. Use grout consisting mainly of cement and water unless gross inside area of duct exceeds five times tendon area, in which case fine sand may be added.
- D. When approved, add aluminum powder of proper fineness or other approved material in quantity sufficient to obtain a maximum of 10-percent expansion of grout when measured unconfined.
- E. Base proportions of materials on results of tests made on grout to achieve the following:
  - 1. Water content: Minimum necessary for proper placement.
  - 2. Water-cement ratio: Limited to maximum of 0.45 by weight.
  - 3. Minimum seven-day compressive strength: 2,500 psi for two-inch cubes molded, cured and tested in accordance with ASTM C109.
- F. Do not retemper grout.
- G. Inject grout into ducts and anchorage fittings. Continue flow until grout of consistency equivalent to that injected, flows from vent openings without presence of air in bubbles. Ensure that there is enough grout in supply bin to prevent suction of air.
- H. Close vent openings progressively in direction of flow. After vent openings are closed, raise grouting pressure to 100-psi minimum and plug injection hole. Keep accurate records of progress of grouting operations.
- I. In the event of blockage or interruption of grouting, remove grout from duct by flushing with water. Provide water pump in standby condition.
- J. Prevent water trapped in ungrouted ducts from freezing.
- K. Maintain temperature of concrete around grouted tendons at 45F or higher for at least three days after grouting.

### **3.06 STRESS TRANSFER:**

- A. Perform stress transfer to pretensioned or post-tensioned members only after concrete strength, as demonstrated by test cylinders, is in accordance with the transfer strength specified or shown.
- B. Minimum transfer strengths of concrete:
  - 1. Centrally stressed members: 3,000 psi.
  - 2. Eccentrically stressed members: 3,500 psi.
  - 3. Bridge beams or other members in which camber must be minimized: 4,000 psi.
  - 4. Post-tensioned members: 4,000 psi or as shown.
- C. If precast concrete has been moist-heat cured, perform de-tensioning immediately following curing period while concrete is still warm and moist.
- D. In de-tensioning operations, release tension so as to minimize eccentricity between resultant of prestressing forces and the vertical centroidal axis of member and so as to minimize

sudden or shock loading. Limit maximum eccentricity about vertical centroidal axis to one strand.

- E. Prior to detensioning, remove or loosen forms, ties, inserts, holddowns or other devices that would restrict longitudinal movement of members along bed.

**END OF SECTION**

## SECTION 03450

### PLANT - ARCHITECTURAL PRECAST CONCRETE

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing precast architectural concrete units and thin-brick-faced, precast architectural concrete units.
- B. Related Work Specified Elsewhere:
  - 1. Concrete Unit Masonry: Section 04220.
  - 2. Flashing and Sheet Metal: Section 07600.
  - 3. Seals and Sealants: Section 07900.

##### 1.02 PERFORMANCE REQUIREMENTS:

- A. Structural Performance: Provide precast architectural concrete units and connections capable of withstanding design loads within limits and under conditions indicated.
- B. Structural Performance: Provide precast architectural concrete units and connections capable of withstanding the following design loads within limits and under conditions indicated:
  - 1. Dead Loads: <Insert applicable dead loads.>
  - 2. Live Loads: <Insert applicable live loads.>
  - 3. Wind Loads: <Insert applicable wind loads or wind-loading criteria including basic wind speed, importance factor, and exposure category.>
  - 4. Earthquake Loads: <Insert applicable earthquake design data including seismic coefficient and importance factor.>
  - 5. Design framing system to maintain clearances at openings, to allow for construction tolerances, and to accommodate live load deflection of primary building structure as follows:
    - a. Upward and downward movement of 1/2 inch.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements specified for each:
  - 1. Product Data: For each type of product indicated.
  - 2. Design Mixes: For each concrete mix.
  - 3. Shop Drawings: Detail fabrication and installation of precast architectural concrete units. Indicate member locations, plans, elevations, dimensions, shapes, cross sections, limits of each finish, and types of reinforcement, including special reinforcement.
    - a. Indicate separate face and backup mix locations and thicknesses.
    - b. Indicate locations and extent and treatment of dry joints if two-stage casting is proposed.
    - c. Indicate welded connections by AWS standard symbols. Detail loose and cast-in hardware, inserts, connections, and joints, including accessories.
    - d. Indicate locations and details of anchorage devices to be embedded in other construction.
    - e. Indicate locations and details of thin brick units and joint treatment.
    - f. Comprehensive engineering analysis signed and sealed by the qualified professional engineer responsible for its preparation.

4. Samples: For each type of finish indicated on exposed surfaces of precast architectural concrete units, in sets of 3, illustrating full range of finish, color, and texture variations expected; approximately 12 by 12 by 2 inches.
5. Samples for each thin brick unit required, including special shapes, showing the full range of colors, textures, and dimensions expected.
  - a. Grout Samples for Initial Selection: Color charts consisting of actual sections of grout showing the manufacturer's full range of colors.
6. Welding Certificates: Copies of certificates for welding procedures and personnel.
7. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.
8. Material Certificates: Signed by manufacturers certifying that each of the following items complies with requirements:
  - a. Concrete materials.
  - b. Reinforcing materials and prestressing tendons.
  - c. Admixtures.
  - d. Bearing pads.
  - e. Water-absorption test reports.
  - f. Thin brick units and accessories.

#### **1.04 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
  1. Comply with codes and regulations of the jurisdictional authorities.
  2. AASHTO: M251
  3. ACI: 211.1, 211.2, 216/TMS 0216.1, 305R, 306.1, 318.
  4. AISI: 1018-1020.
  5. ANSI: A118.6, 108.10.
  6. APA: Architectural Precast Concrete-Color and Texture Selection Guide.
  7. ASTM: A27, A36, A47, A82, A108, A123A, A184, A185, A276, A283, A307, A416, A496, A497, A500, A572, A615, A618, A666, A675, A706, A767, A775, A884, C33, C42, C67, C144, C150, C260, C330, C494, C567, C618, C979, C1088, C1017, C1107, C1240, D412, F593.
  8. AWS: D1.1, D1.4.
  9. CRSI: Manual of Standard Practice.
  10. DOD: P-21035A.
  11. FS: TT-P-664.
  12. PCI: MNL 117, MNL 120, MNL 124.
  13. SSPC: PA 1, Paint 20, Paint 25, SP 3.
- B. Installer Qualifications: An experienced installer who has completed precast architectural concrete work similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.
- C. Fabricator Qualifications: A firm that complies with the following requirements and is experienced in manufacturing precast architectural concrete units similar to those indicated for this Project and with a record of successful in-service performance.
  1. Assumes responsibility for engineering precast architectural concrete units to comply with performance requirements. This responsibility includes preparation of Shop Drawings and comprehensive engineering analysis by a qualified professional engineer.
  2. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are

- defined as those performed for installations of precast architectural concrete that are similar to those indicated for this Project in material, design, and extent.
3. Participates in PCI's Plant Certification program and is designated a PCI-certified plant for Group A, Category A1--Architectural Cladding and Load Bearing Units [or in APA's Plant Certification Program for Production of Architectural Precast Concrete Products and is designated an APA-certified plant].
  4. Has sufficient production capacity to produce required units without delaying the Work.
  5. Is registered with and approved by authorities having jurisdiction.
- D. Design Standards: Comply with ACI 318 and the design recommendations of PCI MNL 120, "PCI Design Handbook--Precast and Prestressed Concrete."
- E. Quality-Control Standard: For manufacturing procedures and testing requirements, quality-control recommendations, and dimensional tolerances for types of units required, comply with PCI MNL 117, "Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products."
- F. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel"; and AWS D1.4, "Structural Welding Code--Reinforcing Steel."
- G. Calculated Fire-Test-Response Characteristics: Where indicated, provide precast architectural concrete units whose fire resistance has been calculated according to [PCI MNL 124, "Design for Fire Resistance of Precast Prestressed Concrete,"] [ACI 216.1/TMS 0216.1, "Standard Method for Determining Fire Resistance of Concrete and Masonry Construction Assemblies,"] and is acceptable to authorities having jurisdiction.
- H. Sample Panels: Before fabricating precast architectural concrete units, produce sample panels to establish the approved range of selections made under sample Submittals. Produce a minimum of 3 sets of full-scale sample panels, approximately 48 inches long by 48 inches high, to demonstrate the expected range of finish, color, and texture variations.
1. Locate panels where directed by the Engineer.
  2. In presence of the Engineer damage part of an exposed-face surface for each finish, color, and texture, and demonstrate materials and techniques proposed for repair of surface blemishes to match adjacent undamaged surfaces.
  3. Maintain sample panels during construction in an undisturbed condition as a standard for judging the completed Work.
  4. Demolish and remove sample panels when directed
- I. Preinstallation Conference: Conduct conference at Project site to comply with requirements of Division 1 Section "Project Meetings."

#### **1.05 PRODUCT DELIVERY, STORAGE, AND HANDLING:**

- A. Deliver precast architectural concrete units to Project site in such quantities and at such times to ensure continuity of installation. Store units at Project site to prevent cracking, distorting, warping, staining, or other physical damage, and so markings are visible.
- B. Lift and support units only at designated lifting and supporting points as shown on Shop Drawings.

#### **1.06 SEQUENCING:**

- A. Furnish anchorage items to be embedded in or attached to other construction without

delaying the Work. Provide setting diagrams, templates, instructions, and directions, as required, for installation.

## **PART 2 - PRODUCTS**

### **2.01 MOLD MATERIALS:**

- A. Molds: Provide molds and, where required, form-facing materials of metal, plastic, wood, or another material that is nonreactive with concrete and dimensionally stable to produce continuous and true precast concrete surfaces within fabrication tolerances and suitable for required finishes
- B. Form Liners: Units of face design, texture, arrangement, and configuration indicated.

### **2.02 REINFORCING MATERIALS:**

- A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.
- B. Low-Alloy-Steel Reinforcing Bars: ASTM A 706/A 706M, deformed.
- C. Galvanized Reinforcing Bars: ASTM A 767/A 767M, Class II zinc coated, hot-dip galvanized after fabrication and bending, as follows:
  - 1. Steel Reinforcement: [ASTM A 615/A 615M, Grade 60] [ASTM A 706/A 706M], deformed.
- D. Epoxy-Coated Reinforcing Bars: ASTM A 775/A 775M or ASTM A 934/A 934M, as follows:
  - 1. Steel Reinforcement: [ASTM A 615/A 615M, Grade 60] [ASTM A 706/A 706M], deformed.
- E. Steel Bar Mats: ASTM A 184/A 184M, assembled with clips, as follows:
  - 1. Steel Reinforcement: [ASTM A 615/A 615M, Grade 60] [ASTM A 706/A 706M], deformed bars.
- F. Plain-Steel Wire: ASTM A 82, [as drawn] [galvanized].
- G. Deformed-Steel Wire: ASTM A 496.
- H. Epoxy-Coated-Steel Wire: ASTM A 884/A 884M, Class A coated, [plain] [deformed].
- I. Plain-Steel Welded Wire Fabric: ASTM A 185, fabricated from [as-drawn] [galvanized] steel wire into flat sheets.
- J. Deformed-Steel Welded Wire Fabric: ASTM A 497, flat sheet.
- K. Epoxy-Coated-Steel Welded Wire Fabric: ASTM A 884/A 884M, Class A coated, [plain] [deformed].
- L. Supports: Manufacturer's bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire fabric in place according to CRSI's "Manual of Standard Practice," PCI MNL 117, and as follows:
  - 1. For uncoated reinforcement, use [all-plastic] [CRSI Class 1 plastic-protected] [CRSI Class 2 stainless-steel] bar supports.
  - 2. For epoxy-coated reinforcement, use [CRSI Class 1A epoxy-coated or other dielectric-polymer-coated wire] [all-plastic] bar supports

3. For zinc-coated reinforcement, use [galvanized wire or dielectric-polymer-coated wire] [all-plastic] bar supports.

#### **2.03 PRESTRESSING TENDONS:**

- A. Prestressing Strand: ASTM A 416/A 416M, Grade 250 or 270, uncoated, 7-wire, low-relaxation strand.

#### **2.04 CONCRETE MATERIALS:**

- A. Portland Cement: ASTM C 150, Type I or Type III, [gray] [and] [white], of same type, brand, and source.
  1. Standard gray portland cement may be used for nonexposed backup concrete.
- B. Normal-Weight Aggregates: Except as modified by PCI MNL 117, ASTM C 33, with coarse aggregates complying with Class 5S.
  1. Face-Mix Coarse Aggregates: Selected, hard, and durable; free of material that reacts with cement or causes staining.
    - a. Gradation: [Uniformly graded] [Gap graded] [To match design reference sample].
  2. Face-Mix Fine Aggregates: Selected, natural or manufactured sand of the same material as coarse aggregate, unless otherwise approved by the Engineer.
- C. Lightweight Aggregates: ASTM C 330.
- D. Coloring Admixture: ASTM C 979, synthetic mineral-oxide pigments or colored water-reducing admixtures, temperature stable, nonfading, and alkali resistant.
- E. Water: Potable; free from deleterious material that may affect color stability, setting, or strength of concrete and complying with chemical limits of PCI MNL 117.
- F. Air-Entraining Admixture: ASTM C 260, certified by manufacturer to be compatible with other required admixtures.
- G. Water-Reducing Admixture: ASTM C 494, Type A.
- H. Retarding Admixture: ASTM C 494, Type B.
- I. Water-Reducing and Retarding Admixture: ASTM C 494, Type D.
- J. High-Range, Water-Reducing Admixture: ASTM C 494, Type F.
- K. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494, Type G.
- L. Plasticizing Admixture: ASTM C 1017.
- M. Fly Ash Admixture: ASTM C 618, Class C or F.
- N. Metakaolin Admixture: ASTM C 618, Class N.
- O. Silica Fume Admixture: ASTM C 1240.

#### **2.05 STEEL CONNECTION MATERIALS:**

- A. Carbon-Steel Shapes and Plates: ASTM A 36/A 36M.

- B. Carbon-Steel Headed Studs: ASTM A 108, AISI 1018 through AISI 1020, cold finished; AWS D1.1, Type A or B, with arc shields.
- C. Carbon-Steel Plate: ASTM A 283/A 283M.
- D. Malleable Steel Castings: ASTM A 47.
- E. Carbon-Steel Castings: ASTM A 27/A 27M, Grade 60-30.
- F. High-Strength, Low-Alloy Structural Steel: ASTM A 572/A 572M.
- G. Carbon-Steel Structural Tubing: ASTM A 500, Grade B.
- H. Wrought Carbon-Steel Bars: ASTM A 675/A 675M, Grade 65.
- I. Deformed-Steel Wire or Bar Anchors: ASTM A 496 or ASTM A 706/A 706M.
- J. Carbon-Steel Bolts and Studs: ASTM A 307, Grade A; carbon-steel, hex-head bolts and studs; carbon-steel nuts; and flat, unhardened steel washers.
- K. Finish: For exterior steel items, steel in exterior walls, and items indicated for galvanizing, apply zinc coating by [hot-dip process according to ASTM A 123/A 123M, after fabrication, and ASTM A 153/A 153M, as applicable] [electrodeposition according to ASTM B 633, SC 3].
  - 1. Galvanizing Repair Paint: High-zinc-dust-content paint with dry film containing not less than 94 percent zinc dust by weight, and complying with DOD-P-21035A or SSPC-Paint 20.
  - 2. Shop-Primed Finish: Prepare surfaces of nongalvanized steel items, except those surfaces to be embedded in concrete, according to requirements in SSPC-SP 3 and shop-apply [lead- and chromate-free, rust-inhibitive primer, complying with performance requirements in FS TT-P-664] [SSPC-Paint 25] according to SSPC-PA 1.
- L. Reglets: [PVC extrusions.] [Stainless steel.] [Copper.] [Reglets are specified in Section 07600, Flashing and Sheet Metal.]
- M. Welding Electrodes: Comply with AWS standards.
- N. Accessories: Provide clips, hangers, plastic shims, and other accessories required to install precast architectural concrete units.

**2.06 STAINLESS-STEEL CONNECTION MATERIALS:**

- A. Stainless-Steel Plate: ASTM A 666, Type 304, of grade suitable for application.
- B. Stainless-Steel Bolts and Studs: ASTM F 593, alloy 304 or 316, hex-head bolts and studs; stainless-steel nuts; and flat, stainless-steel washers.
- C. Stainless-Steel Headed Studs: ASTM A 276.

**2.07 BEARING PADS:**

- A. Provide bearing pads for precast architectural concrete units as follow
  - 1. Elastomeric Pads: AASHTO M 251, plain, vulcanized, 100 percent polychloroprene

- (neoprene) elastomer, molded to size or cut from a molded sheet, 50 to 70 Shore A durometer, minimum tensile strength 2250 psi per ASTM D 412.
2. Random-Oriented, Fiber-Reinforced Elastomeric Pads: Preformed, randomly oriented synthetic fibers set in elastomer. Surface hardness of 70 to 90 Shore A durometer.
  3. Cotton-Duck-Fabric-Reinforced Elastomeric Pads: Preformed, horizontally layered cotton-duck fabric bonded to an elastomer. Surface hardness of 80 to 100 Shore A durometer.
  4. Frictionless Pads: Tetrafluoroethylene, glass-fiber reinforced, bonded to mild-steel plate, of type required for in-service stress.
  5. High-Density Plastic: Multimonomer, nonleaching, plastic strip.

## 2.08 GROUT MATERIALS:

- A. Sand-Cement Grout: Portland cement, ASTM C 150, Type I, and clean, natural sand, ASTM C 144. Mix at ratio of 1 part cement to 2-1/2 parts sand, by volume, with minimum water required for placement and hydration.
- B. Nonmetallic, Nonshrink Grout: Premixed, nonmetallic, noncorrosive, nonstaining grout containing selected silica sands, portland cement, shrinkage-compensating agents, plasticizing and water-reducing agents, complying with ASTM C 1107, of consistency suitable for application.

## 2.09 THIN BRICK UNITS AND ACCESSORIES:

- A. Thin Brick Units: ASTM C 1088, Grade Exterior, Type TBX, [not less than 1/2 inch] [3/4 inch] [1 inch] thick, and as follows:
  1. Face Size: Standard, 2-1/4 inches high by 8 inches long.
  2. Face Size: Modular, 2-1/4 inches high by 7-1/2 to 7-5/8 inches long.
  3. Face Size: Engineer modular, 2-3/4 to 2-13/16 inches high by 7-1/2 to 7-5/8 inches long
  4. Face Size: Closure modular, 3-1/2 to 3-5/8 inches high by 7-1/2 to 7-5/8 inches long.
  5. Face Size: Utility, 3-1/2 to 3-5/8 inches high by 11-1/2 to 11-5/8 inches long.
  6. Where shown to "match existing," provide face brick matching color, texture, and face size of existing adjacent brickwork.
  7. Special Shapes: Include corners, edge corners, and end edge corners.
  8. Initial Rate of Absorption: Less than 30 g/30 sq. in. per minute when tested per ASTM C 67.
  9. Efflorescence: Provide brick that has been tested according to ASTM C 67 and is rated "not effloresced."
  10. Surface Coloring: Brick with surface coloring, other than flashed or sand-finished brick, shall withstand 50 cycles of freezing and thawing per ASTM C 67 with no observable difference in the applied finish when viewed from 10 feet
  11. Face Color and Texture: [Match Architect's samples] [Medium brown, wire cut] [Full-range red, sand molded] [Gray, velour].
  12. Back Surface Texture: Scored, combed, wire roughened, or ribbed.
- B. Setting Mortar: Portland cement, ASTM C 150, Type I, and clean, natural sand, ASTM C 144. Mix at ratio of 1 part cement to 4 parts sand, by volume, with minimum water required for placement.
- C. Latex-Portland Cement Pointing Grout: ANSI A118.6 and as follows: Select one or both types of grout from first two subparagraphs below.
  1. Dry-grout mixture, factory prepared, of portland cement, graded aggregate, and dry, redispersible, ethylene-vinyl-acetate additive for mixing with water; uniformly colored

2. Commercial portland cement grout, factory prepared, with liquid styrene-butadiene rubber or acrylic-resin latex additive; uniformly colored.
3. Colors: [As indicated by manufacturer's designations] [Match Engineer's samples] [As selected by Engineer from manufacturer's full range].

#### **2.10 CONCRETE MIXES:**

- A. Prepare design mixes for each type of concrete required. Delete subparagraph below if fly ash or silica fume is not permitted. Revise percentage to suit Project.
  1. Limit use of fly ash and silica fume to not exceed, in aggregate, 25 percent of portland cement by weight.
- B. Design mixes may be prepared by a qualified independent testing agency or by qualified precast plant personnel at precast architectural concrete fabricator's option.
- C. Limit water-soluble chloride ions to the maximum percentage by weight of cement permitted by ACI 318.
- D. Normal-Weight Concrete Face and Backup Mixes: Proportion mixes by either laboratory trial batch or field test data methods according to ACI 211.1, with materials to be used on Project, to provide normal-weight concrete with the following properties:
  1. Compressive Strength (28 Days): 5000 psi or greater
  2. Maximum Water-Cementitious Materials Ratio: 0.45.
- E. Water Absorption: 12 to 14 percent by volume, tested according to PCI MNL 117.
- F. Lightweight Concrete Backup Mixes: Proportion mixes by either laboratory trial batch or field test data methods according to ACI 211.2, with materials to be used on Project, to provide lightweight concrete with the following properties:
  1. Compressive Strength (28 Days): 5000 psi or greater.
  2. Unit Weight: Calculated equilibrium unit weight of 115 lb/cu. ft., plus or minus 3 lb/cu. ft., according to ASTM C 567.
- G. Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having an air content complying with PCI MNL 117.
- H. When included in design mixes, add other admixtures to concrete mixes according to manufacturer's written instructions.

#### **2.11 MOLD FABRICATION:**

- A. Molds: Accurately construct molds, mortar tight, of sufficient strength to withstand pressures due to concrete-placement operations and temperature changes and for prestressing operation
  1. Place form liners accurately to provide finished surface texture indicated. Provide solid backing and supports to maintain stability of liners during concreting. Coat form liner with form-release agent.
- B. Maintain molds to provide completed precast architectural concrete units of shapes, lines, and dimensions indicated, within fabrication tolerances specified.
  1. Edge and Corner Treatment: Uniformly [chamfered] [radiused].

#### **2.12 THIN BRICK FACINGS:**

- A. Place form liner templates accurately to provide grid for thin brick facings. Provide solid backing and supports to maintain stability of liners while placing thin bricks and during concreting.
- B. Securely place thin brick units face down into form liner pockets.
- C. Completely fill joint cavities between thin brick units with sand-cement mortar, and place precast concrete backing mix while sand-cement mortar is still fluid enough to ensure bond
  - 1. Mix and install grout according to ANSI 108.10. Completely fill joint cavities between thin brick units with grout, and compress into place without spreading grout onto faces of thin brick units. Remove excess grout immediately to prevent staining of brick.
  - 2. Tool joints to a [slightly concave] [grapevine] [V-]shape when pointing grout is thumbprint hard.
- D. Clean faces and joints of brick facing.

### 2.13 FABRICATION:

- A. Cast-in Anchors, Inserts, Plates, Angles, and Other Anchorage Hardware: Fabricate anchorage hardware with sufficient anchorage and embedment to comply with design requirements. Accurately position for attachment of loose hardware, and secure in place during precasting operations. Locate anchorage hardware where it does not affect position of main reinforcement or concrete placement.
- B. Furnish loose steel plates, clip angles, seat angles, anchors, dowels, cramps, hangers, and other hardware shapes for securing precast architectural concrete units to supporting and adjacent construction.
- C. Cast-in reglets, slots, holes, and other accessories in precast architectural concrete units to receive windows, cramps, dowels, reglets, waterstops, flashings, and other similar work as indicated.
- D. Cast-in openings larger than 10 inches in any dimension.
- E. Reinforcement: Comply with recommendations in CRSI's "Manual of Standard Practice" and PCI MNL 117 for fabricating, placing, and supporting reinforcement.
  - 1. Clean reinforcement of loose rust and mill scale, earth, and other materials that reduce or destroy the bond with concrete.
  - 2. Accurately position, support, and secure reinforcement against displacement during concrete-placement and consolidation operations. Completely conceal support devices to prevent exposure on finished surfaces.
  - 3. Place reinforcement to maintain at least 3/4-inch minimum coverage. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position while placing concrete. Direct wire tie ends away from finished, exposed concrete surfaces.
  - 4. Install welded wire fabric in lengths as long as practicable. Lap adjoining pieces at least one full mesh and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.
- F. Reinforce precast architectural concrete units to resist handling, transportation, and erection stresses.
- G. Prestress tendons for precast architectural concrete units by either pretensioning or posttensioning methods. Comply with PCI MNL 117.
  - 1. Delay detensioning or posttensioning of precast, prestressed architectural concrete units until concrete has reached its indicated minimum design release compressive

strength as established by test cylinders cured under the same conditions as concrete.

- H. Mix concrete according to PCI MNL 117 and requirements in this Section. After concrete batching, no additional water may be added.
- I. Place face mix to a minimum thickness after consolidation of the greater of 1 inch or 1.5 times the maximum aggregate size, but not less than the minimum reinforcing cover.
- J. Place concrete in a continuous operation to prevent seams or planes of weakness from forming in precast concrete units. Comply with requirements in PCI MNL 117 for measuring, mixing, transporting, and placing concrete.
  - 1. Place backup concrete to ensure bond with face mix concrete.
- K. Thoroughly consolidate placed concrete by internal and external vibration without dislocating or damaging reinforcement and built-in items. Use equipment and procedures complying with PCI MNL 117.
- L. Comply with ACI 306.1 procedures for cold-weather concrete placement.
- M. Comply with ACI 305R recommendations for hot-weather concrete placement.
- N. Identify pickup points of precast architectural concrete units and orientation in structure with permanent markings, complying with markings indicated on Shop Drawings. Imprint or permanently mark casting date on each precast architectural concrete unit on a surface that will not show in finished structure.
- O. Cure concrete, according to requirements in PCI MNL 117, by moisture retention without heat or by accelerated heat curing using low-pressure live steam or radiant heat and moisture.
- P. Discard precast architectural concrete units that are warped, cracked, broken, spalled, stained, or otherwise defective unless repairs are approved by the Engineer.

#### **2.14 FABRICATION TOLERANCES:**

- A. Fabricate precast architectural concrete units straight and true to size and shape with exposed edges and corners precise and true so each finished panel complies with the following product tolerances:
  - 1. Overall Height and Width of Units, Measured at the Face Exposed to View: As follows:
    - a. 10 feet or under, plus or minus 1/8 inch.
    - b. 10 to 20 feet, plus 1/8 inch, minus 3/16 inch.
    - c. 20 to 40 feet, plus or minus 1/4 inch.
    - d. Each additional 10 feet, plus or minus 1/16 inch.
  - 2. Overall Height and Width of Units, Measured at the Face Not Exposed to View: As follows:
    - a. 10 feet or under, plus or minus 1/4 inch.
    - b. 10 to 20 feet, plus 1/4 inch, minus 3/8 inch.
    - c. 20 to 40 feet, plus or minus 3/8 inch.
    - d. Each additional 10 feet, plus or minus 1/8 inch.
  - 3. Total Thickness or Flange Thickness: Plus 1/4 inch, minus 1/8 inch.
  - 4. Rib Thickness: Plus or minus 1/8 inch.
  - 5. Rib to Edge of Flange: Plus or minus 1/8 inch.
  - 6. Distance between Ribs: Plus or minus 1/8 inch.
  - 7. Variation from Square or Designated Skew (Difference in Length of the Two

- Diagonal Measurements): Plus or minus 1/8 inch per 72 inches or 1/2 inch total, whichever is greater.
8. Length and Width of Block-outs and Openings within One Unit: Plus or minus 1/4 inch.
  9. Location and Dimension of Block-outs Hidden from View and Used for HVAC and Utility Penetrations: Plus or minus 3/4 inch.
  10. Dimensions of Haunches: Plus or minus 1/4 inch.
  11. Haunch Bearing Surface Deviation from Specified Plane: Plus or minus 1/8 inch.
  12. Difference in Relative Position of Adjacent Haunch Bearing Surfaces from Specified Relative Position: Plus or minus 1/4 inch.
  13. Bowing: Plus or minus L/360, maximum 1 inch.
  14. Local Smoothness: 1/4 inch per 10 feet.
  15. Variation between Adjacent Thin-Brick-Facing Products: 1/16 inch.
  16. Warping: 1/16 inch per 12 inches of distance from the nearest adjacent corner.
  17. Tipping and Flushness of Plates: Plus or minus 1/4 inch.
  18. Dimensions of Architectural Features and Rustications: Plus or minus 1/8 inch.
- B. Position Tolerances: For cast-in items measured from datum line location, as indicated on Shop Drawings.
1. Weld Plates: Plus or minus 1 inch.
  2. Inserts: Plus or minus 1/2 inch.
  3. Handling Devices: Plus or minus 3 inches
  4. Reinforcing Steel and Welded Wire Fabric: Plus or minus 1/4 inch where position has structural implications or affects concrete cover; otherwise, plus or minus 1/2 inch.
  5. Reinforcing Steel Extending out of Member: Plus or minus 1/2 inch of plan dimensions.
  6. Tendons: Plus or minus 1/4 inch, vertical; plus or minus 1 inch, horizontal
  7. Location of Rustication Joints: Plus or minus 1/8 inch.
  8. Location of Opening within Panel: Plus or minus 1/4 inch.
  9. Flashing Reglets: Plus or minus 1/4 inch.
  10. Flashing Reglets at Edge of Panel: Plus or minus 1/8 inch.
  11. Reglets for Glazing Gaskets: Plus or minus 1/8 inch.
  12. Electrical Outlets, Hose Bibs: Plus or minus 1/2 inch.
  13. Haunches: Plus or minus 1/4 inch.
  14. Allowable Rotation of Plate, Channel Inserts, Electrical Boxes: 2-degree rotation or 1/4 inch maximum over the full dimension of the unit.

## 2.15 FINISHES:

- A. Finish exposed-face surfaces of precast architectural concrete units to match approved design reference sample and as follows:
1. Design Reference Sample: <Insert description and identify fabricator and code number of sample.>
  2. PCI and APA's "Architectural Precast Concrete--Color and Texture Selection Guide," of plate numbers indicated.
  3. Smooth-Surface Finish: Provide surfaces free of pockets, sand streaks, and honeycombs, with uniform color and texture.
  4. Textured-Surface Finish: Impart by form liners or inserts to provide surfaces free of pockets, streaks, and honeycombs, with uniform color and texture.
  5. Bushhammer Finish: Use power or hand tools to remove matrix and fracture coarse aggregates.
  6. Retarded Finish: Use chemical retarding agents applied to concrete forms and washing and brushing procedures to expose aggregate and surrounding matrix surfaces after form removal.

7. Abrasive-Blast Finish: Use abrasive grit, equipment, application techniques, and cleaning procedures to expose aggregate and surrounding matrix surfaces.
  8. Acid-Etched Finish: Use acid and hot-water solution, equipment, application techniques, and cleaning procedures to expose aggregate and surrounding matrix surfaces.
  9. Honed Finish: Use continuous mechanical abrasion with fine grit, followed by filling and rubbing procedures.
  10. Polished Finish: Use continuous mechanical abrasion with fine grit, followed by filling and rubbing procedures.
  11. Sand-Embedment Finish: Use selected stones placed in a sand bed in bottom of mold, with sand removed after curing.
  12. Finish exposed [top] [bottom] [and back] surfaces of precast architectural concrete units to match face-surface finish.
- B. Finish exposed [top] [bottom] [and back] surfaces of precast architectural concrete units by smooth, steel-trowel finish.
- C. Finish unexposed surfaces of precast architectural concrete units by float finish.

## **2.16 SOURCE QUALITY CONTROL:**

- A. The Authority will employ an independent testing agency to evaluate precast architectural concrete fabricator's quality-control and testing methods.
1. Allow the Authority's testing agency access to material storage areas, concrete production equipment, concrete placement, and curing facilities. Cooperate with the Authority's testing agency and provide samples of materials and concrete mixes as may be requested for additional testing and evaluation.
- B. Quality-Control Testing: Test and inspect precast concrete according to PCI MNL 117 requirements.
- C. Strength of precast concrete units will be considered deficient if units fail to comply with ACI 318 requirements.
- D. Testing: If there is evidence that the strength of precast concrete units may be deficient or may not comply with ACI 318 requirements, the Authority will employ an independent testing agency to obtain, prepare, and test cores drilled from hardened concrete to determine compressive strength according to ASTM C 42.
1. A minimum of three representative cores will be taken from units of suspect strength, from locations directed by the Engineer.
  2. Cores will be tested in an air-dry condition.
  3. Strength of concrete for each series of 3 cores will be considered satisfactory if the average compressive strength is equal to at least 85 percent of the 28-day design compressive strength and no single core is less than 75 percent of the 28-day design compressive strength.
  4. Test results will be made in writing on the same day that tests are performed, with copies to the Engineer, Contractor, and precast concrete fabricator. Test reports will include the following:
    - a. Project identification name and number.
    - b. Date when tests were performed.
    - c. Name of precast concrete fabricator.
    - d. Name of concrete testing agency.
    - e. Identification letter, name, and type of precast concrete unit or units represented by core tests; design compressive strength; type of break; compressive strength at breaks, corrected for length-diameter ratio; and

direction of applied load to core in relation to horizontal plane of concrete as placed.

- E. Patching: If core test results are satisfactory and precast concrete units comply with requirements, clean and dampen core holes and solidly fill with precast concrete mix that has no coarse aggregate, and finish to match adjacent precast concrete surfaces.
- F. Defective Work: Precast architectural concrete units that do not comply with requirements, including strength, manufacturing tolerances, and finishes, are unacceptable. Replace with precast concrete units that comply with requirements.

### **PART 3 - EXECUTION**

#### **3.01 EXAMINATION:**

- A. Examine substrates and conditions for compliance with requirements for installation tolerances, true and level bearing surfaces, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Do not install precast concrete units until supporting concrete has attained minimum design compressive strength.

#### **3.02 INSTALLATION**

- A. Install clips, hangers, and other accessories required for connecting precast architectural concrete units to supporting members and backup materials.
- B. Install precast architectural concrete. Provide temporary supports and bracing as required to maintain position, stability, and alignment as units are being permanently connected.
  - 1. Install bearing pads as precast concrete units are being erected.
  - 2. Maintain horizontal and vertical joint alignment and uniform joint width as erection progresses.
  - 3. Remove projecting hoisting devices and use sand-cement grout to fill voids within recessed hoisting devices flush with surface of concrete.
- C. Anchor precast architectural concrete units in position by bolting, welding, grouting, or as otherwise indicated. Remove temporary shims, wedges, and spacers as soon as possible after anchoring and grouting are completed.
- D. Welding: Perform welding in compliance with AWS D1.1 and AWS D1.4, with qualified welders
  - 1. Protect precast architectural concrete units and bearing pads from damage by field welding or cutting operations and provide noncombustible shields as required.
  - 2. Repair damaged steel surfaces by cleaning and applying a coat of galvanizing repair paint to galvanized surfaces.
  - 3. Repair damaged steel surfaces by cleaning and repriming damaged painted surfaces.
- E. At bolted connections, use lock washers or other acceptable means to prevent loosening of nuts.
- F. Grouting Connections: Grout connections where required or indicated. Retain grout in place until hard enough to support itself. Pack spaces with stiff grout material, tamping until voids are completely filled. Place grout to finish smooth, level, and plumb with adjacent concrete

surfaces. Keep grouted joints damp for not less than 24 hours after initial set. Promptly remove grout material from exposed surfaces before it affects finishes or hardens.

### **3.03 ERECTION TOLERANCES:**

- A. Install precast architectural concrete units level, plumb, square, and true, without exceeding the following noncumulative erection tolerance
  - 1. Plan Location from Building Grid Datum: Plus or minus 1/2 inch.
  - 2. Plan Location from Centerline of Steel: Plus or minus 1/2 inch.
  - 3. Top Elevation from Nominal Top Elevation: As follows:
    - a. Exposed Individual Panel: Plus or minus 1/4 inch.
    - b. Nonexposed Individual Panel: Plus or minus 1/2 inch.
    - c. Exposed Panel Relative to Adjacent Panel: 1/4 inch.
    - d. Nonexposed Panel Relative to Adjacent Panel: 1/2 inch.
  - 4. Support Elevation from Nominal Support Elevation: As follows:
    - a. Maximum Low: 1/2 inch.
    - b. Maximum High: 1/4 inch.
  - 5. Maximum Plumb Variation over the Lesser of Height of Structure or 100 Feet: 1 inch.
  - 6. Plumb in Any 10 Feet of Element Height: 1/4 inch.
  - 7. Maximum Jog in Alignment of Matching Edges: 1/4 inch.
  - 8. Joint Width (Governs over Joint Taper): Plus or minus 1/4 inch.
  - 9. Maximum Joint Taper: 3/8 inch.
  - 10. Joint Taper in 10 Feet: 1/4 inch.
  - 11. Maximum Jog in Alignment of Matching Faces: 1/4 inch.
  - 12. Differential Bowing or Camber, as Erected, between Adjacent Members of Same Design: 1/4 inch.

### **3.04 FIELD QUALITY CONTROL:**

- A. Testing: The Authority will engage a qualified independent testing and inspecting agency to perform field tests and inspections
- B. Field welds and connections using high-strength bolts will be subject to tests and inspections.
- C. Testing agency will report test results promptly and in writing to Contractor and the Engineer.
- D. Remove and replace work that does not comply with specified requirements.
- E. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of corrected work with specified requirements.

### **3.05 REPAIRS:**

- A. Repair exposed exterior surfaces of precast architectural concrete units to match color, texture, and uniformity of surrounding precast architectural concrete if permitted by the Engineer.
- B. Remove and replace damaged precast architectural concrete units if repairs do not comply with requirements.

### **3.06 CLEANING:**

- A. Clean exposed surfaces of precast concrete units after erection to remove weld marks, other markings, dirt, and stains.
  - 1. Wash and rinse according to precast concrete fabricator's written recommendations. Protect other work from staining or damage due to cleaning operations.

2. Do not use cleaning materials or processes that could change the appearance of exposed concrete finishes.

**END OF SECTION**

**DIVISION 4 - MASONRY**

04050 MORTAR, GROUT AND MASONRY ACCESSORIES  
04215 BRICK MASONRY  
04220 CONCRETE UNIT MASONRY  
04415 GRANITE

**END OF SECTION**

## SECTION 04050

### MORTAR, GROUT AND MASONRY ACCESSORIES

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies furnishing mortar, grout, and accessories for masonry work, including brick masonry, concrete unit masonry, granite and other stone masonry. The installation of such material is specified in the various masonry sections.
- B. Related Work Specified Elsewhere:
  - 1. Brick masonry: Section 04215.
  - 2. Concrete unit masonry: Section 04220.
  - 3. Granite: Section 04415.
  - 4. Seals and sealants: Section 07900.
  - 5. Flashing and sheetmetal: Section 07600.
  - 6. Miscellaneous metals: Section 05500.
  - 7. Concrete formwork: Section 03100.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Manufacturer's data: Recommendations for use of materials, preparation of substrate, limitations and special instructions for materials necessary to the work.
    - b. Granite: Section 04415.
  - 2. Samples:
    - a. Three of each type of the following products used in the work:
      - 1) Mortars: Cured samples showing color of each type.
      - 2) Accessories: Representative samples of each type.
      - 3) Certification.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ASTM: A36, A82, A153, A276, A666, A775, C114, C144, C150, C207, C270, C476, C665, C780, C881, C1019, D570, D638, D695, D1525, D2000, D2240, F593, F594.
  - 3. FS: HH-I-521.
- B. Source Quality Control:
  - 1. Obtain mortar ingredients of a uniform quality, including color for exposed masonry, from one manufacturer for each cementitious component and from one source or producer for each aggregate.

##### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver products to job site in their original unopened containers clearly labeled with manufacturer's name and brand designation, referenced specification number, type and class as applicable.

- B. Store products so as to prevent water intrusion, dampness and deterioration. Store loose materials sand and aggregates so as to prevent intrusion of foreign materials.
- C. Handle products so as to prevent breakage of containers and damage to products.

#### **1.05 JOB CONDITIONS:**

- A. Environmental Requirements:
  - 1. Do not use materials or aggregates that are covered with frost. Do not mix mortar when the temperature is below that specified for masonry work.
  - 2. Provide protective covering and heat as specified for masonry work.
  - 3. Perform work under environmental conditions consistent with manufacturer's recommendations for materials being used in the work.

### **PART 2 - PRODUCTS**

#### **2.01 MORTAR AND GROUT MATERIALS:**

- A. Cement:
  - 1. ASTM C150, Type I, portland cement, packaged in one-cubic-foot waterproof bags.
    - a. For exterior walls, use low alkali cement; maximum 0.60 percent total alkali when tested according to ASTM C114.
    - b. For below grade use type II cement and lime.
  - 2. Cement for brick masonry:
    - a. Factory-prepared, color-blended with nonstaining, inorganic coloring pigment.
    - b. Pigments not to exceed 10 percent of weight of cement.
    - c. Pigment blended in such quantity to produce cured mortar color matching face brick when mixed with hydrated lime and fine aggregate.
- B. Hydrated Lime:
  - 1. ASTM C207, Type S.
  - 2. Uniform color for similar work.
- C. Fine Aggregate: Clean, sharp, masonry sand, ASTM C144. For joints less than 1/4 inch, grade aggregate with 100 percent passing the Number 16 sieve.
- D. Water: Potable.
- E. Pigment: As necessary to produce colored mortar matching color of brick unless otherwise indicated.
- F. Admixtures: Do not add admixtures including air-entraining agents, accelerators, retarders, water repellent agents, antifreeze compounds, or other admixtures unless otherwise indicated.
- G. Epoxy for Epoxy Mortar: Two-component, ASTM C881, Type 3, Grade 3, Class C, with the following additional requirements:
  - 1. Component A: Modified-epoxy resin of epichlorohydrin bisphenol A-type, containing suitable viscosity control agents and having epoxide equivalent of 180-200.
  - 2. Component B: Primarily reaction product of aromatic amine and an aliphatic amine with epoxy resin of epichlorohydrin bisphenol A-type.
  - 3. Ratio of Component A to Component B: By volume, 1:2.
  - 4. Properties of mixed components:
    - a. Solids content: 100 percent by weight.

- b. Pot life: 20 to 30 minutes at 73F.
- c. Tack-free time, thin film: Two to four hours at 73F.
- d. Final cure, 75-percent ultimate strength, ASTM D695: Two days at 73F.
- e. Initial viscosity, A plus B: 250 to 350 cps at 73F.
- 5. Properties of cured material:
  - a. Tensile strength, ASTM D638: 5,000-psi minimum at 14 days, 73F cure.
  - b. Tensile elongation, ASTM D638 modified: One to three percent at 14 days, 73F cure.
  - c. Compressive strength, ASTM D695: 10,500-psi minimum at 28 days, 73F cure.
  - d. Water absorption, ASTM D570: One-percent maximum.
  - e. Bond strength: 2,000-psi minimum at 14 days.
  - f. Hardened to hardened: 73F cure.
  - g. Vicat softening temperature, ASTM D1525: 121F minimum.
- H. Aggregate for Epoxy Mortar: Silica sand, Size 20 to Size 40, dust-free and moisture-free.

## 2.02 MORTAR AND GROUT MIXES:

- A. Mortar Mixes for Brick Masonry: ASTM C270, types as follows:
  - 1. Type S: For exterior loadbearing masonry and for masonry in contact with earth, proportioned by volume as follows:
    - a. Portland cement: One part.
    - b. Hydrated lime: 1/4 to 1/2 part.
    - c. Fine aggregate: Not less than 2-1/2 nor more than three times sum of volumes of cement and lime.
    - d. Pigment: As necessary to produce colored mortar matching color of brick unless otherwise indicated.
  - 2. Type N: For interior non loadbearing masonry, proportioned by volume as specified for Type S, except 1/2 to 1-1/4 parts hydrated lime.
  - 3. Color: As shown or as selected by the Engineer.
- B. Mortar Mixes for Concrete Unit Masonry: As specified for brick masonry, except pigment not required.
- C. Mortar Mixes for Granite Setting Bed:
  - 1. Granite, except paving, apron at pylons, platform edging, stair treads and landings: Nonstaining mortar composed of one-part portland cement and one-part plastic lime hydrate to four or five parts fine aggregate, ASTM C270, Type N. Pointing mortar of same composition, colored to matched granite.
  - 2. Granite paving and granite apron at pylons: Nonstaining mortar composed of one-part portland cement to no more than four parts natural sand. For pointing use specified preshrunk mortar.
  - 3. Stair treads and landings: Epoxy mortar consisting of one-part epoxy to 3-1/4 parts of aggregate by loose volume.
  - 4. Platform edging: Epoxy mortar consisting of one-part epoxy to 1-1/2 parts of aggregate by loose volume.
- D. Grout: For setting steel lintels and similar items, grouting mortar composed of one-part portland cement and two parts fine aggregate with sufficient lime putty added to obtain quick set.
- E. Preshrunk Mortar: Dry, premixed, ready-to-use formulation.

## 2.03 ACCESSORIES:

- A. Continuous joint reinforcement:
1. Accessories for Brick and Concrete Unit Masonry:
    - a. Prefabricated continuous-reinforcing tie system fabricated of wire conforming to ASTM A82. Flush-welded cross ties, nine-gauge wire, hot-dip galvanized after fabrication in accordance with ASTM A153, Class B2, 1.50 ounces for side and cross rods.
    - b. Fabricate joint reinforcement in straight lengths of not less than 10 feet of truss design with continuous diagonal cross ties spaced maximum 16 inches o.c.
      - 1) Make width of unit 1-1/2 inches to two inches less than thickness of wall.
      - 2) For multi-wythe wall, provide one side rod for each face shell of masonry more than four inches in width; plus one side rod for each wythe of masonry four inches or less in width.
      - 3) At cavity walls, provide integral drips on cross rods. Where horizontal joints of outer wythe does not align with back-up joints, provide adjustable two-piece tab design to engage the outer wythe by at least 1-1/2 inches.
    - c. Corner reinforcement: Prefabricated, shop-welded corner-L and intersection-T units matching the continuous wall units.
    - d. Spacing: See related work sections.
  2. Dovetail anchors:
    - a. Flexible, adjustable or corrugated 1-inch wide dovetail anchors of 12 gauge galvanized steel. Place anchors every 16 inches in height of wall at intersections of masonry walls and concrete, and for masonry furring of concrete. Dovetail slots are specified in Section 03100, by same manufacturer of anchors.
  3. Wall plugs:
    - a. Galvanized 26-gauge corrugated metal, approximately three inches long and of standard manufacture, where necessary for attaching other work.
  4. Z-type rigid-steel anchors: Steel, ASTM A36, 1/4-inch thick by 1-1/2 inches wide by 28 inches long, galvanized; with one two-inch opposing 90-degree bend at each end.
  5. Corrugated-steel anchors: 14 gauge by 1-1/4 inches by 20 inches with one two-inch 90-degree bend, with 18 inches of corrugation.
  6. Steel framing anchors: Fabricated of 3/16-inch galvanized wire tie and galvanized flat-steel strap one-inch wide by 22 gauge or 3/4-inch wide by 12 gauge.
  7. Weep-hole tubes: 3/8-inch OD, medium density, nonstaining, polyethylene tubes of lengths ensuring complete panel penetration and unobstructed flow. Fire-resistant compressible filler: Inorganic, non-asbestos mineral fiber safing insulation, with foil facing to impede smoke passage; moisture resistant, mildew-proof and vermin-proof, noncorrosive and nondeteriorating; UL-listed; meeting ASTM C665 and FS HH-I-521 Type III, except for identification marking.
  8. Control joint gasket: Solid styrene-butadiene-rubber compound per ASTM D2000, 2AA-805, factory extruded into shapes for use with standard sashblock to provide stability to masonry walls at expansion and control joints; minimum shear strength 540 psi, durometer hardness 80 (plus or minus 5) per ASTM D2240. Provide T-shape and X-shape for vertical joints as appropriate, flat shape beneath load-relieving angles.
  9. Cavity Drainage System: 1 inch thick by 10 inches high by 5 feet long section of high density polyethylene or nylon mesh designed to allow moisture to flow downward in cavity joint.
  10. Masonry Cell Insulation: Molded polystyrene Insulation Units - Rigid, cellular thermal insulation formed by the expansion of polystyrene - resin beads or granules in a closed mold to comply with ASTM 578, Type I. Provide specially shaped units designed for installing in cores of masonry units.

- B. Accessories for Granite:
1. Stainless steel, ASTM A276 or A666, Type 304, for anchors, cramps, angles, dowels, plates, bolts or other accessories in contact with stone.
  2. Anchor sizes:
    - a. Anchors with dowels: 3/16 inch by one inch in cross section.
    - b. Two-way anchors: 1/8 inch by two inches in cross section.
    - c. One-way anchors: 1/8 inch by one inch in cross section.
    - d. Anchors to stone: Anchors of necessary length and of type that turn into stone minimum of 1/2 inch.
    - e. Anchors to concrete: Heavy-duty sleeve style or wedge-type anchors with 3,000-pound hold-fast strength or anchors suitable for use with dovetail slots.
    - f. Lewis anchors for lifting stones: 3/4 inch in diameter.
    - g. Other anchors: Sizes as shown on approved shop drawings.
    - h. Fasteners for Stainless-Steel Anchors: Annealed stainless-steel bolts, nuts, and washers; ASTM F593 for bolts and ASTM F594 for nuts.
    - i. Setting Shims: Strips of vulcanized neoprene, 50 to 70 Shore A durometer, nonstaining to stone, sized to suit joint thicknesses and depths of stone supports without intruding into required depths of joint sealants or causing third-side adhesion between sealant and setting shims.
    - j. Weep and Vent Tubes: Medium-density polyethylene tubing, 1/4-inch OD and of length required to extend from exterior face of stone to cavity behind.
  3. Sizes for other accessories:
    - a. Dowels: Minimum of 1/2 inch in diameter, designed to extend two inches into stone and two inches into concrete.
    - b. Cramps: 1/8-inch by one-inch plate with 3/8-inch dowels at each end designed to extend into stone and concrete a minimum of one inch.
    - c. Angles, plates, and bolts: Sizes as shown on approved shop drawings.
- C. Steel lintels: Section 05500.
- D. Masonry lintels: Section 04220.
- E. Flashing: Section 07600.

### **PART 3 - EXECUTION**

#### **3.01 MIXING OF MORTAR:**

- A. Mix mortar materials in an approved clean mechanical mixer for at least three minutes and not more than five minutes with a minimum amount of water to produce workable consistency.
- B. Mortar which has stiffened because of evaporation of water may be retempered by adding water as needed to restore necessary consistency. Use mortar within 2-1/2 hours of initial mixing.
- C. Use an approved method of measuring materials and mortar that will control and accurately maintain specified proportions throughout the work. Shovel measure is prohibited. Measure sand in damp, loose condition.
- D. Apply pre-shrunk mortar in accordance with the manufacturer's instructions.
- E. For alteration and restoration work, tint or modify mix to match mortar of existing masonry.

- F. The Engineer may direct a test of the mortar in accordance with ASTM C780 and a test of the grout for compressive strength per ASTM C1019 to establish compliance with specified requirements.

**END OF SECTION**

## SECTION 04215

### BRICK MASONRY

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing brick masonry.
- B. Related Work Specified Elsewhere:
  - 1. Mortar, grout and masonry accessories: Section 04050.
  - 2. Miscellaneous metal: Section 05500.
  - 3. Seals and sealants: Section 07900.
  - 4. Demolition: Section 02220.
  - 5. Concrete Unit Masonry: Section 04220.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Samples:
    - a. Three sets of each type of the following products used in the work:
      - 1) Face brick: Assemble each set to show the complete variation and percentage proportion of color, texture and other variable properties of appearance.
        - (a) Size and shape for general use.
        - (b) Special shapes and sizes used in the work.
      - 2) Common brick.
    - b. Brick panels:
      - 1) Construct sample masonry panels of exposed brick masonry, of size not less than four feet square by eight inches thick incorporating reinforcement, flashing, face brick and backup units. Construct sample panel on site, with face brick facing same direction as major facade of the work.
      - 2) If necessary to produce an acceptable standard of appearance and workmanship, construct additional panels until approved.
      - 3) Use types of material, color variation, mortar, bond, thickness and tooling of joints, method of laying and workmanship typical and standard for the installation. Clean sample panel as specified for finished work.
      - 4) Maintain panels in good condition and protect from moisture penetration until completion of masonry work and removal is directed.
  - 2. Certification.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. BIA: Technical Notes on Brick Construction No. 7B.
  - 3. ASTM: C62, C216.
- B. Source Quality Control:

1. All brick used in the work to be from the same run.

**1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Deliver products to the job site in good condition.
- B. Keep products dry. Prevent contact with soil.
- C. Handle products so as to prevent chipping and breaking.

**1.05 JOB CONDITIONS:**

- A. Environmental Requirements:
  1. The following are prohibited:
    - a. Use of products that are covered with frost.
    - b. Erection of masonry when temperature is below 40F or tending to fall below 40F, unless suitable fireproof protective covering and heat are provided to maintain work and materials above 40F.

**PART 2 - PRODUCTS**

**2.01 MATERIALS:**

- A. General:
  1. For alteration and restoration work:
    - a. Provide bricks of same size, type, grade and appearance as existing brick work.
    - b. Brick salvaged under Section 02220 may be used if approved.
- B. Face Brick:
  1. ASTM C216, Type FBS, Grade SW, wire-cut.
  2. Size 2-1/4 inches by 3-5/8 inches by 7-5/8 inches.
  3. Color: Richtex No. 761M by Richland Shale Products Company, Columbia, SC; No. 320 Grey Wirecut by Taylor Clay Products Company, Salisbury, NC.; or approved equal.
  4. Special shapes: 100-percent solid for the following locations:
    - a. Flat header wall caps.
    - b. End units on rowlock header wall caps.
    - c. Corners of soldier courses.
    - d. Corbels.
    - e. Pierced screen walls.
    - f. Where construction would result in exposed cores.
    - g. Where shown.
- C. Common Brick:
  1. ASTM C62, wire-cut; Grade SW.
  2. First quality, hard grade, standard size.
- D. Cleaning Solution:
  1. Formulated for cleaning new brick work, containing no acid.
  2. Type which will not stain, discolor or otherwise adversely affect surfaces with which it comes into contact.
- E. Accessories: Section 04050.

- F. Steel Lintels and Shelf Angles: Section 05500.

### **PART 3 - EXECUTION**

#### **3.01 PREPARATION:**

- A. Remove dirt, debris, oil, grease and other foreign matter from surfaces to receive brick masonry.
- B. Built-In Work:
  - 1. Verify and coordinate locations of chases and openings for pipes, conduit, ducts and locations of flashing and weep holes.
  - 2. Establish layout lines and verify proper setting of bucks and frames.

#### **3.02 ERECTION:**

- A. Construct masonry as recommended in BIA Technical Notes on Brick Construction Number 7B, Water Resistance of Brick Masonry Construction and Workmanship Part III of III.
- B. Erect new masonry to conform to approved sample panels. For alteration and restoration work, match existing masonry.
- C. Erect adjoining walls simultaneously. Do not erect walls more than five feet above adjoining walls. Tothing is prohibited. Cover and protect tops of unfinished walls. Protect cavities from mortar and debris.
- D. Plumb piers and walls. Level brick courses using uniform joint thickness. Use power-driven, masonry saws for cutting material. Build external corners square, unless otherwise shown.
- E. Provide structural and pattern bonding as shown or as specified.
- F. Place reinforcement and build in openings for pipes, conduits, ducts, chases and other work as shown.
- G. Grout and set in place steel lintels furnished by other trades for openings in masonry walls.
- H. Install flashing, reglets and weep holes over lintels and where shown. Lap joints in flashing four inches minimum and bond with mastic. Install through-wall flashing to within ½ inch of inside and outside faces of wall. Set flashing in full bed of mortar and trowel full bed of mortar to ensure complete contact.
- I. Use facing brick for exposed brickwork. Select face brick from various stock piles so that they may be integrated to prevent segregating color ranges and bricks from different runs. Use same color mortar proportions throughout work.
- J. Prior to laying face brick, lay out work so that bond and design are maintained plumb and level and joints are of uniform width throughout the work.
- K. Do not use segments of bricks less than one half in size at corners or at openings. Use same sizes of bricks or same sizes of brick segments in same course at each side of jambs of openings or piers. Where cutting of units is necessary, use motor driven masonry saw.
- L. Thoroughly drench brick with water just before laying. Cover brick uniformly with mortar, shove and press into place, with no voids in wall joints, at window frames or at door frames.

- M. Where dovetail anchors are required, provide anchors vertically at each slot, maximum 16 inches on center and solidly fill in joints against concrete with mortar. Ensure that joints at anchors and bond courses are filled.
- N. Unless otherwise shown, use 3/8-inch concave joints, carefully tooled to form smooth, dense surface. Avoid burrs at intersections and mortar discoloration.
- O. Lay face brick from exterior with bed joints, head joints and collar joints full and level, faces plumb, joints uniform and bonds accurate.
- P. For alteration and restoration work, provide beds, coursing and face joints to match existing brick masonry precisely.
- Q. Place continuous joint reinforcement in courses 16 inches on center as shown. Use specially fabricated sections at corners and intersections.
- R. Provide expansion and control joints in masonry walls as shown. Ensure that joints are straight, uniform and of thickness shown. Ensure that clear joints are free of water, mortar and other obstructions. Leave continuous open joint for caulking and sealing in accordance with Section 07900. Provide cavity drainage system on top of the flashing inside the cavity. Drainage system shall be continuous at cell cavity flashing.
- S. Masonry anchors and accessories: In accordance with Sections 04050 and 04220.
- T. Accessories: Section 04050.
- U. Fill jambs of hollow metal frames solid with grout, as laying of brick progresses.
- V. As the work progresses, clean masonry with stiff brush before mortar sets.
- W. Install steel lintels where shown on Contract Documents or approved shop drawings.

### **3.03 REPAIRING, POINTING AND CLEANING:**

- A. Repairing:
  - 1. Remove and replace units that are loose, chipped, broken, stained or otherwise damaged; or if units do not blend properly with adjoining units. Install item units to match adjoining units and in fresh mortar, pointed to eliminate evidence of replacement.
- B. Pointing:
  - 1. When approved, point holes in joints of exposed brick masonry surfaces by completely filling with preshrunk mortar.
    - a. Pre-wet joint and holes before pointing.
    - b. Tool to match adjacent joints. Protect from premature drying.
  - 2. Correct defective joints by cutting out mortar and solidly refilling with new mortar.
  - 3. Point exposed raked joints of brick masonry with mortar and tool to match approved sample panel.
  - 4. Pre-wet holes and joints before pointing. Protect masonry from premature drying.
- C. Cleaning:
  - 1. After pointing, wet exposed brick-masonry surfaces and clean with soap-and-water solution applied with stiff-fiber brushes leaving masonry clean, free of mortar daubs and with tight mortar joints throughout. The use of acid is prohibited.

2. Allow masonry walls to cure at least three weeks in summer and five weeks in winter before final cleaning.
3. Test clean methods on sample wall panel; leave 1/2 panel uncleaned for comparison purposes. Obtain approval of sample cleaning before proceeding with cleaning of masonry.
4. Begin cleaning at top and work down.
  - a. Remove as much mortar from brick as is possible with scrapers or wire brushes; taking care not to discolor mortar or brick.
  - b. Dampen walls thoroughly with water to prevent loose materials from being drawn into pores of dry brick below and to prevent build-up of dry detergents.
5. Clean surfaces thoroughly with specified cleaning solution. Rinse and flush with clean water immediately after cleaning.
6. Leave work in first class condition, free from mortar stain or other defacement.

**END OF SECTION**

## SECTION 04220

### CONCRETE UNIT MASONRY

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing concrete unit masonry and glazed concrete masonry.
- B. Related Work Specified Elsewhere:
  - 1. Mortar, grout and masonry accessories: Section 04050.
  - 2. Brick masonry: Section 04215.
  - 3. Miscellaneous metal: Section 05500
  - 4. Flashing and sheet metal: Section 07600.
  - 5. Seals and sealants: Section 07900.
  - 6. Concrete reinforcement: Section 03200.
  - 7. Cast-in-place structural concrete: Section 03300.
  - 8. Structural precast concrete: Section 03400.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Samples for Initial Selection: Samples in small-scale form showing the full range of colors and textures available for each different exposed masonry unit required.
  - 2. Samples:
    - a. Three sets of each type of the following products used in the work.
      - 1) Concrete masonry units (CMU):
        - a) Lightweight.
        - b) Normal weight.
        - c) Special shapes.
        - d) Glazed.
      - 2) Precast lintels.
      - 3) CMU lintels.
    - b. Concrete masonry panels:
      - 1) Construct sample panels for exposed work only. Build panels not less than four feet square by eight inches thick, incorporating reinforcement and concrete masonry units. See Section 04215 for brick panels. Construct one panel of concrete glazed and unglazed masonry units.
      - 2) Use types of material, color variation, mortar, bond, tooling of joints, method of laying and workmanship shown or specified.
      - 3) Maintain panels in good condition and protect from moisture penetration until completion of masonry work and removal is directed.
      - 4) Approval of mock ups is for color, texture and blending of masonry unit; relationship of mortar and sealant colors to masonry unit colors; tooling of joints; and aesthetic qualities of workmanship.
      - 5) Maintain panel in good condition and protect from moisture penetration until completion of masonry work. Panel may remain as part of finished work after approval.
  - 3. Shop Drawings: Show fabrication and installation details for the following:
    - a. Comply with ACI 315, "Details and Detailing of Concrete Reinforcement." Show elevations of reinforced walls.

- B. Certification.

#### **1.02 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. NCMA: TEK Manual for Concrete Masonry Design and Construction.
  - 3. ASTM: A615, C33, C55, C90, C129, C150, C744, E119.
  - 4. ACI: 315, 530.1-99.
  - 5. UL: Fire Resistance Directory.
- B. Source Limitations for Masonry Units: Obtain exposed masonry units of a uniform texture and color, or a uniform blend within the ranges accepted for these characteristics, through one source from a single manufacturer for each product required.
- C. Fire-Resistance Ratings: Where indicated, provide materials and construction identical to those of assemblies with fire-resistance ratings determined per ASTM E119 by a testing and inspecting agency, by equivalent concrete masonry thickness, or by another means, as acceptable to authorities having jurisdiction.

#### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Deliver products to jobsite in good condition.
- B. Keep products clean and dry. Prevent contact with soil.
- C. Handle products so as to prevent chipping and breakage.

#### **1.05 JOB CONDITIONS:**

- A. Environmental Requirements:
  - 1. The following are prohibited:
    - a. Use of products that are covered with frost.
    - b. Erection of masonry when the temperature is below 40F or tending to fall below 40F, unless suitable fireproof protection covering and heat are provided to maintain work and materials above 40F.

### **PART 2 - PRODUCTS**

#### **2.01 MATERIALS:**

- A. CMU:
  - 1. General:
    - a. Nominal dimensions:
      - 1) Face size: 7-5/8 inches by 15-5/8 inches.
      - 2) Thickness: As shown.
    - b. For exposed work, units of uniform medium texture, free from defects and of uniform dimensions. Furnish special units as necessary.
    - c. Units having UL Fire Resistance Directory ratings to achieve fire ratings for walls as required by local building codes and as shown.
    - d. Units free from iron and other substances that will stain plaster or paint.
  - 2. Lightweight CMU:
    - a. Hollow, lightweight loadbearing concrete units: ASTM C90, Type I.
    - b. Solid, lightweight loadbearing concrete units: ASTM C90, Type I.

- c. Lightweight concrete brick: ASTM C55, Type I, Grade N.
    - d. Aggregate: Limited to expanded shale or slate.
    - e. Hollow, light-weight non-load bearing concrete units: ASTM C129, Type 1
  - 3. Normal-weight CMU:
    - a. Solid loadbearing units: ASTM C90, Type I.
    - b. Exposed alteration and restoration work: Units of same type, grade, size, color variation, texture and appearance as existing masonry work.
  - 4. Concrete fill for CMU bond beams and reinforced masonry unit cores: Class 3500; maximum aggregate size, 3/4 inch, and in accordance with Section 03300.
- B. Glazed CMU:
  - 1. Prefaced or glazed concrete masonry units shall conform to the requirements specified above for C90 concrete masonry units, and the facing to the following requirements:
    - a. Glazing (Facing): ASTM C744.
- C. Lintels:
  - 1. General:
    - a. Provide lintels of same height and width, texture and density as CMU and 16 inches longer than width of opening, free of cracks and chipped and broken edges.
    - b. Concrete:
      - 1) Portland cement in accordance with Section 03300: ASTM C150, Type I.
      - 2) Reinforcing steel bars in accordance with Section 03200: ASTM A615, Grade 60.
      - 3) Aggregate: ASTM C33, graded from 1/8 inch to 3/8 inch.
  - 2. Precast lintels: Class 3500 concrete in accordance with Section 03400, reinforced full length with No. 5 reinforcing bars in accordance with Section 03200, one at top and one at bottom for each four inches nominal width, and No. 2 ties at eight inches on center at each end, unless otherwise shown.
    - a. CMU lintels:
    - b. Lightweight loadbearing lintel-type CMU complying with specified requirements.
    - c. Filled with Class-3000 concrete minimum in accordance with Section 03300 and reinforced in accordance with Section 03200 for width and span as specified for precast lintels, unless otherwise shown.
  - 3. Steel Lintels: Section 05500.
- D. Masonry Accessories: Section 04050.
- E. Cleaning Solution: Section 04215.
- F. Mortar and Grout: Sections 04050 and 03300.

## **PART 3 - EXECUTION**

### **3.01 PREPARATION:**

- A. Clean foreign substances which would affect bond of mortar from surfaces to receive CMU.
- B. Built-In Work.
  - 1. Verify locations of chases and openings for pipes, conduits and ducts.
  - 2. Establish locations for walls and partitions; verify that door frames and other built-in work provided by others are or can be properly located.

### 3.02 ERECTION:

- A. Erect exposed CMU masonry work to conform to approved sample panel.
- B. Use of loadbearing and non-loadbearing units shall be governed by locations and purposes to be served. Except as otherwise shown, follow these general uses:
  - 1. Loadbearing: Backup loadbearing masonry walls and for bearing partitions.
  - 2. Non-loadbearing: Furring, non-bearing partitions and backup non-loadbearing masonry walls.
  - 3. Solid: Where specifically required by drawings, for fireproofing structural steel and for partitions with fire ratings.
- C. Erect adjoining walls simultaneously. Do not erect walls more than five feet above adjoining walls. Tothing is prohibited. Cover and protect the tops of unfinished walls.
- D. Plumb piers, walls and partitions. Level courses using uniform joint thickness for interior work, build external corners with bullnose units.
- E. Place reinforcement and build in openings for pipes, conduits, ducts, chases, frames and other work as shown.
- F. Grout in accordance with Sections 04050 and 03300 and set in place miscellaneous steel lintels furnished by other trades for openings in masonry walls in accordance with Section 05500. Provide eight-inch minimum bearing on adjacent masonry unless otherwise indicated.
- G. As the work progresses, keep masonry clean by stiff brushing with fiber brush. Do not wet units before laying up. Unless otherwise shown, lay units in running bond.
  - 1. Set cored units with cells vertical, unless manufactured with horizontal cores. Open ends not permitted.
  - 2. Lay out so that at jambs and internal and external angles, the headers in alternate courses are at least 2 inches long. Use "Z shapes if necessary , especially with glazed masonry units.
  - 3. Lay units out so that no cut piece is less than 5 inches long; not less that 2 inches high
  - 4. Lay concrete units up suitable for painting. See finish schedules.
- H. Prevent smearing mortar on surface of exposed units. If mortar smears occur, remove while soft.
- I. Carefully cut faces of units for electrical or other outlets and cut-out backs for conduit and other piping. Where possible, use full-size units. Do not use portions of units shorter than four inches. Perform cutting with power-driven masonry saws.
- J. Build partitions straight, plumb, true to line and uniform in thickness unless shown otherwise. Anchor partitions at junctions with CMU exterior walls using Z-type steel anchors, rigid or corrugated, Z-bar anchors vertically 24 inches on center maximum unless otherwise shown. Use dovetail anchors spaced not over 16 inches on vertical centers where partitions abut concrete walls or concrete columns and steel framing anchors where partitions abut steel columns. Start partitions on concrete slabs and extend to structure above, except where shown to be erected only to ceiling.

- K. Use CMU or precast lintels except where steel lintels are shown. Use precast lintels for four-inch CMU partitions. For other CMU partitions and walls, use lintels fabricated at plant or at jobsite from concrete-masonry lintel units. Provide eight-inch minimum bearing on adjacent masonry unless otherwise indicated.
- L. Fill cells of CMU with mortar in accordance with Section 04050, adjacent to openings and around built-in and embedded items.
- M. Place prefabricated continuous joint reinforcement in alternate horizontal joints above grade and each horizontal joint below grade. Terminate each side of expansion joints. Use specially fabricated sections at corners and intersections.
- N. Fill cells solid with grout in accordance with Sections 04050 and 03300 where vertical reinforcement is installed within CMU walls.
- O. Fill heads and jambs of hollow metal frames solid with mortar in accordance with Section 04050, as laying of units progresses.
- P. Tooling joints:
  1. After mortar has attained initial set, finish and compact with non-staining metal jointing tool, forcing mortar tight against masonry units and closing all hair line cracks and crevices.
  2. All interior and exterior joints tooled concave type, except as stated below or noted otherwise.
    - a. At wall faces to receive other facing materials having mortar backing, strike joints flush.
    - b. At concealed joints and joints on cavity side of cavity walls, strike flush.
- Q. Mortar Bedding in accordance with Section 04050:
  1. Hollow units shall be laid with full mortar coverage on horizontal and vertical face shells, except that webs shall also be bedded in all courses of piers, columns, and pilasters, and in the starting course of footings and solid foundation walls, and where adjacent to cells or cavities to be reinforced and/or filled with mortar or grout.
  2. Solid units laid with full head and bed joints.
  3. Masonry units:
    - a. Laid in beds of mortar of such plasticity and fullness and spread with trowel so that pressing and shoving units will obviate dashing or slushing joints after units are laid. Mortar shall not be "furrowed".
    - b. In cavity walls, mortar shall be beveled on cavity side to prevent protruding mortar fins and subsequent dropping of mortar into cavity.
    - c. For interior and exterior faces of walls, prior to placing units, one end of each stretcher shall be fully covered with mortar.
    - d. For any wall thickness, leave no voids whatever, except space in cavity walls.
- R. Top of Non-Loadbearing Partitions: Build non-loadbearing interior partitions full height of story to underside of solid floor or roof structure above, unless shown otherwise. Build as follows depending on the movement requirements of floor or structure above, and as shown:
  1. Install fire resistant compressible filler in joint between top of partition and underside of structure above.
  2. Fill top joint with mortar in accordance with Section 04050, after dead-load deflection of structure above approaches final position.
- S. Installation of Masonry Accessories:
  1. Wall anchors:

- a. Space Z-type rigid-steel anchors at intersections of loadbearing CMU walls and control joints.
  - b. Space corrugated-steel anchors 16 inches on centers vertically at control joints located not more than two feet from intersections of CMU walls.
2. Steel framing anchors: Install anchors to attach CMU walls to structural steel building frame at 16 inches on centers horizontally and vertically. Weld anchors to structural steel so as to achieve full strength of anchor system.
  3. Soldier-course anchors: Install corrugated-steel anchors in horizontal mortar joints of soldier coursing, except where continuous wall reinforcement is used. Space anchors 24 inches on centers horizontally.
  4. Flashing: Install flashing to provide positive keying to mortar.
  5. Weep holes: Install at two feet on centers at terminations of through-wall flashing, base flashings, lintels, or relief angles, and as shown.
  6. Control joint gasket: Install in sash-type CMU and between wythes in accordance with manufacturer's instructions and as shown. Seal weather side of control joints with sealant and backup rod as specified in Section 07900.
- T. Bond Beams:
1. Provide bond beams in walls where shown.
  2. Construct similar to CMU lintels, except beams to be continuous, except at control joints.

### **3.03 POINTING AND CLEANING:**

- A. Pointing:
1. When approved, point holes in joints of exposed CMU masonry surfaces by completely filling with preshrunk mortar.
  2. Point exposed raked joints of CMU masonry with mortar and tool to match approved samples panels.
- B. Cleaning:
1. After pointing, wet and clean exposed CMU masonry surfaces with soap-and-water solution, applied with stiff-fiber brushes leaving masonry clean, free of mortar daubs and with tight mortar joints throughout. The use of acid is prohibited.
  2. Allow masonry walls to cure at least three weeks in summer and five weeks in winter before cleaning.
  3. Begin cleaning at top and work down.
  4. Remove as much mortar from masonry as is possible by hand with wooden paddles and nonmetallic scraper hoes or chisels or stiff bristle brushes taking care not to deface masonry units.
  5. Remove specific stains by cleaning method indicated in NCMA TEK 8-2 applicable to type of stain present on exposed surfaces.
  6. Clean surfaces thoroughly and carefully with specified cleaning solution.
  7. Rinse and flush with clean water immediately after cleaning.
  8. Leave work in clean condition, free from mortar stain or other defacement.

**END OF SECTION**

## SECTION 04415

### GRANITE

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing granite for architectural work.
- B. Related Work Specified Elsewhere:
  - 1. Mortar, grout and masonry accessories: Section 04050.
  - 2. Seals and sealants: Section 07900.
  - 3. Cast-in-place structural concrete: Section 03300.
  - 4. Platform edge light glass lenses and sealant: Section 08800.

##### 1.02 PERFORMANCE REQUIREMENTS:

- A. Stone Abrasion Resistance: Minimum abrasive-hardness value of 12, as determined per ASTM C241.
- B. Static Coefficient of Friction: ASTM C1028, values as follows:
  - 1. Level Surfaces: A minimum of 0.6.
  - 2. Step Treads: A minimum of 0.6.
  - 3. Ramp Surfaces: A minimum of 0.8.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Show the following:
      - 1) Bedding, bonding and jointing of granite, including typical and special anchoring, expansion-joint details and interface with other work.
      - 2) Dimensions and setting numbers of each stone in plan and elevation, including grading data for drainage.
  - 2. Working Drawings:
    - a. Include full explanation of erection methods and installation procedures, temporary loading, anchor design, surface preparation, setting materials, bonding, testing and other work as directed.
    - b. For granite walls, include structural analysis data signed and sealed by the qualified professional structural engineer responsible for their preparation.
  - 3. Samples:
    - a. Submit three sets of samples of each type of granite used in the work, showing full range of color, texture, veining, fissures and finish of each type; each sample 12 inches square by one-inch thick. Include a minimum of two pieces in each set with maximum number of pieces in each set as necessary to demonstrate full range and variations.
      - 1) Material delivered or erected not within approved range samples will be rejected.
    - b. Epoxy for mortar dams and epoxy fill and for setting dowels: Manufacturer's standard container.
    - c. Non-staining wedge.

- d. Stainless steel dowel.
- e. Platform edge glass lens and sealant: Section 08800.
  - 1) Cured six-inch long strip of grout matching existing white granite grout joint color for granite slab transverse joint grouting: Section 04050.
  - 2) Platform joint sealant: Section 07900.
- 4. Documentation:
  - a. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.
  - b. Quality-Assurance Program.
- 5. Certification.

**1.04 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications.
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. NBGQA: Specifications for Architectural Granite.
  - 3. ASTM: C241, C615, C1028.
- B. Qualifications of Granite Quarries:
  - 1. Obtain granite from approved quarries having capacity and facilities for furnishing the quantity, size and quality of granite required.
  - 2. Provide the product of one quarry matching approved samples.
  - 3. Source Limitations for Stone: Obtain each variety of stone, regardless of finish, from a single quarry with resources to provide materials of consistent quality in appearance and physical properties.
  - 4. Installer Qualifications: An experienced installer who has completed dimension stone cladding systems similar in material, design, and extent to those indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.
- C. Quality Assurance Program: Before installing granite edging, walls and stairs, construct mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and qualities of materials and execution. Build mockups to comply with the following requirements, using materials indicated for completed work.
  - 1. Granite edging:
    - a. Demonstration installation:
      - 1) Demonstration installation to consist of three adjacent units to be installed in the work or as otherwise directed.
      - 2) Perform work as shown and in accordance with approved shop drawings and working drawings, using specified materials.
    - b. Testing:
      - 1) In the presence of the Engineer and in accordance with approved working drawings, test each unit of the demonstration installation by placing end of crowbar at each end of unit and prying with a force that would lift an unbonded piece of stone with 50 psf live load. Protect stone from touching crowbar directly. In the presence of the Engineer, before joint sealants are installed, test the bonded strength of each unit after two-hour cure time by applying an uplift load of 2,000 pounds at each drainage opening below the granite as approved.
      - 2) If a unit fails to pass test by lifting or cracking of unit or setting bed, remove unit, revise setting procedures and reset unit. Repeat, as necessary, until approval is obtained.

- 3) Do not proceed with remainder of the work until demonstration installation, procedures and personnel are approved.
  2. Stair treads and landings:
    - a. Prior to erection at site, test each stair tread and stair landing to withstand live load of 300 psf for duration of not less than 15 minutes. Test only components which perform a structural function and are not supported over their entire length by cast-in-place concrete.
  3. Granite walls:
    - a. Build mockups of typical exterior wall with dimension stone cladding, approximately 72 inches long by 48 inches high or as directed by the Engineer.
    - b. Show typical components, attachments to building structure, and methods of installation. Include sealant-filled joint complying with requirements in Section 07900.
- D. Professional Structural Engineer Qualifications: A professional structural engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of granite wall cladding systems that are similar to those indicated for this Project in material, design, and extent.

#### **1.05 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Pack granite so as to prevent damage in transit, and deliver in accordance with Contract schedule and setting sequence.
- B. Deliver each piece of granite with code mark on unexposed face, corresponding to shop drawings using nonstaining paint. Deliver and unload granite. Prevent damage and soiling during delivery and unloading of granite.
- C. Protect from disfiguring elements.
- D. Separate granite from wood skids with polyethylene or other nonstaining material. Store under waterproof covering, and keep dry.
- E. Remove rejected stones from jobsite immediately.

#### **1.06 JOB CONDITIONS:**

- A. Environmental Requirements:
  1. Do not use frozen materials or materials mixed or coated with ice or frost. Remove and replace dimension stone cladding damaged by frost or freezing conditions.
  2. Erection and pointing of granite when ambient temperature is below 50F and or tending to fall below 50F is prohibited.
- B. Cold-Weather Protection: When night-time temperature is forecasted within 50 to 25 Deg F: Cover dimension stone cladding with a weather-resistant membrane for 48 hours after construction. Do not install granite when night time temperature is forecasted below 25 Deg.

### **PART 2 - PRODUCTS**

#### **2.01 MATERIALS:**

- A. Granite:
  1. Granite Building Stone Standard: ASTM C615.

2. NBGQA Specifications for Architectural Granite, free from starts, cracks or seams which might impair its structural integrity or appearance.
  3. Color classification: Granite matching grain, color and variegation of all white, fine-to-medium-grain granite as listed in referenced NBGQA standard.
  4. Exposed surfaces finished in accordance with the following and as shown:
    - a. Type 1: Thermal finish or four-cut, slip-resistant.
    - b. Type 2: Six-cut, stippled.
    - c. Type 3: Honed-dull sheen without reflections.
    - d. Type 4: Split face, nominal depth of 3-1/2 inches. Use Type 4 for all Granite Sets.
  5. Where stone thickness permits, provide lewis holes for lifting stones weighing over 100 pounds. Make lewis holes not closer than two inches from finished face of stone nor in exposed portions of stone.
  6. For alteration and restoration work, use granite salvaged from existing work. If salvaged granite is not sufficient, provide new granite to match existing granite in type, size and appearance.
- B. Mortar Materials and Granite Accessories: Section 04050.
- C. Portland Cement Paste: Section 03300.
- D. Granite platform edge glass lenses and setting materials:
  1. Glass lenses: Salvage and reuse existing lenses to greatest extent possible. If Engineer determines existing lenses cannot be reused: Section 08800.
  2. Glass lens sealant: Section 08800.
  3. Lead shims or lead rope: Section 08800.
- E. Dowels: Salvage and reuse existing dowels to greatest extent possible. If Engineer determines existing dowels cannot be reused: Dowels for platform edge granite slab dowels: Section 04050, minimum 1/2-inch diameter, of sufficient length to extend into stone 1/2 thickness of stone and to extend two inches into structural concrete.
- F. Epoxy mortar and epoxy fill for mortar dams and epoxy for setting dowels for Granite Edge Slabs: Section 04050.
- G. Non-staining shim wedges to support granite slabs during curing of epoxy mortar dams: As approved.

### **PART 3 - EXECUTION**

#### **3.01 EXAMINATION:**

- A. Examine surfaces to receive dimension stone cladding and conditions under which dimension stone cladding will be installed, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of dimension stone cladding.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.02 PREPARATION:**

- A. Runways, Scaffolds and Hoists: Provide and move scaffolding, temporary runways, temporary floors, staging and hoists in accordance with specified safety requirements.

- B. Substrate: Remove foreign substances that would affect bond of mortar from surfaces to receive granite.
- C. Advise installers of other work about specific requirements for placement of inserts, flashing reglets, and similar items to be used by dimension stone cladding Installer for anchoring, supporting, and flashing of dimension stone cladding system. Furnish installers of other work with Drawings or templates showing locations of these items.

### **3.03 FABRICATION AND ERECTION:**

- A. General:
  - 1. Fabricate granite in sizes and with joint patterns shown on Contract Drawings and approved shop drawings.
  - 2. Installation of granite which is not within the approved range of color, texture, finish, veining and fissures; is mismatched; shows flaws or imperfection in cutting; or has other defects is prohibited.
  - 3. Provide openings for installation of work of other trades in accordance with approved shop drawings. Coordinate size of rabbet at expansion joint in granite platform edging with the expansion joint dimension and the size of compression seal.
  - 4. Provide 1/4-inch joints, unless otherwise shown on Contract Drawings and approved shop drawings.
  - 5. Unless otherwise shown, completely fill joints in granite work and rake out to depth of 3/4 inch, except paving joints and pylon-apron joints showing grout.
  - 6. Set stones accurately in alignment with other stones and adjacent work. Set stones in full mortar beds. Level and plumb stones as work progresses.
  - 7. Set finish surfaces in true and even planes, with uniform jointing. Take up and reset loose, hollow sounding slabs. Leave surface free of mortar stain and other defacements.
  - 8. Where epoxy materials are used, follow manufacturer's recommendations.
  - 9. Granite paving over waterproofing: Carefully place granite and setting materials over waterproofing so protection materials are not displaced and waterproofing is not punctured or otherwise damaged. Replace protection materials that become displaced and arrange for repair of damaged waterproofing before covering with paving.
    - a. Provide cork joint filler in accordance with Section 07900, where indicated, at waterproofing that is turned up on vertical surfaces or, if not indicated, provide temporary filler or protection until granite paving installation is complete.
- B. Tolerances: Meet NBGQA Specifications for Architectural Granite.
- C. Paving and Granite Apron at Pylons:
  - 1. Do not put down more setting bed than can be covered in the same day.
  - 2. Dust setting bed with portland cement and butter underside of stone with neat portland cement paste in accordance with Section 03300 and pound into place at proper elevation.
  - 3. Where concrete is to be cast against stone, parge contact surface with not less than 1/2 inch of nonstaining setting mortar in accordance with Section 04050.
- D. Benches: Provide bench seats and backs in one piece with no joints.
- E. Walls:
  - 1. Fabrication: Fabricate granite wall units in sizes and shapes required to comply with requirements indicated, including details on Drawings and Shop Drawings.

- a. Cut and drill sinkages and holes in granite for anchors, fasteners, supports, and lifting devices as indicated or needed to set stone securely in place; shape beds to fit supports.
  - b. Cut granite to produce pieces of thickness, size, and shape indicated and to comply with fabrication and construction tolerances recommended by applicable stone association or, if none, by stone source, for faces, edges, beds, and backs.
  - c. Minimum Thickness: 1-½ inches.
  - d. Cut granite panels to produce joints of uniform width and in locations indicated.
  - e. Provide minimum anchorage as follows and in accordance with standard practice:
    - 1) Not less than one anchor for every six square feet of stone.
    - 2) Minimum of two anchors at each head and bed joint.
- F. Application to Floor Hatches and Other Metal Items:
- 1. Apply granite to recessed floor hatches and other metal surfaces by the use of epoxy mortar in accordance with Section 04050.
  - 2. Use epoxy of type and brand recommended by manufacturer to set granite on metal and in accordance with Section 04050. Continue paving pattern of adjacent surfaces over hatch covers.
- G. Application of Granite Platform Edging:
- 1. Set granite with epoxy mortar in accordance with recommendations of epoxy manufacturer, and with Section 04050 and with approved quality-assurance program.
  - 2. Set dowels with epoxy mortar not less than 1-1/2 inches into granite. Allow mortar to cure to not less than 75 percent of its ultimate compressive strength.
  - 3. Place epoxy mortar as shown, using mortar dams or other approved method of forming. Adjust as required to obtain full contact of epoxy mortar with granite. Apply epoxy mortar in a self-leveling consistency. Set granite, embedding it into epoxy mortar. To permit drainage, maintain spaces between mortar dams as shown.
  - 4. Expansion joints: Coordinate the distance between granite edge stones with the required expansion joint size (width) for the temperature of the structure at the time stones are set. See structural drawings.
  - 5. Install lamps in accordance with Division 16 and install lead shims, glass lenses, and seal lenses in accordance with Section 08800.
  - 6. Resetting platform edge granite slabs:
    - a. The following is Red Tag work and is limited to only the number of granite slabs that can be reset in one work shift:
      - 1) Preparation for raising granite slabs: Remove IRIS screw anchors and metal wireway sections. Sawcut granite edge slabs' transverse joints both vertically and horizontally. Remove platform edge light lenses and lamps. Dig out epoxy bedding material.
      - 2) Provide and move staging and hoists in accordance with safety requirements and as approved. Lift up existing granite slab edge unit(s). Store units to be reset so as to prevent damage and discoloration. Replacement of damaged and broken slabs in kind is the responsibility of the Contractor.
      - 3) Remove dowels and salvage as many as possible of the existing stainless steel granite anchoring pins for re-use. Replacement of damaged and missing items in kind is the responsibility of the Contractor.
      - 4) Demolish existing epoxy setting dams that support granite and remove to expose structural slab.

- 5) Clean and prepare surfaces of unit(s) and structural slab to receive new epoxy setting dams. Where existing concrete has not been treated with MMA, scarify slab to provide proper substrate for new epoxy mortar dams. Do not scarify MMA patches or MMA-treated concrete. Remove foreign substances that would affect bond of epoxy mortar from surfaces of concrete slab receiving granite.
- 6) Laser survey or set string line as necessary to establish elevations for granite slabs as necessary.
- 7) Mix epoxy mortar in accordance with manufacturer's instructions and place mortar bulkheads or other approved forming method to form setting dams at a width to match existing and at a height as required to set granite slabs to proper elevation, leaving eight-inch wide drainage channels between setting dams. Pour neat epoxy between epoxy mortar bulkheads to a slighter higher elevation. Remove excess mortar and neat epoxy and adjust as required to obtain full contact between epoxy and granite.
- 8) Reset dowels or set new dowels as necessary at not less than two inches into concrete structural slab and to extend into granite 1/2 depth of granite. Set non-staining wedges for support to allow proper curing of epoxy dams when granite is reset.
- 9) Set original granite slab unit(s) on intermittent epoxy dams and dowels at proper elevations, providing uniform 1/4-inch joints between adjacent units, except as necessary to match existing. Set granite slabs accurately to corrective alignment between adjacent slabs and existing work and with finish surfaces in true and even planes. After each granite edge unit is set, take measurements to verify that unit is at proper elevation and location. Level and plumb granite slabs as work progresses. Take up and reset loose, hollow sounding units.
- 10) Install lead shims, reinstall platform edge lamps, and reinstall glass lenses and reseal lenses in accordance with Section 08800.
- 11) Remount IRIIS metal wireway sections with screw anchors.
- 12) After epoxy dams have cured, perform bond strength testing as previously specified.

H. Granite Sets:

1. Random ashlar pattern with broken course and range or stacked bond, as shown.

**3.04 POINTING AND CLEANING:**

A. Pointing:

1. After setting mortar has cured, point voids in joints of exposed granite paving and pylon aprons with preshrunk mortar. Remove excess mortar.
2. Seal joints in granite work with sealants in accordance with Section 07900, except paving joints and pylon-apron joints.

B. Cleaning:

1. Clean joint surfaces and remove dirt, coatings, moisture and other foreign substances which could interfere with bond. Recaulk granite edge slabs' transverse joints both vertically and horizontally with grout and let cure.
2. Thoroughly and carefully clean work by approved means and leave in first class condition, free from mortar or other defacement. Clean all exposed granite surfaces, including joints, with water and washing compound soap powder solution in accordance with recommendations of manufacturer. Sponge and wash thoroughly. Use of acid or acid cleaners is prohibited. Remove stains by approved means. Clean granite masonry surfaces, including those grouted or sealed, with soap-

powder solution and fiber brushes to remove stains. Thoroughly and carefully clean work and leave in first-class condition, free from mortar stains or other defacement. Immediately after cleaning, rinse surfaces with clear water. Polish with clean dry cloths.

- C. Protection:
  - 1. Protect granite work from damage after erection. Provide protective boxing or other suitable means whenever necessary in the absence of specific instructions from the Engineer. Do not use materials that will stain or deface granite. Use galvanized nails in protective boxing.
  - 2. Continuously protect granite work from water during construction and until installation is complete and is approved.
  - 3. Protect granite work from traffic of any kind for not less than two hours after setting. Remove protection immediately after two hours curing.

**3.05 FIELD QUALITY ASSURANCE:**

- A. Granite Platform Edging:
  - 1. Perform work in accordance with approved quality-assurance program.
  - 2. Change of procedures and personnel without approval is prohibited.

**END OF SECTION**

## **DIVISION 5 - METALS**

05091	RAIL WELDING
05120	STRUCTURAL STEEL
05210	STEEL JOISTS
05310	METAL DECKING
05500	MISCELLANEOUS METAL
05511	METAL STAIRS
05521	HANDRAILS AND RAILINGS
05531	GRATINGS AND FLOOR PLATES
05581	FORMED METAL FABRICATIONS - STATION KIOSKS
05651	GENERAL TRACK CONSTRUCTION
05652	BALLASTED TRACK CONSTRUCTION
05653	DIRECT FIXATION TRACK CONSTRUCTION
05654	SPECIAL TRACKWORK CONSTRUCTION - BALLASTED
05655	SPECIAL TRACKWORK CONSTRUCTION - DIRECT FIXATION
05656	RUNNING RAIL
05657	DIRECT FIXATION RAIL FASTENERS
05658	TRACK APPURTENANCES AND OTHER TRACK MATERIAL
05659	SPECIAL TRACKWORK
05660	RESTRAINING RAIL AND LUBRICATORS
05661	CONTACT RAIL AND APPURTENANCE FOR TRACTION POWER
05700	ORNAMENTAL METAL
05810	EXPANSION JOINT COVER ASSEMBLIES
05811	EXPANSION JOINT SYSTEMS
05840	BEARINGS

**END OF SECTION**

## SECTION 05091

### RAIL WELDING

#### NOTE:

Section 1 (Parts 1 - 4) of this specification includes rail welding by Electric Flash-Butt Welding method.

Section 2 (Parts 5 - 8) of this specification includes rail welding by the Thermite Rail Welding method.

#### SECTION 1 - ELECTRIC FLASH-BUTT WELDING

##### PART 1 - GENERAL

###### 1.01 SECTION INCLUDES

- A. The work specified in this section shall include the fabrication of continuous welded rail (CWR) strings by electric flash-butt welding, including testing, inspection, and qualification of welding and welders.
- B. The work specified in this section shall also include movement of rail from the manufacturer to the Contractor's welding plant, from the welding plant to the welded string storage location and from the storage location to the final placement in track location.

###### 1.02 RELATED SECTIONS

- A. Section 05651- General Track Construction
- B. Section 05652 - Ballasted Track Construction
- C. Section 05653 - Direct Fixation Track Construction
- D. Section 05656 - Running Rail

###### 1.03 REFERENCES

- A. American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering, Vol. I, Chapter 4, Specification for Fabrication of Continuous Welded Rail (**latest addition**).
- B. ASTM E18
- C. **ASTM E709 (replaced E109)**
- D. **ASTM E94 (replaced E142)**
- E. ASTM E164
- ~~F. **ASTM E709 (duplicate)**~~
- G. AWS D1.1

- H. USNRC Rules and Regulations, Title 10, Atomic Energy, Part 20.
- I. ASNT SNT-TC-1A Recommended Guidelines for Qualification and Certification of Non-Destructive Testing Personnel.

#### 1.04 SUBMITTALS

- A. The Contractor shall submit procedures and documentation in accordance with the Section 01300 and as follows.
- B. Approval of the following items shall be obtained prior to production welding:
  - 1. Identification of welding plant with internal shear and major items of equipment to be used.
  - 2. Standards of welding machine performance as recommended by the manufacturer.
  - 3. Oscillograph record of each qualification weld showing number and duration of preheat impulses, flashing time, upset current time, platen travel during flashing, and platen travel distance for upset cycle.
  - 4. Report of test results of each qualification weld.
  - 5. Schedule showing string number, length, proposed stockpile location and installation location.
- C. Production weld approval shall be based on these items:
  - 1. Oscillograph records of production welds.
  - 2. Production welding record.
- D. Deliver five each taper gauges graduated in hundredths of an inch, with cases, to the Engineer. Taper gauges shall become Authority property.
- E. Deliver four (4) each 36 inch steel straight edges, as manufactured by L. S. Starrett Company of Athol, Massachusetts, or approved equal, to the Engineer. Straight edges shall become Authority property.

#### 1.05 QUALITY ASSURANCE

- A. The Contractor shall inspect rail for straightness at the manufacturer's plant.
- B. Plant Qualification
- C. General
  - 1. Using the welding plant, personnel and procedures proposed for production welding, make six qualification welds, three for each type of rail.
  - 2. The qualification welds shall be made in the presence of the Engineer. Pieces of the Authority furnished short rails shall be used for making the qualification welds.
  - 3. Weld tests shall provide sufficient detail to establish capability of the welding apparatus to meet specified welding requirements.
- D. Qualification Weld Testing: The six qualification welds shall be tested by radiography, hardness testing, metallurgical testing and ultrasonic testing in the following manner:
  - 1. Radiography:
    - a. Radiography shall be conducted in accordance with **ASTM E94** using short wave length radiation. The use of nuclear by products for radiography shall be in accordance with USNRC Rules and Regulations, Title 10, Atomic Energy, Part 20. The transportation, handling and storage of hazardous materials used in the examination of welds shall be performed only by or

- under the supervision of a person of proven experience and ability, operating under a proper license.
- b. Film shall be capable of producing sharp images, and be free of processing and mechanical defects. High speed, coarse-grained film is prohibited. Fine films shall be used covering head, web and each side of base as shown on **Exhibit 05091-A**. Identify each film by contract number, rail identification, date of test, name of testing agency and the view.
  - c. Acceptance of the weld shall be based on the weld having full penetration, complete fusion and being free of flaws. A letter shall accompany each film plate bearing information given on the film, certifying compliance with **ASTM E94** and stating whether or not the weld satisfies specified requirements.
  - d. Radiograph plates shall be compared to ultrasonic scans to determine the ability of ultrasonic equipment to identify inclusions or other weld defects. If necessary, compare radiograph plates with ultrasonic scans using the ultrasonic reference blocks. Results of this comparison shall be made in a separate report and include recommended ultrasonic equipment to be used and sensitivity requirements.
2. Hardness testing:
- a. Hardness testing shall be in accordance with current AREMA "Specification for Fabrication of Continuous Welded Rail" (**latest edition**) and "Specification for the Quality Assurance of Electric Flash-butt Welding of Rail."
  - b. The hardness test shall be performed in accordance with ASTM E18, using a 150kgf diamond sphere conical penetrator. Hardness and location shall be recorded.
3. Metallurgical Tests:
- a. A one foot specimen of each weld shall be sectioned longitudinally through the centerline of the rail. Each specimen shall be etched to enable observation of the hardness pattern, metallurgical properties and the heat affected zone.
  - b. An acceptable weld as determined by the metallurgical test shall meet the following criteria:
    - 1) Steel shall consist of fine-grained pearlite structure with small interlamellar spacing.
    - 2) The hardness pattern in the etched section shall have a uniform distribution.
    - 3) The heat affected zone shall be parallel and fully extended on both sides of the weld.
    - 4) The weld joint shall be planar.
    - 5) Uniform zone of plastic deformation resulting from upset operation shall extend equally on both sides of the weld point.
  - c. An 8x10 black and white photograph and a description of the metallurgical properties including grain structure and distribution shall be submitted.
4. Ultrasonic test, slow bend test and magnetic particle test in accordance with the AREMA Manual (**latest edition**).
5. All test samples are to be permanently marked for identification and returned to the Engineer at the completion of testing.

#### **1.06 DELIVERY, STORAGE AND HANDLING**

- A. It shall be the Contractor's responsibility to make all arrangements for shipment and handling of the rail. The Contractor shall:
1. Coordinate unwelded rail stick movement from the manufacturer's plant to the welding site by rail and truck as necessary.
  2. Obtain any required permits from state, regional or local jurisdictions.
  3. Make arrangements for loading, unloading and stacking rail sticks.

- B. Handle and store rail so that it is not damaged either before or after welding.
  - 1. Stacking of sticks shall be as approved by the Engineer and layers shall be separated by wood lathing.
  - 2. Rail shall be handled in a manner that prevents damage to fasteners, rail and structures.
  - 3. Rail shall not be dropped or dragged on the trackbed. The use of rollers is required.

## **PART 2 - PRODUCTS**

### **2.01 RAIL FOR CONTINUOUS WELDED RAIL**

- A. Rail for the Work shall be furnished by the Contractor in accordance with **WMATA** Standard Specification Section 05656, Running Rail.

## **PART 3 - EXECUTION**

### **3.01 PREPARATION FOR WELDING**

- A. The welding plant shall be set up on Authority property as approved by the Engineer.
- B. Rail welding shall be in accordance with the current AREMA Manual "Specification for Fabrication of Continuous Welded Rail" (**latest edition**), "Specification for the Quality Assurance of Electric Flash-butt Welding of Rail" and as specified herein.
- C. Rail for installation in this Contract shall be welded in accordance with a string schedule approved by the Engineer. Strings should be not less than 720 feet in length in order to minimize field connections, unless shorter strings are required to satisfy conditions of rail type or installation. Each string shall be of only one rail type; standard or head hardened rail.
- D. Rails shall be welded using an electric flash butt welding plant equivalent to the Chessie System plant at Russell, KY or Amtrak Plant at New Haven, CT. An equivalent portable plant may be set up within the contract area.
- E. Rail Inspection Prior to Welding
  - 1. Inspect each rail end prior to welding for deviations from lateral line in either direction and for upsweep, downsweep or droop.
  - 2. Rail with upsweep, downsweep or droop and rail failing to comply with the tolerances shown on **Exhibit 05091-B** shall be cut back a sufficient distance to achieve the required alignment. Rails shall be cut clean and within 1/32 inch of square by means of rail saws or abrasive cutting discs.
  - 3. Torch cutting of rail is prohibited. Cutting shall be done at no additional cost to the Authority.
- F. Rail End Preparation for Welding: Immediately prior to welding, all rail ends shall be wire brushed to remove mill scale or other dirt which might hinder the flow of electric current.
- G. Alignment in Weld Machine:
  - 1. Alignment of the rail in the welding machine shall be done on the head of the rail.
  - 2. Vertical alignment shall provide for a flat running surface within 0.01 inch between the abutting rail ends.
  - 3. Horizontal alignment shall distribute head width differences evenly between each side of the head. No horizontal offset shall exceed 0.03 inch on either side of the head. No horizontal offset shall exceed 0.10 inch on either side of the base of the rail.

### 3.02 WELDING OF RAILS

- A. All welding procedures shall be approved prior to use and as a minimum shall be in accordance with the following:
  - 1. Forge welds to point of no further plastic deformation with upset of 5/8 inch minimum.
  - 2. Each weld to achieve full penetration, complete fusion, and be free of flaws and inclusions.
- B. Record welding machine performance with an oscillograph recorder or computer printout.
  - 1. Record platen movement and current impulses.
  - 2. The oscillograph record shall be compared with the approved procedure record from the qualification welds. If the record indicates performance which is not in conformance with the approved procedure, the weld will be rejected.
  - 3. The recorder shall be calibrated each day.
- C. If flashing is interrupted with less than ½ inch of flashing distance remaining before upsetting, the rails shall be reclamped and flashing initiated again.
- D. Grinding shall be done immediately following welding at an elevated temperature.
- E. Welds shall be ground to meet the following finishing tolerances:
  - 1. A finished deviation of not more than plus or minus 0.005 inch of the parent section of the rail head shall be allowed.
  - 2. The weld at the top and sides of the rail head shall be finished to plus or minus 0.010 inch of the parent section.
  - 3. The bottom and sides of rail base shall be finished to within plus or minus 0.010 inch of the parent section.
  - 4. The web zone, underside of head, web, top of base, both fillet each side, shall be finished to within 1/8 inch of parent contour or closer but shall not be deeper than parent section.
  - 5. Finishing shall eliminate all cracks visible to the unaided eye.
  - 6. All notches created by offset conditions or twisted rails shall be eliminated by grinding to blend the variations on both sides of the head and base for a distance of 18 inches.
  - 7. All fins on the weld due to grinding and/or shear drag shall be removed prior to final inspection.
- F. All rails used for electric-flash-butt welds shall have scale removed down to bring metal in those areas of the rail where welding current-carrying electrodes contact the rail. The weld and adjacent rail for a distance clearing the electrodes shall be rejected if the areas of the electrodes contact there is not more than 95% of the mill scales removed. Rails showing evidence of electrode burns shall be rejected. An electrode burn is considered to exist where the metal has been displaced.

### 3.03 WELD QUALITY AND TESTING

- A. Inspection and Testing of Welds: Each weld shall be tested and examined by the magnetic particles method, ultrasonic examination method and by the visual method as follows:
  - 1. Magnetic Particle Examination:
    - a. Magnetic particle inspection shall be performed using the dry powder method in accordance with ASTM E709, with the rail at a temperature of less than 800 deg. F.

- b. To be acceptable the particles shall form a regular longitudinal pattern indicating homogeneity of the weld and freedom from defects, surface irregularities and internal discontinuities.
  - 2. Ultrasonic Examination:
    - a. Ultrasonic examination shall be performed by an independent testing agency under contract to the Authority who will perform ultrasonic examination to the following standards:
    - b. Subsequent to the magnetic particle inspection, all welds will be ultrasonically inspected in accordance with ASTM E164.
    - c. Ultrasonic test equipment will be capable of detecting a 3/64 inch discontinuity, 6-1/2 inches below the top rail. The sensitivity and resolutions of the proposed equipment shall use appropriate area amplitude and distance amplitude reference blocks made of material similar to the rail steels being tested.
    - d. All equipment will be equipped with a distance amplitude correction feature. The equipment will be calibrated daily using an 11W calibration block made of rail steel.
    - e. All welds giving fault indication in ultrasonic testing shall be cut out and the rails rewelded according to these specifications.
    - f. The Contractor shall provide a weather resistant enclosure with adequate ventilation and light for ultrasonic inspection.
  - 3. Visual Inspection for Final Alignment of Finished Welds:
    - a. The combined vertical offset and crown camber at ambient temperature shall not exceed 0.060 inches as shown on **Exhibit 05091-C, Fig. 1.**
    - b. No dip camber shall be allowed as shown on **Exhibit 05091-C, Fig. 2.**
    - c. Combined horizontal offer and horizontal kink camber at ambient temperature shall not exceed 0.060 inches as shown on **Exhibit 05091-C, Fig. 3.**
    - d. Welds shall be free of cracks, fins, and sharp edges.
- B. Correction of Defective Welds: Each production weld failing to meet all acceptance criteria will be considered defective. This shall include welds considered defective by the Authority contracted Ultrasonic Inspector.
  - 1. Defective welds shall be cut out by means of rail saw or abrasive disc.
  - 2. Use extra initial flash to burn off cut surface, reclamp, and reweld.
  - 3. Rewelds shall be inspected as specified for initial welds.
- C. Submit Production Welding Records to the Engineer at the end of each days production.
  - 1. Oscillograph record of each weld and reweld.
  - 2. Production welding record in accordance with **Exhibit 05091-D and 05091-E.**
- D. Marking of Rail Strings:
  - 1. Mark each end and every 100 feet of each rail string with a paint suitable for application to steel and which is weather resistant for a period of two years. High strength rail strings shall be marked with orange paint. Standard rail strings shall be marked with white paint.
  - 2. Each string shall be sequentially numbered and the beginning of welding end marked to permit correlation of each weld with the Production Welding Record.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.01 MEASUREMENT**

- A. Measurement and payment for work specified in this Section shall be made in the following manner:
  - 1. No separate measurement.

## **4.02 PAYMENT**

- A. Compensation for work specified in this Section will be made in the following manner:
  - 1. Included in the price of the work of which it is a part.

## **SECTION 2 - THERMITE RAIL WELDING**

### **PART 5 - GENERAL**

#### **5.01 SECTION INCLUDES**

- A. The work specified in this section shall include the fabrication of continuous welded rail (CWR) strings by thermite rail welding, including testing, inspection, and qualification of welding and welders.
- B. The work specified in this section shall also include movement of rail from the manufacturer to the Contractor's welding plant, from the welding plant to the welded string storage location and from the storage location to the final placement in track location.

#### **5.02 RELATED SECTIONS**

- A. Section 05651- General Track Construction
- B. Section 05652 - Ballasted Track Construction
- C. Section 05653 - Direct Fixation Track Construction
- D. Section 05656 - Running Rail

#### **5.03 REFERENCES**

- A. American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering, Vol. I, Chapter 4, Specification for Fabrication of Continuous Welded Rail (latest addition).
- B. ASTM E18
- C. ASTM E709 (replaced E109)
- D. ASTM E94 (replaced E142)
- E. ASTM E164
- ~~F. ASTM E709 (duplicate)~~
- F. AWS D1.1
- G. USNRC Rules and Regulations, Title 10, Atomic Energy, Part 20.
- H. ASNT SNT-TC-1A Recommended Guidelines for Qualification and Certification of Non-Destructive Testing Personnel.

#### 5.04 SUBMITTALS

- A. The Contractor shall submit procedures and documentation in accordance with the Section 01300 and as follows.
- B. Approval of the following items shall be obtained prior to production welding:
  - 1. Identification of welding kit and major items of equipment to be used.
  - 2. Record of welding kit performance as recommended by the manufacturer.
  - 3. Record of each qualification weld, including manufacturer's kit shelf life/expiration date, rail temperature before and after weld installation, and straightness test acceptance.
  - 4. Report of test results of each qualification weld.
  - 5. Schedule showing string number, length, proposed stockpile location and installation location.
- C. Production weld approval shall be based on these items:
  - 1. Ultrasonic test results .
  - 2. Production welding record.
- D. Deliver two each rail thermometers and taper gauges graduated in hundredths of an inch, with cases, to the Authority Representative. Taper gauges shall become Authority property.
- E. Deliver two each 36 inch steel straight edges, as manufactured by L. S. Starrett Company of Athol, Massachusetts, or approved equal, to the Authority Representative. Straight edges shall become Authority property.

#### 5.05 QUALITY ASSURANCE

Quality Assurance/Quality Control shall be in accordance with the Design-Builder's Construction Quality Management Plan.

- A. The Contractor shall inspect rail for straightness in the initial qualification weld.
- B. Qualification
  - 1. Initial welds shall be inspected and tested in the presence of qualified Authority personnel to assure quality of procedures and workmanship.
- C. General
  - 1. Using the welding kit, personnel and procedures proposed for production welding, make four qualification welds, two for each type of rail. These welds may be retained for the project if acceptable.
  - 2. The qualification welds shall be made in the presence of the Authority Representative.
  - 3. Weld tests shall provide sufficient detail to establish capability of the welding apparatus and procedures to meet specified welding requirements with the rail supplied.
- D. Qualification Weld Testing - The six qualification welds shall be tested by ultrasonic testing in the following manner:
  - 1. Ultrasonic test, in accordance with AREMA Manual requirements (latest edition).
  - 2. All test samples are to be permanently marked for identification and returned to the Authority Representative at the completion of testing.

## **5.06 DELIVERY, STORAGE AND HANDLING**

- A. It shall be the Contractor's responsibility to make all arrangements for shipment and handling of the rail. The Contractor shall:
  - 1. Coordinate unwelded rail stick movement from the manufacturer's plant to the welding site by rail and truck as necessary.
  - 2. Obtain any required permits from state, regional or local jurisdictions.
  - 3. Make arrangements for loading, unloading and stacking rail sticks.
- B. Handle and store rail so that it is not damaged either before or after welding.
  - 1. Stacking of sticks shall be as approved by the Authority Representative and layers shall be separated by wood lathing.
  - 2. Rail shall be handled in a manner that prevents damage to fasteners, rail and structures.
  - 3. Rail shall not be dropped or dragged on the trackbed. The use of rollers is required.

## **PART 6 - PRODUCTS**

### **6.01 RAIL FOR CONTINUOUS WELDED RAIL**

Rail for the Work shall be furnished by the Design-Builder in accordance with the Standard Specification Section 05656, Running Rail.

## **PART 7 - EXECUTION**

### **7.01 PREPARATION FOR WELDING**

- A. The welding location may be set up on Authority property as approved by the Authority Representative.
- B. Rail welding shall be in accordance with the current AREMA Manual "Specification for Fabrication of Continuous Welded Rail", and as specified herein.
- C. Rail for installation in this Contract shall be welded in accordance with a string schedule approved by the Authority Representative. Strings shall be designed in order to minimize field connections and to the maximum length practical for fabrication and handling. The schedule shall show the following for each string.
  - 1. The string designation.
  - 2. The track name where the string will be placed.
  - 3. The begin and end track station where the string will be located.
  - 4. Whether the string will be in the left or right rail when facing up station.
  - 5. The rail type in the string or for each portion of a string.
  - 6. Where there is more than one rail type in a string, the track station where rail types join in a string.
  - 7. The end of the string where welding will begin.The track names and stationing systems shown on the Track Alignment Plan and Profile drawings shall be used in the string schedule.
- D. The string designation shall be a unique code identification for each string that indicates
  - 1. The track
  - 2. Left or right rail
  - 3. A consecutive sequential number or letter system that increases with increasing track station.

- E. (Not used).
- F. Rails shall be stacked and welded so that when the resulting rail string is stored and subsequently placed in track, rail brands for both rails will face to the right when looking up stationing.
- G. Rail Inspection Prior to Welding
  - 1. Inspect each rail end prior to welding for deviations from lateral line in either direction and for upsweep, downsweep or droop.
  - 2. Rail with upsweep, downsweep or droop and rail failing to comply with the tolerances shown on **Exhibit 05091-B** shall be cut back a sufficient distance to achieve the required alignment. Rails shall be cut clean and within 1/32 inch of square by means of rail saws or abrasive cutting discs.
  - 3. Torch cutting of rail is prohibited. Cutting shall be done at no additional cost to the Authority.
- H. Rail End Preparation for Welding: Immediately prior to welding, all rail ends shall be wire brushed to remove mill scale or other dirt.
- I. Alignment of Rail for Weld:
  - 1. Alignment of the rail in the welding machine shall be done on the head of the rail.
  - 2. Vertical alignment shall provide for a flat running surface within 0.01 inch between the abutting rail ends.
  - 3. Horizontal alignment shall distribute head width differences evenly between each side of the head. No horizontal offset shall exceed 0.03 inch on either side of the head. No horizontal offset shall exceed 0.10 inch on either side of the base of the rail.

## 7.02 WELDING OF RAILS

- A. All welding procedures shall be approved prior to use and as a minimum shall be in accordance with the following:
  - 1. Produce welds with upset of 5/8 inch minimum before shearing.
  - 2. Each weld to achieve complete fusion, and be free of flaws and inclusions.
- B. (Not used).
- C. (Not used).
- D. Grinding shall be done immediately following welding at an elevated temperature.
- E. Welds shall be ground to meet the following finishing tolerances:
  - 1. A finished deviation of not more than plus or minus 0.005 inch of the parent section of the rail head shall be allowed.
  - 2. The weld at the top and sides of the rail head shall be finished to plus or minus 0.010 inch of the parent section.
  - 3. (Not used).
  - 4. The bottom and sides of rail base, the web zone, underside of head, web, top of base, both fillet each side, shall be finished to within 1/4 inch of parent contour or closer but shall not be deeper than parent section.
  - 5. Finishing shall eliminate all cracks visible to the unaided eye.
  - 6. All notches created by offset conditions or twisted rails shall be eliminated by grinding to blend the variations on both sides of the head and base for a distance of 18 inches.

7. All fins on the weld due to grinding and/or shear drag shall be removed prior to final inspection.
- F. Welds at pedestal tracks shall not be suspended; i.e., the rail weld shall be located at the pedestal support plate. The rail base of these welds shall be ground to the same tolerances as the rail head.

### 7.03 WELD QUALITY

- A. Inspection of Welds: Each weld shall be examined by ultrasonic examination method and by the visual method as follows:
1. Ultrasonic Examination:
    - a. Ultrasonic examination shall be performed by an independent testing agency under contract to the Authority who will perform ultrasonic examination to the following standards:
    - b. Subsequent to the magnetic particle inspection, all welds will be ultrasonically inspected in accordance with ASTM E164.
    - c. Ultrasonic test equipment will be capable of detecting a 3/64 inch discontinuity, 6-1/2 inches below the top rail. The sensitivity and resolutions of the proposed equipment shall use appropriate area amplitude and distance amplitude reference blocks made of material similar to the rail steels being tested.
    - d. All equipment will be equipped with a distance amplitude correction feature. The equipment will be calibrated daily using an 11W calibration block made of rail steel.
    - e. All welds giving fault indication in ultrasonic testing shall be cut out and the rails rewelded according to these specifications.
    - f. The Contractor shall provide a weather resistant enclosure with adequate ventilation and light for ultrasonic inspection.
  2. Visual Inspection for Final Alignment of Finished Welds:
    - a. The combined vertical offset and crown camber at ambient temperature shall not exceed 0.060 inches as shown on **Exhibit 05091-C, Fig. 1**.
    - b. No dip camber shall be allowed as shown on **Exhibit 05091-C, Fig. 2**.
    - c. Combined horizontal offset and horizontal kink camber at ambient temperature shall not exceed 0.060 inches as shown on **Exhibit 05091-C, Fig. 3**.
    - d. Welds shall be free of cracks, fins, and sharp edges.
- B. Correction of Defective Welds: Each production weld failing to meet all acceptance criteria will be considered defective. This shall include welds considered defective by the Authority contracted Ultrasonic Inspector.
1. Defective welds shall be cut out by means of rail saw or abrasive disc.
  2. Use extra initial flash to burn off cut surface, reclamp, and reweld.
  3. Rewelds shall be inspected as specified for initial welds.
- C. Submit Production Welding Records to the Authority Representative at the end of each days production.
1. Production welding record in accordance with **Exhibit 05091-D and 05091-E**.
- D. Marking of Rail Strings:
1. Mark each end and on both sides of the rail web every 100 feet of each rail string with a paint suitable for application to steel and which is weather resistant for a period of two years.
  2. High strength rail shall be marked with orange paint.
  3. Standard rail shall be marked with white paint.

4. Each string shall be marked on both ends with its string designation code and the respective beginning and ending station shown on the string schedule.
  - a. When two or more strings are welded into one longer string, then, where the ends of two strings join, the strings shall be marked with their string designation codes and the respective beginning and ending station shown on the string schedule.
5. The end of the string where welding began shall be marked to show that is the end where welding began. The welding shall begin on the end shown on the string schedule. The string designation code and the beginning of welding mark shall be coordinated to permit correlation of each weld with the Production Welding Record.

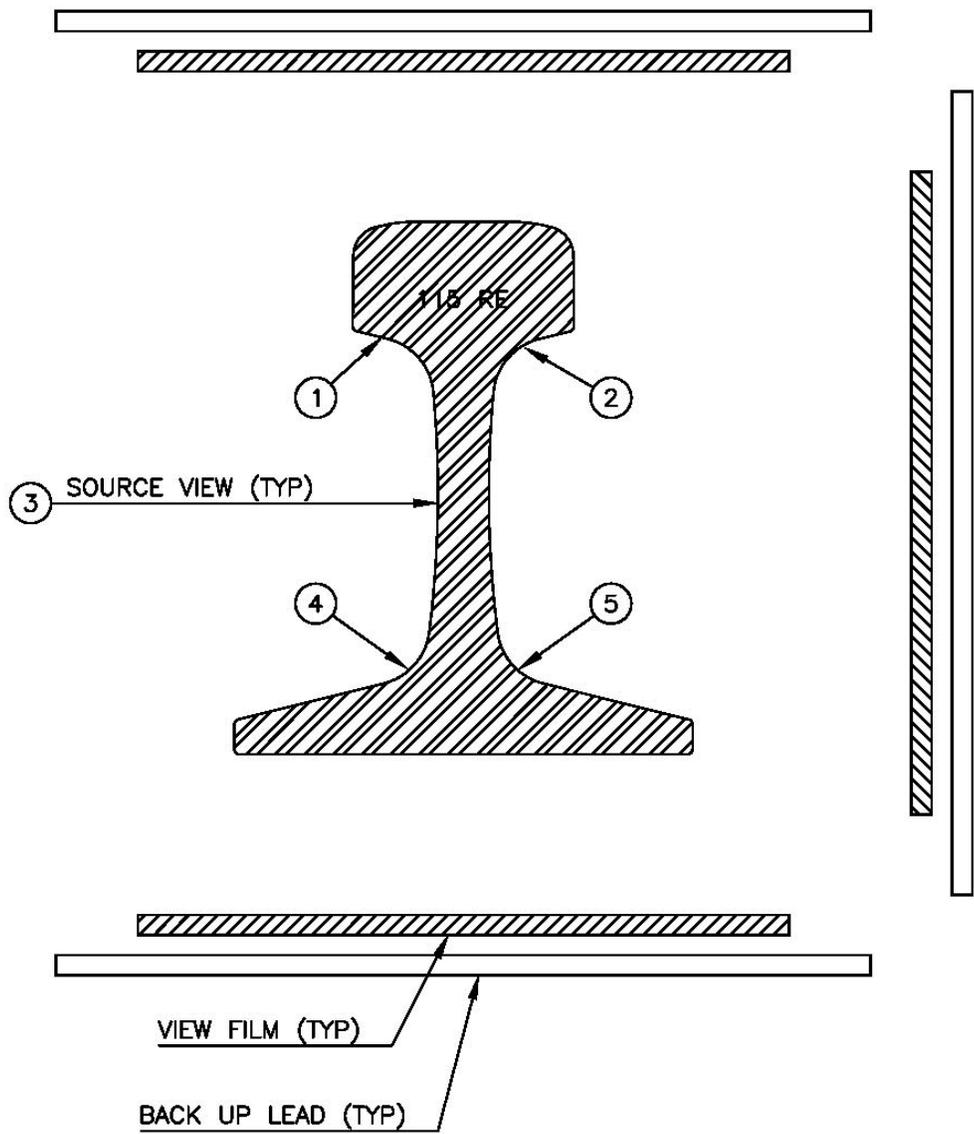
## **PART 8 - MEASUREMENT AND PAYMENT**

### **8.01 MEASUREMENT**

No separate measurement of work specified in this Section will be made.

### **8.02 PAYMENT**

Compensation for work specified in this Section will be included in the price of the work of which it is a part.



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RADIOGRAPHY SHOOTING SKETCH  
EXHIBIT 05091-A

**NOTE: Not used for Thermite Rail Welding (only applicable for Electric Flash-Butt Welding)**

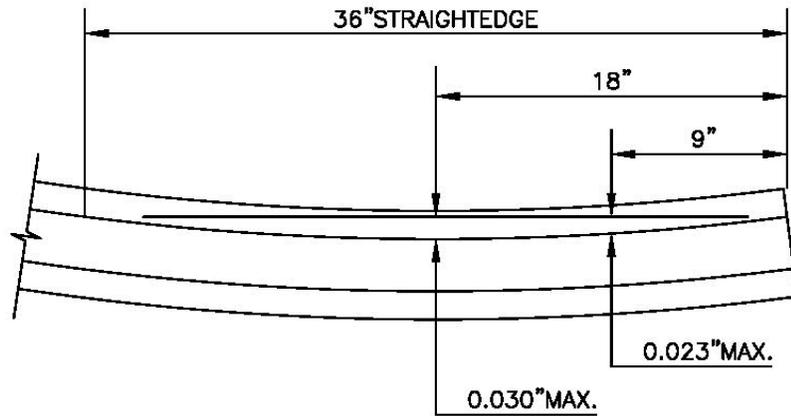


FIGURE 1  
 TOP VIEW OF RAIL  
 LATERAL (HORIZONTAL) LINE  
 TOLERANCE AT RAIL ENDS

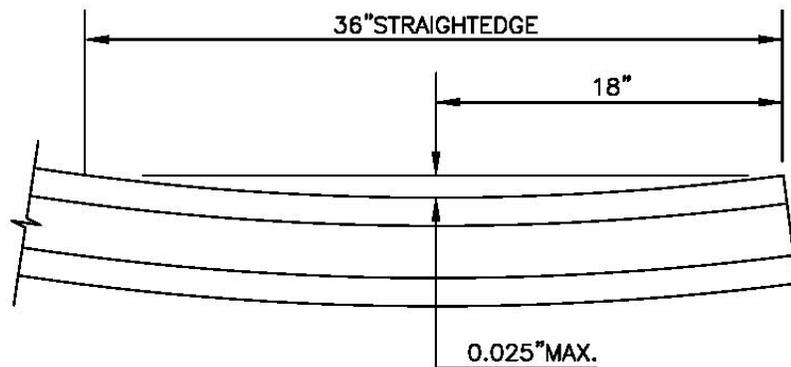


FIGURE 2  
 SIDE ELEVATION OF RAIL  
 UNIFORM UPSWEEP  
 TOLERANCE AT RAIL ENDS

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<b>DEPARTMENT OF          TRANSIT SYSTEM DEVELOPMENT          OFFICE OF          ENGINEERING &amp; ARCHITECTURE</b>	<b>TOLERANCES FOR INSPECTION OF RAIL          EXHIBIT 05091-B</b>

**NOTE: Applicable for both Electric Flash-Butt and Thermite Rail Welding.**

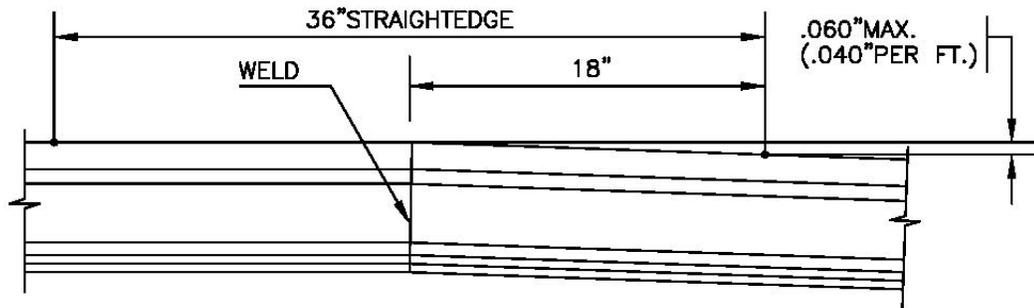


FIGURE 1  
ELEVATION OF RAIL SHOWING WELD MISALIGNMENT  
TOLERANCE IN VERTICAL ALIGNMENT

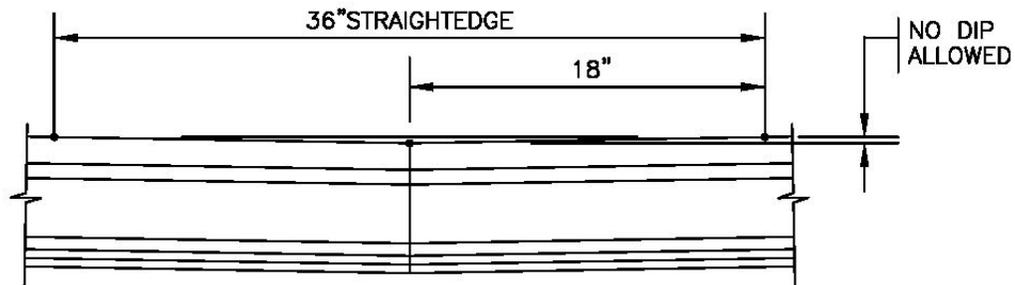


FIGURE 2  
ELEVATION OF RAIL SHOWING WELD MISALIGNMENT  
TOLERANCE IN VERTICAL ALIGNMENT

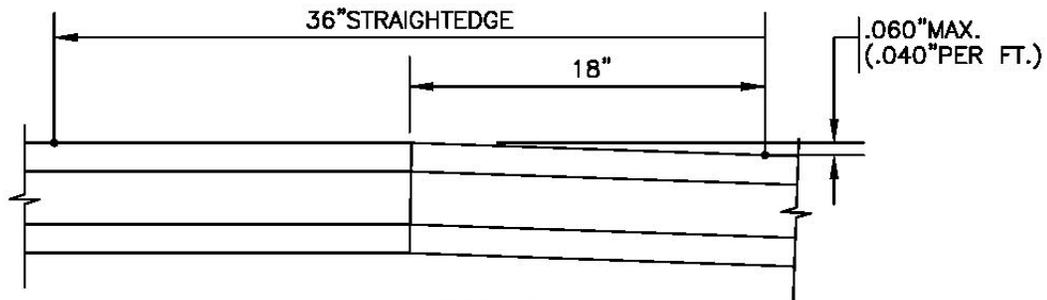


FIGURE 3  
PLAN VIEW OF RAIL SHOWING WELD MISALIGNMENT  
TOLERANCE IN HORIZONTAL ALIGNMENT

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TOLERANCES FOR INSPECTION  
OF WELDED RAIL  
EXHIBIT 05091 -C

**NOTE: Applicable for both Electric Flash-Butt and Rail Thermite Welding.**

RAIL STRING NUMBER \_\_\_\_\_

RAIL TYPE:    STANDARD \_\_\_\_\_ HIGH STRENGTH \_\_\_\_\_ (CHECK ONE)

FINISH STRING LENGTH (NEAREST FOOT) \_\_\_\_\_

STAMPING ON FIRST AND LAST RAIL IN STRING:

FIRST \_\_\_\_\_

LAST \_\_\_\_\_

WELD NO.	WELD MACHINE RECORD IDENTIFIER	MAGNETIC PARTICLE TEST RESULT	VISUAL INSPECTION RESULTS MAXIMUM DIMENSION RECORDED	
			VERTICAL ALIGNMENT	HORIZONTAL ALIGNMENT
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				

REWELDS

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**PRODUCTION WELDING RECORD  
EXHIBIT 05091 -D**

**NOTE: Applicable for both Electric Flash-Butt and Thermite Rail Welding.**



## SECTION 05120

### STRUCTURAL STEEL

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies structural steel work.
- B. Options:
  - 1. Substitution of rolled shapes for welded sections and vice versa is permitted, provided that shapes and sections to be substituted are approved and comply with the following:
    - a. Keep depth, width, average or mean thickness, web shear area, moments of inertia, torsional constant and warping constant to be at least equal to those for shape or section shown. Maintain clearances and other dimensions shown as critical.
    - b. Have steel shapes, plates and bars conform to same ASTM designation as material for which substitution is made.
- C. Related Work Specified Elsewhere:
  - 1. Finish painting for structural steel: Section 09920.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. AWS: D1.1.
  - 3. AASHTO: Interim 1981 Fracture Control Plan; Standard Specifications for Highway Bridges, including supplements. Where conflict occurs between AWS and AASHTO, AASHTO governs.
  - 4. AISC:
    - a. Specification for Structural Steel Buildings-Allowable Stress Design and Plastic Design.
    - b. Manual of Steel Construction-Allowable Stress Design.
    - c. Code of Standard Practice for Steel Buildings and Bridges.
    - d. Allowable Stress Design Specification for Structural Joints using ASTM A325 or A490 Bolts.
    - e. Specifications for Architecturally Exposed Structural Steel.
  - 5. ASNT: Recommended Practice SNT-TC-1A.
  - 6. SSPC: SP-6, SP-10.
  - 7. ANSI: B27.2.
  - 8. MS: MIL-P-21035.
  - 9. FS: TT-P-645
  - 10. ASTM: A6, A27, A36, A108, A109, A123, A148, A153, A242, A307, A325, A370, A449, A490, A500, A501, A514, A517, A572/572M, A588, A668, A673, A709, A780, B663, B766.
- B. Source Quality Control:
  - 1. Testing and inspection:
    - a. Nondestructive-test requirements for welded members:
      - 1) Perform the following:

- 2) Tension butt welds in fracture-critical nonredundant members and member components of structures subject to repetitive dynamic loading: 100 percent of welds inspected by radiographic and ultrasonic examination.
  - 3) Butt welds of flange material for compression and tension splices: 100 percent of welds inspected by ultrasonic examination.
  - 4) Butt welds for web splices beginning at point of maximum stress: 40 percent of welds inspected by ultrasonic examination.
  - 5) Fillet welds connecting web plates to flange plates: 25 percent of welds inspected by magnetic particle inspection.
  - 6) For all other fillet-weld connections: 10 percent of welds inspected by magnetic particle inspection.
  - 7) The Engineer may designate additional items to be inspected by radiography.
- b. Mill testing:
- 1) For identified stock materials provide three specimens from each heat number, one for tension test, one for bend test and one for Charpy V-notch impact test.
  - 2) Cut, machine and test specimens in accordance with ASTM A370.
  - 3) Perform Charpy V-notch impact test for tension flanges and other tension components of aerial structures in accordance with Table 05120-1.
- c. Bolts:
- 1) The Engineer will randomly select at least five bolts for test purposes from each bin of bolts furnished.
- C. Qualification of Welding Personnel and Procedures:
1. Prior to qualifying welding personnel and welding procedures, confirm an agreement with the Engineer as to procedural details, sequence of welding, handling of materials to be inspected, and approval of electrodes, wire, flux and other welding materials and equipment.
  2. Employ welding personnel whose qualification is certified in accordance with AWS D1.1. Such certification is to remain in force for the duration of the welding operations under this Contract.
  3. Do not start fabrication until qualification has been successfully completed.
- D. Qualification of Nondestructive-Testing Personnel:
1. Nondestructive testing of fracture-critical members to be conducted by personnel qualified as NDT Level II or Level III in accordance with ASNT SNT-TC-1A.
  2. Level-II technicians to be supervised by Level III-personnel.
- E. Stock Material:
1. For qualification of welding personnel and procedures and for quality-assurance testing, use only stock materials which can be identified as having been rolled from a given heat and for which certified mill tests can be produced.
  2. When stock material is proposed, inform the Engineer of such intention at least 10 days in advance of commencing fabrication to permit sampling and testing. Select identified material from as few heats as possible.
- F. Welder's Identification Mark (for Fabrication Shops):
1. Assign each welder and welding operator an identification mark to stamp on pieces he has welded.
  2. Have welder or welding operator place his identification mark by metal-die stamp in letters 3/8-inch high in position that identification of welder or operator will appear

adjacent to each of his welds in finally assembled members for ready reference to radiographic films and for identification by the Engineer.

- G. Elevator Hoistways:
  - 1. Fabricate framing not to exceed 1/8-inch deviation from dimensions shown throughout. Perform straightening where necessary.

### **1.03 SUBMITTALS:**

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Shop Drawings:
  - 1. Structural details: Include the following:
    - a. Bills of materials giving complete information for fabrication and erection of component parts of structures including material and finish information.
    - b. Details of location, type, sizes of bolts and welds and for welded structures details of welding as specified.
    - c. Structural computations for Contractor-designed work certified by a professional engineer registered in the jurisdiction where the work is to be performed.
  - 2. Match marks:
    - a. Provide diagram showing match marks for connecting structural parts assembled in shop for purpose of drilling or reaming holes in field connections.
  - 3. Welding:
    - a. Complete shop details of qualification test specimens.
    - b. Include information on specimen identification, number of pieces and welding procedure specification, type of material, sizes of pieces and welds and other variables affecting detail or tests.
  - 4. Erection Plan:
    - a. Details of methods of erection proposed to be used, including calculated stresses for proposed erection certified by a professional engineer registered in the jurisdiction where the work will be performed. Do not proceed until approval has been received.
  - 5. Manufacturer's test procedures for bolts.
- B. Certification:
  - 1. Certified mill test reports of structural steel at least 10 days prior to start of fabrication.
  - 2. Certified quality-assurance testing and inspection reports.
  - 3. Certification verifying that welding personnel have been qualified in accordance with AWS D1.1 and as specified above under Qualifications of Welding Personnel and Procedures.
  - 4. Manufacturer's certification that bolts meet approved testing.
  - 5. Certification of nondestructive-testing personnel.

### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. General:
  - 1. Load, transport, unload and store structural materials so as to keep them clean and free from damage.
  - 2. Store material on platforms, skids or other supports above the ground and ensure proper drainage and protection from corrosion.

- B. Steelwork:
  - 1. When handling and shipping steelwork, prevent bending, scraping or over stressing members.
  - 2. Block projecting parts likely to be bent or damaged during handling with wood or other approved material
  - 3. Replace pieces bent or damaged unless repair is approved.
  - 4. Indicate weight on members weighing more than three tons by means of paint contrasting with shop coat.
- C. Bolts and Nuts:
  - 1. Ship small parts such as bolts, nuts, washers, pins, fillers and small connecting plates or angles in boxes, crates or barrels.
  - 2. Pack separately bolts of each length and diameter and loose nuts or washers of each size.
- D. Paint:
  - 1. Have paint materials delivered in manufacturer's original sealed containers, bearing manufacturer's label and name, specification identification number where applicable as well as month and year of manufacture.

#### **1.05 JOB CONDITIONS:**

- A. Environmental Requirements:
  - 1. Welding:
    - a. When welding during cold weather, avoid chilling weld metal within zone of welding influence and avoid restraining manual functions of welder or welding operator.
    - b. When temperature where steel is stored is more than 20F below that of welding shop, move steel to be welded into shop sufficiently in advance of welding to allow it to attain shop temperature prior to welding.
    - c. Steel to be free of moisture. Dry as necessary by application of heat not exceeding 100F.
    - d. Do not weld when shop temperature is below 40F.
  - 2. Painting:
    - a. Apply paint when temperature of steel and paint is above 40F and temperature is forecast to remain above 40F until paint has dried.
    - b. Painting steel at a temperature which can cause blistering, porosity or conditions otherwise detrimental to life of paint is prohibited. When paint is applied in hot weather or thinned in cold weather, ensure that specified thickness of paint coating is obtained.
    - c. Application of paint in rain, wind, snow, fog or mist or when steel surface temperature is below dew point is prohibited, unless otherwise approved. If painting in damp or cold weather is unavoidable, provide protective covering and heat steel and surrounding air to 40F minimum. Maintain this temperature until weather conditions permit discontinuance.

### **PART 2- PRODUCTS**

#### **2.01 MATERIALS:**

- A. General Requirements for Rolled-Steel Plates, Shapes and Bars: ASTM A6.
- B. Carbon-Steel Plates, Shapes and Bars: ASTM A36, ASTM A709, Grade 36.

- C. High-Strength, Low-Alloy, Structural-Steel Plates, Shapes and Bars: ASTM A242.
- D. High-Strength, Low-Alloy, Structural, Columbium-Vanadium Structural Steel: ASTM A572/A572M.
- E. Corrosion-Resistant Structural Steel: ASTM A242., A588
- F. High-Strength, Low-Alloy, Corrosion-Resistant Structural-Steel Shapes, Plates, and Bars: ASTM A588.
- G. Low-Carbon Steel Bolts and Nuts: ASTM A307, Grade A or B.
- H. High-Strength Carbon-Steel Bolts, Nuts and Washers for Structural Joints: ASTM A325; for bolts over one-inch diameter, ASTM A449.
- I. High-Strength Alloy-Steel Bolts, Nuts and Washers for Structural Joints: ASTM A490.
- J. Round Washers Other Than Those In Contact With High-Strength Bolt Heads And Nuts: ANSI B27.2, Type B.
- K. Beveled Washers:
  - 1. Square, smooth and sloped to make contact surfaces of bolt head and nut parallel.
  - 2. Diameter of hole in square beveled washers as follows:
    - a. For bolts less than one-inch diameter: 1/16-inch larger than bolt size.
    - b. For bolts larger than one-inch diameter: 1/8-inch larger than bolt size.
- L. Carbon-Steel Forgings: ASTM A668, Class C.
- M. Alloy-Steel Forgings: ASTM A668, Class G.
- N. Structural-Steel Tubing:
  - 1. Structural framing for elevator hoistways: ASTM A500, Grade B.
  - 2. Other structural tubing: ASTM A501.
- O. High-Strength Steel Casting: ASTM A148, metal type as shown.
- P. Mild-To-Medium-Strength Carbon-Steel Castings: ASTM A27, grade as shown.
- Q. Shear Connectors:
  - 1. Cold-rolled carbon-steel strip.
  - 2. Stud-welding fasteners with upset head developing tensile strength of 65,000 psi-minimum and yield strength of 52,000-psi minimum.
  - 3. Complying otherwise to the following:
    - a. Cold-finished bars, Grade 1015, Grade 1018 or Grade 1020, semi-killed or fully killed: ASTM A108.
    - b. Low-carbon steel suitable for welding: ASTM A109.
  - 4. Stud welding conforming to AWS D1.1.
  - 5. Sizes and shapes: As shown.
  - 6. Lengths to be after-weld lengths.
  - 7. Studs arc-welded to parent metal as shown.
  - 8. Before welding, parent-metal surface to be free from rust, oil, paint, plating and other foreign matter.
  - 9. Heat treat parent metal where needed to develop full weld strength.
- R. Galvanizing:

1. Steel products specified as galvanized to be hot-dip galvanized after fabrication in accordance with the following:
  - a. Zinc coatings on products fabricated from rolled, dressed and forged steel shapes, plates and strips: ASTM A123.
  - b. Zinc coating on iron and steel hardware: ASTM A153.
  - c. Zinc coating on assembled steel products: ASTM A123.
  - d. Zinc-coating weight: Two ounces per square foot minimum.
  - e. Zinc-dust zinc-oxide primer conforming to MS MIL-P-21035 applied in accordance with ASTM A780 in two coats for repairs to damaged surfaces after removal of loose or cracked zinc coating.
- S. Electroplated Zinc Coating: ASTM B663 for type specified.
- T. Cadmium Plating: ASTM B766 for type specified.
- U. Paint for Shop Prime Coating: FS TT-P-645.
- V. Cleaning Solution: Muriatic acid solution, specific gravity 1.18, prepared in a solution of one-part muriatic acid and five parts water.

### **PART 3 - EXECUTION**

#### **3.01 FABRICATION:**

- A. Workmanship and finish to best commercial practice accomplished in structural or bridge shops.
- B. Straightening Material:
  1. Use rolled material that, before being laid off or worked, is straight within tolerances specified in ASTM A6.
  2. Perform straightening where necessary by approved methods which will not overstress material.
  3. Do not heat-shrink low-alloy structural steel.
  4. Achieve fabrication tolerances which will result in full bearing.
  5. Perform straightening, planing and connecting of portions of members in bearing assemblies and in direct bearing after fabrication as necessary to provide full bearing assemblies and bearing areas.
- C. Cutting:
  1. Flame-cut edges of members subject to dynamic loading by mechanically guided torch or by hand. Remove nicks by grinding to depth not exceeding 1/4 inch.
  2. Shape re-entrant corners notch-free to radius of 1/2-inch minimum.
  3. Perform flame cutting so that metal does not carry stress during cutting operation.
  4. Direct flame so that remaining material is not damaged.
- D. Planing and Facing:
  1. Plane to depth of 1/4 inch sheared edges of plates more than 5/8-inch thick which will carry calculated stress.
  2. Face and bring abutting joints to even bearing where shown.
  3. Fabricate floor beams, stringers and girders having end connection angles to exact length back-to-back of connection angles.
  4. For compression joints depending on contact, prepare bearing surfaces to a common plane by milling, sawing or other approved means.

5. Where end connections are faced, ensure that finished thickness of angle is not less than that shown.
- E. Bolt Holes:
1. Punch or drill holes for bolts.
  2. Subpunch or subdrill and ream assemblies using steel template for alignment of connections as necessary. Flame cutting is prohibited.
  3. Subdrill or subpunch holes 3/16-inch less than nominal diameter of bolt; drill or ream holes 1/16-inch greater than nominal diameter of bolt.
- F. Connections:
1. Except where welded or ASTM A307 bolted connections are shown, use ASTM A325 or ASTM A490 bolts for shop connections.
  2. Unless otherwise shown, bolt field connections using ASTM A325 or ASTM A490 bolts in accordance with AISC Specifications for Structural Joints.
  3. Use of ASTM A490 bolts for dynamic or fluctuating loadings is prohibited.
- G. Plates:
1. Bent plates: For load carrying cold-bent plates, use identified stock and arrange direction of bending at right angles to direction of rolling. Ensure radius of bend, measured on concave face of metal, is not less and preferably more than the following:

Angle of Plate Bend in Degrees	Minimum Radius
61 - 90	1.0T*
91 - 120	1.5T*
121 - 150	2.0T*

\*T = Plate thickness.

2. Sheared plates: For gusset plates or connection plates, use sheared plates designed to resist applied loads in more than one direction in plane of plate.

### 3.02 WELDING:

- A. Perform welding in accordance with AWS D1.1.
- B. Perform procedure and sequence of welding so as to avoid needless distortion and to minimize stresses. Straighten transverse warpage of flanges, if necessary, by controlled heating along outside face.
- C. Make allowance in shop for expected weld shrinkage in laying out and assembling members. Trim members to size when most or all of welding has been completed.
- D. Complete butt welds in flange joints before flanges are assembled on web. Use extension blocks on such joints when making ends of butt welds, removing extension blocks only upon completion and cooling of weld. Ensure ends of welds are finished smooth and flush with edges of abutting parts. Use double-V-flange butt welds, unless otherwise shown. Back puddle all end craters.
- E. Make welds in web plates where shown.

- F. Prior to ultrasonic or radiographic testing of butt welds of flanges and webs, grind or machine weld reinforcement of joint to remove irregularities of weld surface so that it merges smoothly with base surface; one side for ultrasonic testing and both sides for radiographic testing.
- G. Ensure that welded joints which are to be radiographed are free of paint, scale and grease. Grind off welded ripples and surface irregularities on both sides of joint. Grind perpendicular to length of weld and to such a degree that resulting radiographic contrast due to remaining irregularities cannot mask or be confused with that of objectionable defect and so that weld surface will merge smoothly into adjoining surface.
- H. Repair defective welds by chipping or melting out such defects from one or both sides of joint removing no more weld metal than necessary to correct defect. Reweld and have weld retested radiographically.
- I. Welded Structures Subjected to Dynamic Loads:
  - 1. Do not use backup bars for fracture-critical nonredundant members or member components, as defined by AASHTO on Interim 1981 Fracture Control Plan.
  - 2. Avoid use of backup bars elsewhere, unless explicitly permitted by original design.
  - 3. When use of backup bars is unavoidable because of practicality but not explicitly permitted by original design, remove backup bar after welding is completed and affected surfaces of weld metal and base metal is ground flush. Roughness of ground surfaces to be similar to that of surrounding unaffected plate surface.

### **3.03 BOLTING:**

- A. Connections using high-strength steel bolts in accordance with AISC Specifications for Structural Joints using ASTM A325 or ASTM A490 bolts.
- B. Assemble high-strength bolted parts so that they fit solidly together when assembled. Do not use gaskets or other compressible materials.
- C. Remove scale, dirt, burrs and other defects likely to prevent proper seating when assembling joint surfaces, including those adjacent to washers.
- D. Remove oil, paint, lacquer and galvanizing from contact surfaces of friction joints.
- E. Use two nuts on unfinished bolts and turned bolts in tension.
- F. Tightening Bolts:
  - 1. Tighten ASTM A325 or A490 bolts to bolt tension not less than proof load given in AISC Specifications for Bolts.
  - 2. If approved, tighten by means of properly calibrated wrenches or turn-of-nut method.
  - 3. When tightening, place hardened washer under nut or bolt head, depending on which element is turned in tightening operation.
  - 4. Calibrate torque wrenches daily by tightening bolt assembly in device capable of indicating actual bolt tension.
  - 5. Install three bolts minimum from each lot.
  - 6. Nuts or bolts to be in tightening motion when torque is measured.
  - 7. Adjust power wrenches to cut-out or stall at required tension.
- G. Arrange bolts so that heads show in areas exposed to public view.

### **3.04 SHOP ASSEMBLY:**

- A. Undertake complete or progressive shop assembly of continuous plate and box girders, rigid frames, bents and towers when shown. Obtain approval of progressive shop-assembly procedure.
- B. Clean surfaces of metals in contact with each other with high speed wire brushes before assembling.
- C. Assemble parts to line and fit; drill or ream bolt holes while assembled. Hand reaming is prohibited unless approved.

### **3.05 SHOP PRIME PAINTING:**

- A. Clean steel surfaces in accordance with SSPC SP-6 or SP-10.
- B. Shop Painting:
  - 1. Shop paint structural-steel work which will be left bare in finished structures.
  - 2. Do not shop paint the following:
    - a. Surfaces within three inches of joints to be field welded.
    - b. Galvanized surfaces and surfaces to be galvanized.
    - c. Contact surfaces: Apply rust-inhibitive treatment to such surfaces; remove by means of appropriate solvent prior to assembly.
    - d. Surfaces to be encased in concrete or in fire-protection material.
    - e. Weathering steel.
  - 3. Use paint-spraying equipment, if approved, with type of spray gun recommended by paint manufacturer for paint being applied.
  - 4. Use brushes of good quality bristle. Nylon brushes and roller coaters are prohibited.
  - 5. Neutralize areas of welding which are to be painted by applying specified cleaning solution. Wash neutralized area thoroughly with clean water and allow to dry before painting.
  - 6. Apply shop prime coat at minimum wet-film thickness of three mils. Give surfaces which will be inaccessible after assembly or erection three coats of paint before assembly.
  - 7. Caulk small cracks, cavities and open seams around stiffeners and connections with pasty mixture of red lead and linseed oil or approved caulking putty and allow to dry before applying full shop coat.
  - 8. Apply stripe coat of paint to edges, corners, bolts, welds and other sharp edges before giving steel full shop coat of paint. Apply stripe coat at least one-inch beyond area to be striped and allow to dry before applying full shop coat.
  - 9. Paint erection marks and weight on each member after shop coat has dried.
  - 10. Complete shop painting and ensure paint has completely dried prior to shipment of steel.

### **3.06 ERECTION:**

- A. Install anchor bolts accurately in positions shown.
- B. If anchor bolts are cast in substructure masonry during its construction, ensure that each bolt is firmly held in its correct position and elevation by suitable templates.
- C. If approval is given for installing anchor bolts in preformed holes or in drilled holes in concrete or masonry, use approved nonshrink, nonstaining grout to secure them in place.

- D. Set bearing assemblies to lines and grades shown and adjust to horizontal position shown.
- E. Erect steel structures true and plumb following match marks.
- F. Use temporary bracing to support loads to which structures may be subjected including erection equipment and their operations. Leave bracing in place as long as safety requires.
- G. Report immediately to the Engineer errors in shop fabrication or deformation resulting from handling or transportation which prevent proper erection and fitting of parts.
- H. As erection progresses perform sufficient bolting of work to support dead load, wind load and erection load. Perform permanent bolting when enough alignment has been accomplished to ensure that as much of structure as possible will be supported by such fastening work.
- I. Ensure that holes are not enlarged and that metal in vicinity of holes is not disturbed by drifting during assembly.
- J. Enlargement of holes to accept bolts for connections is prohibited unless approved. Make enlargement by reaming not by burning. Avoid hand reaming.
- K. Do not field weld main stress members.
- L. Bond premolded elastic filler with adhesive to structural framing at elevator hoistways.

**3.07 NONDESTRUCTIVE TESTING OF FIELD WELDS:**

- A. Perform pertinent testing specified for source quality control.

**3.08 FIELD TOUCH-UP PAINTING:**

- A. Retouch surfaces where shop coat has been damaged using paint and paint-film thickness identical to original shop coat.
- B. After erection, clean field bolts, nuts and adjacent areas and apply coat of paint identical to original shop coat.
- C. Finish painting for structural steel in accordance with Section 09920.

<b>TABLE 05120-1</b>				
<b>BASE METAL CHARPY V-NOTCH REQUIREMENTS<sup>a</sup> FOR FRACTURE-CRITICAL MEMBERS</b>				
<b>ASTM</b>	<b>Thickness, Inches (mm)</b>	<b>Zone 1<sup>b</sup></b>	<b>Zone 2<sup>c</sup></b>	<b>Zone 3<sup>d</sup></b>
A36	Up to 4 inches (101.6)	25 at 70F (33.9 Nm at 21.1C)	25 at 40F (33.9 Nm at 4.4C)	25 at 10F (33.9 Nm at minus 12.2C)
A572 <sup>e</sup>	Up to 4 inches (101.6) mechanically fastened	25 at 70F (33.9 Nm at 21.1C)	25 at 40F (33.9 Nm at 4.4C)	25 at 10F (33.9 Nm at minus 12.2C)
	Up to 2 inches (50.8) welded	25 at 70F (33.9 Nm at 21.1C)	25 at 40F (33.9 Nm at 4.4C)	25 at 10F (33.9 Nm at minus 12.2C)
A588 <sup>e</sup>	Up to 4 inches (101.6) mechanically fastened	25 at 70F (33.9 Nm at 21.1C)	25 at 40F (33.9 Nm at 4.4C)	25 at 10F (33.9 Nm at minus 12.2C)
	Up to 2 inches (50.8) welded	25 at 70F (33.9 Nm at 21.1C)	25 at 40F (33.9 Nm at 4.4C)	25 at 10F (33.9 Nm at minus 12.2C)
	Over 2 inches to 4 inches (50.8 to 101.6) welded	30 at 70F (40.7 Nm at 21.1C)	30 at 40F (40.7 Nm at 4.4C)	30 at 10F (40.7 Nm at minus 12.2C)
A514 <sup>f</sup>	Up to 4 inches (101.6) mechanically fastened	35 at zero degree F (47.5 Nm at minus 17.8C)	35 at zero degree F (47.5 Nm at minus 17.8C)	35 at minus 30F (47.5 Nm at minus 34.4C)
	Up to 2-1/2 inches (63.5) welded	35 at zero degree F (47.5 Nm at minus 17.8C)	35 at zero degree F (47.5 Nm at minus 17.8C)	35 at minus 30F (47.5 Nm at minus 34.4C)
	Over 2-1/2 inches to 4 inches (63.5) welded	45 at zero degree F (61.0 Nm at minus 17.8C)	45 at zero degree F (61.0 Nm at minus 17.8C)	Not permitted

<sup>a</sup> CVN impact testing to be P-plate frequency testing in accordance with ASTM A673. Code Charpy test pieces with respect to heat/plate number and record such code on mill-test report of steel supplier with test result. If directed, package broken pieces from each test (three specimens, six halves) and forward to the quality-assurance organization of the jurisdictional authority. Use average of three tests. If energy value for more than one of three specimens is below minimum average requirements or if energy value for one of three specimens is less than 2/3 of specified minimum requirements, retest and obtain energy value from each of three retest specimens equal to or exceeding specified minimum average requirement.

<sup>b</sup> Zone 1: Minimum service temperature zero degree F (minus 17.8C) and above.

- \*c Zone 2: Minimum service temperature from minus 1F to minus 30F (minus 28.3C to minus 34.4C).
- \*d Zone 3: Minimum service temperature from minus 31F to minus 60F (minus 35C to minus 51.1C).
- \*e If the yield strength of the material exceeds 65 ksi (448.159MPa), reduce temperature for CVN value for acceptability by 15F (8.3C) for each increment of 10 ksi (68.947MPa) above 65 ksi (448.159MPa). Yield strength is value given in certified mill-test report.
- \*f ASTM A517 Charpy requirements are the same as for ASTM A514.

**END OF SECTION**

## SECTION 05210

### STEEL JOISTS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing steel joists.
- B. Related Work Specified Elsewhere:
  - 1. Bearing plates and miscellaneous steel framing: Section 05120.
  - 2. Field painting: Section 09920.

##### 1.02 QUALITY ASSURANCE:

- A. Reference Codes and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. AWS: D1.1.
  - 3. SJI (Steel Joint Institute): Standard Specifications and Load Tables for Series-K Open-Web Steel Joist, Series-LH Longspan Steel Joists and Joist Girders.
  - 4. SSPC: Steel Structures Painting Manual.
  - 5. FS: TT-P-645.
- B. Qualification of Welding Personnel:
  - 1. Employ welding personnel whose qualification is certified in accordance with AWS D1.1. Such certification is to remain in force for the duration of the welding operations under this Contract.

##### 1.03 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Shop Drawings:
  - 1. Detailed joist and erection drawings showing erection marks, SJI-designation numbers, locations and spacing; bearing-plate and anchor-bolt layouts; bridging details and connections; shop coating; and details necessary for installation. Drawings to be signed and sealed by a professional engineer registered in the jurisdiction where the work will be performed.
- B. Certification:
  - 1. Certificate verifying compliance with SJI specifications.
  - 2. Certification that welding personnel are currently qualified in accordance with AWS D1.1, and as specified above under Qualification of Welding Personnel.

##### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Load, transport, unload and store steel joists by means which will prevent damage.
- B. Use waterproof coverings during transit and storage to protect shop coats and prevent corrosion.
- C. Store off the ground preferably supported by their end bearings.

#### PART 2 - PRODUCTS

## **2.01 MATERIALS:**

- A. Steel Joists: Designations shown, fabricated in accordance with SJI requirements. Extended ends and ceiling extensions designed to support loads shown.
- B. Shop Coating: In accordance with FS TT-P-645 and SSPC recommendations of the Steel Structures Painting Manual, except that asphalt coating is prohibited for joists specified to be field-painted.
- C. Bridging: Member sizes, end anchorages and accessories in accordance with SJI requirements.
- D. Bearing plates and miscellaneous steel framing: Section 05500.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION:**

- A. Install steel joists and bridging in accordance with SJI recommendations.
- B. Ensure that bearing plates are set in accordance with approved working drawings. Install joists of proper designations at locations shown.
- C. Perform welding in accordance with AWS D1.1. Burning of holes, undercutting or other operations which reduce strength of joists are prohibited.
- D. Permanently secure bridging and decking before applying construction or design loads to steel-joist installation.
- E. Ensure that construction loads, such as stacked materials, do not exceed designed capacity of the installation.
- F. Repair or replace damaged joists as directed.

### **3.02 FIELD PAINTING:**

- A. Repair shop coating where damaged. Remove welding flux, rust and other foreign matter. Coat welded and damaged areas with coating to match shop-applied coating.
- B. Use joists with asphalt coating only in areas which have ceilings.
- C. Paint joists exposed to view in completed project in accordance with Section 09920.

### **3.03 FIELD QUALITY CONTROL:**

- A. Inspect steel joists for broken welds, bent chords or web members and other damage harmful to structural integrity of joists.
- B. Verify size, spacing, top-chord alignment and level, and tightness of fasteners.
- C. Monitor field welding for compliance with AWS D1.1 requirements.

**END OF SECTION**

## SECTION 05310

### METAL DECKING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing metal roof decking.
- B. Related Work Specified Elsewhere:
  - 1. Touch up and field painting of metal deck: Section 09920.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. AISI Specifications for the Design of Light-Gauge Cold-Formed Steel Structural Members.
  - 3. AWS: D1.1.
  - 4. SDI (Steel Deck Institute): Design Manual for Floor Decks and Roof Decks.
  - 5. ASTM: A653/A653M.
- B. Qualification of Welding Personnel:
  - 1. Employ welding personnel whose qualification is certified in accordance with AWS D1.1. Such certification is to remain in force for the duration of the welding operations under this Contract.

##### 1.03 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Shop Drawings:
  - 1. Include details of fabrication and erection including materials, dimensions, methods of joining, welding, accessories, fastenings and openings through decking.
- B. Samples:
  - 1. Three of each type of the following products used in the work.
    - a. Decking: Six inches by width of material.
    - b. Accessories.
    - c. Fasteners.
- C. Certification:
  - 1. Certification that welding personnel have been qualified in accordance with AWS D1.1.

##### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver products in good condition.
- B. Store products so as to preclude corrosion, deterioration and damage.
- C. Handle products so as to prevent damage.

### **1.05 JOB CONDITIONS:**

- A. Do not apply construction loads, such as roofing materials and aggregate, in excess of the live loads for which the deck is designed.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS:**

- A. Steel Decking:
  - 1. Galvanized: ASTM A653/A653M, Coating G60 or G90, gauge as shown.
  - 2. Where terne-coated stainless steel is to be installed over decking, fabricate decking with clear space between ribs 1/2-inch wide maximum.
- B. Accessories:
  - 1. Types shown or necessary to complete installation, such as 14-gauge recessed sump pans for roof drains, cover plates where panels abut or change direction and closure plates.
  - 2. Same gauge and finish as decking, unless otherwise shown or specified.
- C. Fasteners: As shown on approved shop drawings.

### **2.02 FABRICATION:**

- A. Deck units countersunk at ends to form smooth, flush top surface at overlapping ends, except for 12-gauge and 14-gauge material.
- B. Deck units having interlocking side laps, in standard width and longest practicable lengths
- C. Steel Roof Deck: Gage and depth as shown.
- D. Metal Forming (corrugated):
  - 1. Maximum Flexural Working Stress: 33,000 psi.
  - 2. Maximum Roof Deflection: 1/240 of span, c/c of supports, under live load.
  - 3. Maximum Floor Deflection: 1/360 of span, c/c of supports, under live load.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION:**

- A. Erect steel decking and accessories in accordance with approved shop drawings and manufacturer's recommendations.
- B. Place decking units on the supporting steel, align and adjust to final position before permanently fastening.
- C. If supporting beams are not in proper alignment or at correct elevation to provide bearing and alignment of deck units; do not place decking units in deficient areas until necessary corrections have been made.
- D. Continue decking over three or more spans.
- E. Perform welding in accordance with AWS D1.1.

- F. Use electric-arc welding to weld deck panels to end supports as shown on the Contract Drawings or on approved shop drawings. Where panel ends meet, provide minimum two-inch overlap and weld to fuse ends of units together.
- G. Crimp side joints of adjacent panels and weld at intervals not exceeding three feet.
- H. Remove burrs and sharp edges.
- I. Where welding occurs through deck, use welding washers and plug welds to ensure proper attachment.
- J. Cut bevels and perform other special cutting and fitting at jobsite.
- K. Provide necessary support framing and reinforcement and openings for items penetrating deck panels.
- L. Coordinate cutting of openings for work of other trades with trades involved.
- M. Do not hang mechanical equipment or other loads from steel deck.
- N. Repair areas where galvanizing has been damaged by welding or cutting operations using cold galvanizing compound acceptable to the Engineer.
- O. Clean galvanized roof sheets with zinc oxide residue or evidence of rusting with solvent and apply zinc-rich paint to restore corrosion resistance.

**3.02 CLEAN-UP:**

- A. Clean up rubbish and debris caused by this work and remove from site.
- B. Leave decks and areas surrounding work in broom-clean condition.

**END OF SECTION**

## SECTION 05500

### MISCELLANEOUS METAL

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing miscellaneous metal, with the exception of ornamental (architectural) metal and metalwork provided as a part of mechanical, electrical and construction systems.
- B. Related Work Specified Elsewhere:
  - 1. Concrete, concrete fill and nonshrink grout: Section 03300.
  - 2. Structural steel: Section 05120.
  - 3. Handrails and Railings: Section 05521.
  - 4. Gratings and Floor Plates: Section 05531.
  - 5. Field painting: Section 09920.
  - 6. Concrete formwork: Section 03100.
  - 7. Concrete reinforcement: Section 03200.
  - 8. Wire Mesh Partitions: Section 10605

##### 1.02 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Shop Drawings: Detail fabrication and erection of each metal fabrication indicated.
  - 1. Include plans, elevations, sections, and details of metal fabrications and their connections. Show anchorage and accessory items. Provide templates for anchors and bolts specified for installation under other Sections.
  - 2. Manufacturer's standard drawings may be submitted in lieu of Contractor-prepared shop drawings if manufacturer's standard drawings show required details.
- B. Certification:
  - 1. Certification that welding personnel are currently qualified in accordance with AWS D1.1.
  - 2. Mill Certificates: Signed by manufacturers of stainless-steel sheet certifying that products furnished comply with requirements for corrosion resistance of Type 316 stainless steel.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. AWS: D1.1.
  - 3. AISC: Specification for Structural Steel for Buildings-Allowable Stress Design and Plastic Design (Do not use plastic design).
  - 4. SSPC: SP 11, Paint 12.
  - 5. FED STD: 595.
  - 6. MS: MIL-P-21035.
  - 7. FS: A-A-462, FF-B-588, FF-H-116, FF-P-395, FF-S-325, RR-T-650, TT-P-86.

8. ASTM: A36, A53, A74, A108, A123, A167, A193, A229, A242, A276, A307, A313, A325, A413, A490, A501, A536, A570, A572, A588, A666, A780, A786/A786M, B 221, B 632, B633, D412, D1187, E488, F 593, F 594, F1554.
9. AGA: The Design and Fabrication of Galvanized Products.
10. ANSI: A14.3
11. ASME: A 17.1, B18.6.3, B18.21.1, B18.22.1.

B. Qualifications of Welding Personnel:

1. Welding: Qualify procedures and personnel according to the following:
  - a. AWS D1.1, "Structural Welding Code--Steel."
  - b. AWS D1.2, "Structural Welding Code--Aluminum."
  - c. AWS D1.3, "Structural Welding Code--Sheet Steel."
  - d. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification. Such certification is to remain in force for the duration of the welding operations under this Contract.

C. Fabricator Qualifications: A firm experienced in producing metal fabrications similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.

D. Coordinate installation of anchorages for metal fabrications. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

**1.04 PROJECT CONDITIONS:**

A. Field Measurements: Where metal fabrications are indicated to fit walls and other construction, verify dimensions by field measurements before fabrication and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.

1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating metal fabrications without field measurements. Coordinate construction to ensure that actual dimensions correspond to established dimensions. Allow for trimming and fitting.

**1.06 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Deliver products undamaged.
- B. Store products so as to prevent rust.
- C. Handle products so as to prevent damage.
- D. After completion of factory testing, package and ship hatches as directed.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS:**

- A. General Requirements:
  - 1. Insofar as practicable, furnish similar products of a single manufacturer.
  - 2. Metal Surfaces, General: For metal fabrications exposed to view in the completed Work, provide materials with smooth, flat surfaces without blemishes. Do not use materials with exposed pitting, seam marks, roller marks, rolled trade names, or roughness.

### **2.02 FERROUS METALS:**

- A. Structural steel: Plates, shapes, bars and angles, ASTM A36.
- B. Rolled-Steel Floor plate: ASTM A786/A786M; Fabricate raised-pattern floor plates from rolled-steel floor plate, galvanized after fabrication, of thickness and in pattern indicated below:
  - 1. Thickness: Minimum 1/4 inch, unless otherwise shown or calculated.
  - 2. Pattern: No. 2, or as selected from manufacturer's standard patterns; flat back.
- C. High-strength low-alloy structural steel:
  - 1. ASTM A242.
  - 2. Resistance to atmospheric corrosion: Four times that of carbon steel, minimum.
- D. Load-carrier beams: ASTM A588.
- E. Structural tubing: ASTM A501.
- F. Steel Pipe: ASTM A 53, standard weight (Schedule 40), unless another weight is indicated or required by structural loads.
- G. Stainless-Steel Sheet, Strip, Plate, and Flat Bars: ASTM A666, Type 304. Type 316L for corrosive environments.
- H. Stainless-Steel Bars and Shapes: ASTM A276, Type 304. Type 316L for corrosive environments.
- I. Hot-rolled carbon steel sheets and strips: ASTM A570.
- J. Pipe, Pipe Sleeves and Pipe Fittings:
  - 1. Cast iron: ASTM A74, service weight.
  - 2. Steel: ASTM A53, galvanized unless otherwise shown or specified.
- K. Guard Chain: ASTM A413, Class Grade 28, galvanized steel, 9/32-inch thick, complete with stainless-steel eyes, spring-loaded catches and mounting components.

### **2.03 ALUMINUM:**

- A. Aluminum Extrusions: ASTM B221, Alloy 6063
- B. Aluminum-Alloy Rolled Tread Plate: ASTM B632/B 632M, Alloy 6061.
- C. Cast Aluminum.

## 2.04 COATINGS:

- A. Shop Primer for Ferrous Metal: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with performance requirements in FS TT-P-664; selected for good resistance to normal atmospheric corrosion, compatibility with finish paint systems indicated, and capability to provide a sound foundation for field-applied topcoats despite prolonged exposure.
- B. Zinc-rich paint: MS MIL-P-21035.
- C. Electrodeposited zinc coating: ASTM B63
- D. Galvanizing repair compound: Stick form, melting point 600F to 650F, GALVABAR or equal.
- E. Bituminous coating: Cold-applied asphalt mastic complying with SSPC Paint 12, except containing no asbestos fibers, or cold-applied asphalt emulsion complying with ASTM D1187.

## 2.05 FASTENERS:

- A. General: Provide Type 304 or 316 stainless-steel fasteners for exterior use and zinc-plated fasteners with coating complying with ASTM B 633, Class Fe/Zn 5, where built into exterior walls. Select fasteners for type, grade, and class required.
- B. Screws: Material, type and size to suit the purpose; steel, except stainless, cadmium-plated.
  - 1. Stainless steel, ASTM A193, Alloy S30400.
- C. Machine bolts: Material, type and size best suited to the purpose. Minimum tensile strength 60,000 psi.
  - 1. Carbon steel: ASTM A307, Grade B, galvanized.
  - 2. Stainless steel: ASTM A193, Class 1A.
- D. Toggle bolt: FS FF-B-588.
- E. Drive stud: FS FF-S-325, Group 6.
- F. Expansion shield: FS FF-S-325 Group I, Type 2, Class 2, Style 1; Group II, Type 3, Class 1; Group IV, Type 1; best suited to the purpose.
- G. Screw anchors: Lead or plastic for wood or metal screws.
- H. Anchor-bolt sleeve: Corrugated high-density polyethylene plastic.
- I. Powder actuated: FS FF-P-395.
- J. Expansion Anchors: Anchor bolt and sleeve assembly of material indicated below with capability to sustain, without failure, a load equal to six times the load imposed when installed in unit masonry and equal to four times the load imposed when installed in concrete, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.
  - 1. Material: Alloy Group 1 or 2 stainless-steel bolts complying with ASTM F593 and nuts complying with ASTM F594.
- K. Internally Threaded Steel Anchor: ASTM A108.

## 2.06 CONCRETE AND GROUT:

- A. Nonshrink Grout: Section 03300.
- B. Concrete Fill: Normal weight, minimum 3,000 psi structural concrete as required in Section 03300, except limit the max. coarse aggregate size to #8.
  - 1. Non-slip aggregate: Fused aluminum oxide grits or crushed emery, factory graded and packaged, rust-proof, non glazing and unaffected by moisture and cleaning materials.
  - 2. Surface hardener: Water-soluble, inorganic fluosilicate compound for curing, hardening and dustproofing fresh concrete.

## **2.07 FABRICATION, GENERAL:**

- A. Shop Assembly: Preassemble items in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.
- B. Shear and punch metals cleanly and accurately. Remove burrs.
- C. Ease exposed edges to a radius of approximately 1/32 inch, unless otherwise indicated. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
- D. Weld corners and seams continuously to comply with the following:
  - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
  - 2. Obtain fusion without undercut or overlap.
  - 3. Remove welding flux immediately.
  - 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- E. Provide for anchorage of type indicated; coordinate with supporting structure. Fabricate and space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.
- F. Cut, reinforce, drill, and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.
- G. Fabricate joints that will be exposed to weather in a manner to exclude water, or provide weep holes where water may accumulate.
- H. Allow for thermal movement resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening up of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
  - 1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.
- I. Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges
- J. Remove sharp or rough areas on exposed traffic surfaces.

- K. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Use exposed fasteners of type indicated or, if not indicated, Phillips flat-head (countersunk) screws or bolts. Locate joints where least conspicuous.

## **2.08 LADDERS:**

- A. General: Fabricate ladders for locations shown, with dimensions, spacings, details, and anchorages as indicated.
  - 1. Comply with ANSI A14.3, unless otherwise indicated.
  - 2. For elevator pit ladders, comply with ASME A17.1.
- B. Siderails: Continuous, 1/2-by-2-1/2-inch steel flat bars, with eased edges.
- C. Bar Rungs: 3/4-inch diameter steel bars, spaced 12 inches o.c., unless shown otherwise.
- D. Fit rungs in centerline of side rails; plug-weld and grind smooth on outer rail faces.
- E. Support each ladder at top and bottom and not more than 48 inches o.c. with welded or bolted steel brackets. Size brackets to support design loads specified in ANSI A14.3.
- F. Provide nonslip surfaces on top of each rung by coating with abrasive material metallurgically bonded to rung by a proprietary process.
- G. Galvanize ladders, including brackets and fasteners, in exterior locations and in areas with corrosive environments:

## **2.09 LADDER SAFETY CAGES:**

- A. General: Fabricate ladder safety cages to comply with ANSI A14.3. Assemble by welding or riveting.
- B. Primary Hoops: 5/16-by-4-inch steel flat bar hoops. Provide at tops and bottoms of cages and spaced not more than 20 feet o.c.
- C. Secondary Intermediate Hoops: 5/16-by-2-inch steel flat bar hoops, spaced not more than 48 inches o.c. between primary hoops.
- D. Vertical Bars: 5/16-by-2-inch steel flat bars secured to each hoop, spaced approximately 9 inches o.c.
- E. Fasten assembled safety cage to ladder rails and adjacent construction by welding or riveting, unless otherwise indicated.
- F. Galvanize ladder safety cages, including fasteners, in exterior locations and in areas with corrosive environments.

## **2.10 SHIP'S LADDERS:**

- A. General: Design in accordance with AISC Specification for Structural Steel for Buildings-Allowable Stress Design, NAAMM Metal Stairs Manual and applicable OSHA requirements.
  - 1. Minimum live load for stairs: 100 psf.
  - 2. Stringers: At platforms and landings, extend stringers around perimeters. Close ends with continuously welded closure plates, ground smooth and flush.

- B. Provide ship's ladders where shown or indicated. Fabricate of open-type construction with structural-steel channel or steel plate stringers, steel pipe handrails, and steel bar grating treads, unless otherwise indicated. Provide brackets and fittings for installation.
- C. Treads, platforms and landings fabricated of steel plate with nonslip surface or steel grating, as shown.
- D. As far as practicable, holes for rivets, bolts and screws located in concealed positions.
- E. Galvanize ship's ladder, including fasteners, in exterior locations and in areas with corrosive environments.
- F. Comply with applicable requirements in Section 05520 for steel pipe railings.

**2.11 SAFETY TREAD:**

- A. FS RR-T-650, Type C, metallic, nonskid, class and style as shown.
- B. Drilled and countersunk to receive flathead screws.

**2.12 STEEL LINTELS:**

- A. Fabricated of structural steel.
- B. Multiple members riveted or welded back-to-back or separated by spacers.
- C. Shop-painted, except hot-dip galvanized after fabrication where used in exterior walls.

**2.12 SHELF ANGLES:**

- A. Fabricate shelf angles from steel angles of sizes indicated and for attachment to concrete framing. Provide horizontally slotted holes to receive 3/4-inch bolts, spaced not more than 6 inches from ends and 24 inches o.c., unless otherwise indicated.
- B. For cavity walls, provide vertical channel brackets to support angles from backup masonry and concrete. Align expansion joints in angles with indicated control and expansion joints in cavity-wall exterior wythe.
- C. Galvanize shelf angles to be installed in exterior walls.
- D. Furnish wedge-type concrete inserts, complete with fasteners, to attach shelf angles to cast-in-place concrete.

**2.13 CORNER GUARD, CURB ANGLE AND BUMPER:**

- A. Fabricated of structural steel.
- B. Shop-painted.

**2.14 UNDERGROUND SAFETY WALK:**

- A. Locking pin: Stainless steel, diameter to fit receptacle in hinge assembly with tolerance not greater than plus-or-minus 1/64 inch.
- B. Locking-pin chain: Fabricated of 0.128-inch diameter steel spring wire.

- C. Plug-welded in accordance with AWS D1.1.
- D. Stainless steel: ASTM A276, Alloy S20200.
- E. Bolts and washers: ASTM A325 or ASTM A490, nonrising and vibration-proof.
- F. Spring wire: ASTM A229, Class 1 or 4.
- G. Ferrous-metal components galvanized after fabrication.
- H. Gratings and Floor Plates: Section 05531.

**2.15 AERIAL SAFETY WALK:**

- A. Fabricated of floor plate, diamond pattern, flatback.
- B. Abrasive surface on plates, unless otherwise shown.
- C. Structural-steel angle frames anchored to supporting structure.
- D. Plates in sections of convenient lengths for handling and with finger holes for lifting.
- E. Galvanized after fabrication.
- F. Bolts: Stainless steel.

**2.16 SCREEN AT PLATFORM BENCH:**

- A. Materials:
  - 1. Base: Steel, welded.
  - 2. Bar frame: Steel, welded.
  - 3. Screen:
    - a. Wire cloth: 0.080-inch diameter steel-wire mesh, galvanized after weaving.
    - b. Frame: Steel, drilled for fasteners, holes punched for wire mesh and corners welded, galvanized.
- B. Fabrication: Insert wire cloth with wires parallel to frame members, with ends of wires through holes in frame and welded to inner surface of channel.
- C. Finish: Field-painted in accordance with Section 09920; FED STD 595, Color No. 20040.

**2.17 CAST NOSING:**

- A. Cast aluminum: Cross-hatched units, 4 inches wide with 1-inch lip, for casting into concrete steps
- B. Apply bituminous paint to concealed bottoms, sides, and edges of units set into concrete.

**2.18 PEDESTRIAN BARRIER:**

- A. Tubing: Hot-formed square steel. Fabricated as follows:
  - 1. Heated and bent smoothly without distortion
  - 2. Joints fully welded as shown.
  - 3. Intersections coped, fully welded and ground smooth and flush.

- B. Plate: Structural steel.
- C. Floor-cover flange: Cast steel, as shown.
- D. Finish: Shop-coated and finish painted in accordance with Section 09920.

**2.19 BOLLARDS:**

- A. Pipe: Black Steel, ASTM A53, Type E, Grade A, Schedule 80, sized as shown, with 1/4-inch steel-plate cap welded all around and weld ground smooth
- B. Eyebolt: 1/4-inch diameter steel rod with 1/2-inch diameter eye.
- C. Concrete fill: Section 03300, Class 3000.
- D. Coating:
  - 1. Shop paint.
  - 2. Finish paint: Aliphatic system as specified in Section 09920.
  - 3. Hot-dip galvanize exterior bollards in accordance with ASTM A123 before bonderizing and shop priming.
- E. Chain: Guard chain, galvanized and painted to match bollard.

**2.20 PARKING METER POSTS:**

- A. Pipe: Black steel, ASTM A53, Type E, Grade A, Schedule 40, two-inch nominal OD.
- B. Hot-dip galvanize after cutting to length.
- C. See Sections 03100, 03200, and 03300 for concrete footing.

**2.21 MISCELLANEOUS ITEMS:**

- A. Fabricate metal items indicated on the drawings from materials shown or, if not otherwise described, from steel or from galvanized steel wherever exposed to the weather or in contact with concrete or masonry.
- B. Make miscellaneous items to the size and configuration indicated, welded or bolted at joints to develop full strength equal to a continuous member, and in every way complete for the intended purpose and finished in appearance.
- C. Pylon-Base Ring: Structural steel, galvanized after fabrication.
- D. Lifting Eye: ASTM A572, Grade 50, one-inch diameter steel rod, welded, galvanized after fabrication.

**2.22 FINISHES:**

- A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
  - 1. Finish metal fabrications after assembly.
- B. Galvanizing:
  - 1. Clean ferrous metal thoroughly before applying zinc coating.
  - 2. Apply zinc coating to products after fabrication, by hot-dip method, using coating weighing not less than 2.0 ounces per square foot.

- C. Shop Paint:
  - 1. Ferrous metal thoroughly cleaned as recommended by primer manufacturer and in accordance with SSPC SP11 and, except for items to be encased in concrete, given prime coat of paint.
  - 2. Zinc yellow iron-oxide primer or red-lead base primer applied so as to thoroughly cover surfaces without leaving runs or sags.
- D. Stainless Steel: Remove tool and die marks and stretch lines or blend into finish. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.
- E. Aluminum: AA-M10 (Mechanical Finish: as fabricated, unspecified).
- F. Non-Slip Abrasive Surfaces: SLIP-NOT as manufactured by the W. S. Molnar Company or approved equal. Fabricate from steel plate or bar with abrasive material metallurgically bonded to steel by a proprietary process. Provide material with coefficient of friction of 0.6 or higher when tested according to ASTM C1028.

### **PART 3 - EXECUTION**

#### **3.01 PREPARATION:**

- A. Remove foreign substances from surfaces to receive metal items.
- B. Protect surrounding surfaces from damage while performing the work of this section.

#### **3.02 INSTALLATION, GENERAL:**

- A. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing metal fabrications to in-place construction. Include threaded fasteners for concrete and masonry inserts, toggle bolts, through-bolts, lag bolts, wood screws, and other connectors.
- B. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.
- C. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.
- D. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.
- E. Field Welding: Comply with the following requirements:
  - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
  - 2. Obtain fusion without undercut or overlap.
  - 3. Remove welding flux immediately.
  - 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

- F. Corrosion Protection: Coat concealed surfaces of aluminum that will come into contact with grout, concrete, masonry, wood, or dissimilar metals with a heavy coat of bituminous paint.

**3.03 INSTALLING NOSINGS:**

- A. Center nosings on tread widths.
- B. For nosings embedded in concrete steps or curbs, align nosings flush with riser faces and level with tread surfaces.

**3.04 INSTALLING BOLLARDS:**

- A. Anchor bollards in concrete with pipe sleeves preset and anchored into concrete. After bollards have been inserted into sleeves, fill annular space between bollard and sleeve solidly with nonshrink, nonmetallic grout, mixed and placed to comply with grout manufacturer's written instructions. Slope grout up approximately 1/4 inch toward bollard.

**3.05 PAINTING AND REPAIRING COATED SURFACES:**

- A. Before erection or enclosing construction, paint items that support masonry or will be concealed in finished work, except items encased in concrete.
- B. Where shop coat is abraded or burned by welding, clean and touch-up.
- C. Touch-up primed surfaces with same material as coating.
- D. Where aluminum parts come in contact with concrete or steel, coat contact surfaces of aluminum with bituminous coating.
- E. Coat field welds and repair damage to zinc-coated surfaces in accordance with ASTM A780 and as follows:
  - 1. Wire-brush areas to be coated to bright metal.
  - 2. Apply galvanizing repair compound at rate of two ounces per square foot.

**END OF SECTION**

## SECTION 05511

### METAL STAIRS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing Adjust list below to suit Project. steel stairs with concrete-filled treads, industrial stairs with steel floor plate treads, industrial stairs with steel grating treads.
- B. Related Work Specified Elsewhere:
  - 1. Cast-In-Place Structural Concrete: Section 03300.
  - 2. Handrails and Railings: Section 05521.
  - 3. Miscellaneous Metal: Section 05500.
  - 4. Field Painting: Section 09920.

##### 1.02 PERFORMANCE REQUIREMENTS:

- A. Structural Performance: Provide metal stairs capable of withstanding the following structural loads without exceeding the allowable design working stress of the materials involved, including anchors and connections. Apply each load to produce the maximum stress in each component of metal stairs.
  - 1. Treads and Platforms of Metal Stairs: Capable of withstanding a uniform load of 100 lbf/sq. ft. or a concentrated load of 300 lbf on an area of 4 sq. in., whichever produces the greater stress; or higher load if required by the jurisdictional authority where the stair is installed.
  - 2. Stair Framing: Capable of withstanding stresses resulting from loads specified above in addition to stresses resulting from railing system loads.
  - 3. Limit deflection of treads, platforms, and framing members to L/360 or 1/4 inch, whichever is less or as required by the jurisdictional authority where the stair is installed.
- B. Metal stairs shall be designed in accordance with AISC's "Specification for Structural Steel for Buildings-Allowable Stress Design," NAAMM's "Metal Stairs Manual" and applicable OSHA requirements.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each.
  - 1. Product Data: For metal stairs and the following:
    - a. Prefilled metal-pan stair treads.
    - b. Precast concrete treads.
    - c. Nonslip aggregates and nonslip-aggregate finishes.
    - d. Steel floor plate.
    - e. Grout.
  - 2. Shop Drawings: Show fabrication and installation details for metal stairs. Include plans, elevations, sections, and details of metal stairs and their connections. Show anchorage and accessory items. Provide templates for anchors and bolts specified for installation under other Sections.
  - 3. For installed products indicated to comply with design loads, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

4. Samples for Initial Selection: Manufacturer's color charts or sections of units showing the full range of colors and patterns for the following products
5. Samples for Verification: For the following products. Prepare Samples from the same material to be used for the Work.
  - a. Stair treads with nonslip-aggregate surface finish.
  - b. Floor plate treads.
  - c. Grating treads.
6. Welding Certificates: Copies of certificates for welding procedures and personnel.

### **1.03 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
  1. Comply with codes and regulations of the jurisdictional authorities.
  2. ADA: Americans with Disabilities Act.
  3. AGA: The Design and Fabrication of Galvanized Products.
  4. AISC: Specification for Structural Steel for Buildings-Allowable Stress Design
  5. ASME: B18.2.1, B18.6.3, B18.21.1, B18.22.1.
  6. ASTM: A36, A82, A90, A123, A143, A153, A185, A283, A307, A366, A384, A500, A510, A563, A611, B633, C1028, C1107, D1187, E488, F593, F594.
  7. AWS: D1.1, D1.3.
  8. FS: TT-P-664
  9. MS: MIL-P-21305.
  10. NAAMM: Metal Bar Grating Manual for Steel, Stainless Steel, and Aluminum Gratings and Stair Treads, Metal Finishes Manual for Architectural and Metal Products, Metal Stairs Manual.
  11. SSPC: Paint 12, PA-1, SP 3, SP 6/NACE No. 3.
- B. Installer Qualifications: Arrange for metal stairs specified in this Section to be fabricated and installed by the same firm.
- C. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of metal stairs (including handrails and railing systems) that are similar to those indicated for this Project in material, design, and extent.
- D. Fabricator Qualifications: A firm experienced in producing metal stairs similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.
- E. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," and AWS D1.3, "Structural Welding Code--Sheet Steel."

### **1.05 COORDINATION:**

- A. Coordinate installation of anchorages for metal stairs. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

## **PART 2 - PRODUCTS**

### **2.01 FERROUS METALS:**

- A. Metal Surfaces, General: Provide metal free from pitting, seam marks, roller marks, and other imperfections where exposed to view on finished units. Do not use steel sheet with variations in flatness exceeding those permitted by referenced standards for stretcher-leveled sheet.
- B. Steel Plates, Shapes, and Bars: ASTM A36.
- C. Steel Tubing: Cold-formed steel tubing complying with ASTM A500.
- D. Rolled-Steel Floor Plate: ASTM A 786/A 786M, rolled from plate complying with ASTM A 36/A 36M or ASTM A 283/A 283M, Grade C or D.
- E. Steel Bars for Gratings: ASTM A36.
- F. Wire Rod for Grating Crossbars: ASTM A510.
- G. Uncoated, Cold-Rolled Steel Sheet: Commercial quality, complying with ASTM A366/A366M; or structural quality, complying with ASTM A611, Grade A, unless another grade is required by design loads.
- H. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

## **2.02 FASTENERS:**

- A. General: Provide zinc-plated fasteners with coating complying with ASTM B633, Class Fe/Zn 25 for exterior use, and Class Fe/Zn 5 where built into exterior walls. Select fasteners for type, grade, and class required.
- B. Bolts and Nuts: Regular hexagon-head bolts, ASTM A307, Grade A; with hex nuts, ASTM A563; and, where indicated, flat washers.
- C. Machine Screws: ASME B18.6.3.
- D. Lag Bolts: ASME B18.2.1.
- E. Plain Washers: Round, carbon steel, ASME B18.22.1.
- F. Lock Washers: Helical, spring type, carbon steel, ASME B18.21.1.
- G. Expansion Anchors: Anchor bolt and sleeve assembly of material indicated below with capability to sustain, without failure, a load equal to six times the load imposed when installed in unit masonry and equal to four times the load imposed when installed in concrete, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.
  - 1. Material: Carbon-steel components zinc-plated to comply with ASTM B 633, Class Fe/Zn 5.
  - 2. Material: Alloy Group 1 or 2 stainless-steel bolts complying with ASTM F593 and nuts complying with ASTM F594.

## **2.03 COATINGS:**

- A. Shop Primer for Ferrous Metal: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with performance requirements in FS TT-P-664, selected for good resistance to normal atmospheric corrosion, compatibility with finish paint systems indicated, and capability to provide a sound foundation for

- B. Galvanizing (zinc-coating by hot-dipped process): ASTM A90, ASTM A123, or ASTM A143, ASTM A153 or ASTM A384, as applicable.
- C. Zinc-rich paint: MS MIL-P-21305.
- D. Galvanizing Repair Compound: Stick form, melting point 600-degree F to 650-degree F, GALVABAR or equal.

**2.04 CAST ABRASIVE NOSINGS:**

- A. Fabricate units from cast iron in sizes and configurations indicated and in lengths necessary to accurately fit openings or conditions. Provide units with an integral corundum or silicon carbide abrasive finish. See Section 05500, "Miscellaneous Metals."
- B. Provide anchors for embedding units in concrete, either integral or applied to units, as standard with manufacturer.
- C. Apply bituminous paint to concealed bottoms, sides, and edges of units set into concrete.
- D. Provide a cross-hatched surface texture, unless other surfaces are indicated.

**2.05 GROUT:**

- A. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107. Provide grout specifically recommended by manufacturer for interior and exterior applications.

**2.06 CONCRETE FILL AND REINFORCING MATERIALS:**

- A. Concrete Materials and Properties: Comply with requirements in Section 03300, "Cast-in-Place Concrete" for normal-weight, ready-mixed concrete with a minimum 28-day compressive strength of 3000 psi, limit the max. coarse aggregate size to #8, unless higher strengths are indicated.
- B. Nonslip-Aggregate Finish: Factory-packaged and graded abrasive aggregate made from fused, aluminum-oxide grits or crushed emery; rustproof and nonglazing; unaffected by freezing, moisture, or cleaning materials.
- C. Welded Wire Fabric: ASTM A185, 6 by 6 inches--W1.4 by W1.4, unless otherwise indicated.
- D. Surface Hardener: Water-soluble, inorganic fluosilicate compound for curing, hardening and dustproofing fresh concrete.

**2.07 PRECAST CONCRETE TREADS:**

- A. Concrete Materials and Properties: Comply with requirements in Section 03300, "Cast-in-Place Concrete" for normal-weight, ready-mixed concrete with a minimum 28-day compressive strength of 5000 psi and a total air content of not less than 4 percent or more than 6 percent.
- B. Reinforcing Wire Fabric: Galvanized, welded wire fabric, 2 by 2 inches by 0.062-inch-diameter wire; comply with ASTM A185 and ASTM A82, except for minimum wire size.

**2.08 FABRICATION, GENERAL:**

- A. Fabricate and prepare products required to be galvanized in accordance with recommendations of AGA.
- B. Provide complete stair assemblies, including metal framing, hangers, struts, clips, brackets, bearing plates, and other components necessary to support and anchor stairs and platforms on supporting structure. Delete subparagraphs below if not required.
  - 1. Join components by welding, unless otherwise indicated.
  - 2. Use connections that maintain structural value of joined pieces.
  - 3. Fabricate treads and platforms of exterior stairs so finished walking surfaces slope to drain.
- C. NAAMM Stair Standard: Comply with "Recommended Voluntary Minimum Standards for Fixed Metal Stairs" in NAAMM AMP 510, "Metal Stairs Manual," for class of stair designated, unless more stringent requirements are indicated.
  - 1. Architectural class, where indicated.
  - 2. Commercial class, unless otherwise indicated.
  - 3. Service class, unless otherwise indicated.
  - 4. Industrial class, where indicated.
- D. Shop Assembly: Preassemble stairs in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation
- E. Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges. Shear and punch metals cleanly and accurately. Remove sharp or rough areas on exposed surfaces.
- F. Ease exposed edges to a radius of approximately 1/32 inch, unless otherwise indicated. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
- G. Weld connections to comply with AWS and the following:
  - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
  - 2. Obtain fusion without undercut or overlap.
  - 3. Remove welding flux immediately.
  - 4. Weld exposed corners and seams continuously, unless otherwise indicated.
  - 5. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- H. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Use exposed fasteners of type indicated or, if not indicated, Phillips flat-head (countersunk) screws or bolts. Locate joints where least conspicuous.
- I. Fabricate joints that will be exposed to weather in a manner to exclude water, or provide weep holes where water may accumulate.

## **2.09 STEEL-FRAMED STAIRS:**

- A. Stair Framing: Fabricate stringers of structural-steel channels, plates, or a combination of both, as indicated. Provide closures for exposed ends of stringers. At platforms and landings, extend stringers around perimeters. Close ends with continuously welded closure plates, ground smooth and flush. Construct platforms of structural-steel channel headers and miscellaneous framing members as indicated. Bolt or weld headers to stringers; bolt or weld

framing members to stringers and headers. If using bolts, fabricate and join so bolts are not exposed on finished surfaces.

1. Where masonry walls support metal stairs, provide temporary supporting struts designed for erecting steel stair components before installing masonry.
- B. Metal Risers, Subtread Pans, and Subplatforms: Form to configurations shown from steel sheet of thickness necessary to support indicated loads, but not less than 0.0677 inch.
1. Steel Sheet: Uncoated cold-rolled steel sheet, unless otherwise indicated.
  2. Directly weld metal pans to stringers; locate welds on side of subtreads to be concealed by concrete fill. Do not weld risers to stringers.
  3. Attach cast abrasive nosings to risers. Make nosings full width of tread, with noses flush with riser faces and level with tread surfaces.
- C. Steel Floor Plate Treads, Risers, and Platforms: Form to configurations shown from abrasive-surface floor plate of thickness necessary to support indicated loads, but not less than 1/4 inch.
1. Abrasive-Surface Floor Plate: Fabricate from steel plate, with abrasive material metallurgically bonded to steel by a proprietary process. Provide material with coefficient of friction of 0.6 or higher when tested according to ASTM C1028.
    - a. Products: Subject to compliance with requirements, provide one of the following:
      - 1) Mebac; IKG Borden.
      - 2) SLIP-NOT; W. S. Molnar Company.
      - 3) Or equal.
  2. Form treads with integral nosing and back edge stiffener. Weld steel supporting brackets to stringers and weld treads to brackets.
  3. Fabricate platforms with integral nosings matching treads and weld to platform framing.
- D. Floor Grating Treads and Platforms: Form to configurations shown from metal bar grating; fabricate to comply with NAAMM MBG 531, "Metal Bar Grating Manual for Steel Stainless Steel, and Aluminum Gratings and Stair Treads."
1. Fabricate treads and platforms from welded steel grating or pressure-locked steel grating with bearing bars and crossbars of sizes to meet the required loads.
  2. Surface: Serrated.
  3. Finish: Galvanized.
  4. Fabricate grating platforms with nosing matching that on grating treads. Provide toeplates at open-sided edges of grating platforms. Weld grating to platform framing.

## **2.10 STAIR HANDRAILS AND RAILINGS:**

- A. General: Comply with applicable requirements in Section 05521 Delete paragraph above or below.
1. Railings may be bent at corners, rail returns, and wall returns, instead of using prefabricated fittings.
  2. Connect railing posts to stair framing by direct welding, unless otherwise indicated.

## **2.11 FINISHES:**

- A. General:
1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
  2. Finish metal stairs after assembly.
- B. Galvanizing:

1. Clean ferrous metal thoroughly before applying zinc coating.
  2. Apply zinc coating to products after fabrication, by the hot-dip method, using coating weighing not less than two ounces per-square-foot.
- C. Preparation for Shop Priming: Prepare uncoated or non-alvanized ferrous-metal surfaces to comply with minimum requirements indicated below for SSPC surface-preparation specifications and environmental exposure conditions of installed items:
1. Interiors (SSPC Zone 1A): SSPC-SP 3, "Power Tool Cleaning."
- D. Apply shop primer to non-galvanized surfaces of gratings, frames, and supports, except those with galvanized finishes and those to be embedded in concrete or masonry, unless otherwise indicated. Comply with SSPC-PA 1, "Paint Application Specification No. 1," for shop painting.
1. Do not apply primer to galvanized surfaces.
  2. Stripe paint corners, crevices, bolts, welds, and sharp edges.
  3. For items shown or indicated to receive paint: Section 09920.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION, GENERAL:**

- A. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing metal stairs to in-place construction. Include threaded fasteners for concrete and masonry inserts, through-bolts, lag bolts, and other connectors.
- B. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal stairs. Set units accurately in location, alignment, and elevation, measured from established lines and levels and free from rack.
- C. Install metal stairs by welding stair framing to steel structure or to weld plates cast into concrete, unless otherwise indicated.
- D. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.
- E. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.
- F. Field Welding: Comply with the following requirements:
1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
  2. Obtain fusion without undercut or overlap.
  3. Remove welding flux immediately.
  4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- G. Install precast treads with adhesive supplied by manufacturer.

#### **3.02 INSTALLING METAL STAIRS WITH GROUTED BASEPLATES:**

- A. Clean concrete and masonry bearing surfaces of bond-reducing materials, and roughen to improve bond to surfaces. Clean bottom surface of baseplates.

- B. Set steel stair baseplates on wedges, shims, or leveling nuts. After stairs have been positioned and aligned, tighten anchor bolts. Do not remove wedges or shims but, if protruding, cut off flush with edge of bearing plate before packing with grout.
  - 1. Use nonmetallic, nonshrink grout, unless otherwise indicated.
  - 2. Pack grout solidly between bearing surfaces and plates to ensure that no voids remain.

### **3.03 INSTALLING STEEL RAILINGS AND HANDRAILS:**

- A. Adjust handrails and railing systems before anchoring to ensure matching alignment at abutting joints. Space posts at spacing indicated or, if not indicated, as required by design loads. Plumb posts in each direction. Secure posts and railing ends to building construction as follows:
  - 1. Anchor posts to steel by welding directly to steel supporting members.
  - 2. Anchor handrail ends to concrete and masonry with steel round flanges welded to rail ends and anchored with postinstalled anchors and bolts.
- B. Attach handrails to wall with wall brackets. Provide bracket with 1-1/2-inch clearance from inside face of handrail and finished wall surface. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads. Secure wall brackets to building construction as follows:
  - 1. For concrete and solid masonry anchorage, use drilled-in expansion shields and hanger or lag bolts.
    - a. For hollow masonry anchorage, use toggle bolts.

### **3.04 PAINTING AND REPAIRING COATED SURFACES:**

- A. Before erection or enclosing construction, paint items that support masonry or will be concealed in finish work, except items encased in concrete.
- B. Where shop coat is abraded or burned by welding, clean and touch-up.
- C. Touch-up primed surfaces with same material as coating.
- D. Where aluminum parts come in contact with concrete or steel, coat contact surfaces of aluminum with bituminous coating.
- E. Coat field welds and repair damage to zinc-coated surfaces in accordance with ASTM A780 and as follows:
  - 1. Wire brush areas to be coated to bright metal.
  - 2. Apply galvanizing repair compound at rate of two ounces per-square-foot.

**END OF SECTION**

**SECTION 05521  
HANDRAILS AND RAILINGS**

**PART 1 - GENERAL**

**1.01 DESCRIPTION:**

- A. This section specifies providing Adjust list below to suit Project.steel pipe and tube handrails and railings and PVC pipe handrails and railings.
  
- B. Related Work Specified Elsewhere:
  - 1. Miscellaneous Metal: Section 05500.
  - 2. Metal Stairs: Section 05511.
  - 3. Ornamental Metal: Section 05700.
  - 4. Field Painting: Section 09920
  - 5. Wire Mesh Partitions: Section 10605

**1.02 PERFORMANCE REQUIREMENTS:**

- A. General: In engineering handrails and railings to withstand structural loads indicated, determine allowable design working stresses of handrail and railing materials based on the following: Retain only those requirements below that apply to materials specified in Part 2.
  - 1. Structural Steel: AISC S335, "Specification for Structural Steel Buildings Allowable Stress Design and Plastic Design with Commentary."
  - 2. Cold-Formed Structural Steel: AISI SG-673, Part I, "Specification for the Design of Cold-Formed Steel Structural Members."
  
- B. Structural Performance of Handrails and Railings: Provide handrails and railings capable of withstanding the following structural loads without exceeding allowable design working stresses of materials for handrails, railings, anchors, and connections:
  - 1. Top Rail of Guards: Capable of withstanding the following loads applied as indicated or higher if required by the jurisdictional authority where installed
    - a. Concentrated load of 200 lbf applied at any point and in any direction.
    - b. Uniform load of 50 lbf/ft. applied horizontally and concurrently with uniform load of 100 lbf/ft. applied vertically downward.
    - c. Concentrated and uniform loads above need not be assumed to act concurrently.
  - 2. Handrails Not Serving As Top Rails: Capable of withstanding the following loads applied as indicated or higher if required by the jurisdictional authority where installed:
    - a. Concentrated load of 200 lbf applied at any point and in any direction.
    - b. Uniform load of 50 lbf/ft. applied in any direction.
    - c. Concentrated and uniform loads above need not be assumed to act concurrently.
  - 3. Infill Area of Guards: Capable of withstanding a horizontal concentrated load of 200 lbf applied to 1 sq. ft. at any point in system, including panels, intermediate rails, balusters, or other elements composing infill area or higher if required by the jurisdictional authority where installed.
    - a. Load above need not be assumed to act concurrently with loads on top rails in determining stress on guard.

- C. Thermal Movements: Provide handrails and railings that allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
  - 1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.
- D. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

### **1.03 SUBMITTALS:**

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Product Data: For the following:
  - 1. Manufacturer's product lines of handrails and railings.
  - 2. Grout, anchoring cement, and paint products.
- B. Shop Drawings: Show fabrication and installation of handrails and railings. Include plans, elevations, sections, component details, and attachments to other Work.
  - 1. For installed handrails and railings indicated to comply with design loads, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
- C. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for products with factory-applied color finishes.
- D. Samples for Verification: For each type of exposed finish required, prepared on components indicated below and of same thickness and material indicated for the Work. If finishes involve normal color and texture variations, include sample sets showing the full range of variations expected.
  - 1. 6-inch-long sections of each distinctly different linear railing member, including handrails, top rails, posts, and balusters.
  - 2. Fittings and brackets.
  - 3. Assembled sample of railing system, made from full-size components, including top rail, post, handrail, and infill. Show method of finishing members at intersections. Sample need not be full height
- E. Product Test Reports: From a qualified testing agency indicating products comply with requirements, based on comprehensive testing of current products.
- F. Welding Certificates: Copies of certificates for welding procedures and personnel.

### **1.04 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ADA: Americans with Disabilities Act.
  - 3. AGA: The Design and Fabrication of Galvanized Products.
  - 4. AISC: S335.
  - 5. AISI: SG-673, Part I.
  - 6. ASTM: A36, A53, A90, A123, A143, A153, A384, A500, A780, B633, C1107, D256, D635, D638, D695, D790, E488, E548.

7. AWS: D1.1, D1.3.
  8. FED STD: 595.
  9. FS: A-A-462, FF-B-588, FF-H-116, FF-P-395, FF-S-325, TT-P-644.
  10. NAAMM: Metal Finishes Manual for Architectural and Metal Products, Pipe Railing Manual.
  11. SSPC: PA 1, Paint 5, SP 6, SP 7.
- B. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of handrails and railings that are similar to those indicated for this Project in material, design, and extent.
- C. Testing Agency Qualifications: An independent testing agency with the experience and capability to conduct the testing indicated, as documented according to ASTM E548.
- D. Welding: Qualify procedures and personnel according to AWS D1.1 "Structural Welding Code-Steel, and AWS D1.3," Structural Welding Code-Sheet Steel".
- E. Source Limitations: Obtain each type of handrail and railing through one source from a single manufacturer.

#### **1.05 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Deliver products undamaged.
- B. Store handrails and railings in a dry, well-ventilated, weathertight place.
- C. Handle products so as to prevent damage.

#### **1.06 PROJECT CONDITIONS:**

- A. Field Measurements: Verify handrail and railing dimensions by field measurements before fabrication and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating handrails and railings without field measurements. Coordinate construction to ensure that actual dimensions correspond to established dimensions.

#### **1.07 COORDINATION:**

- A. Coordinate installation of anchorages for handrails and railings. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

#### **1.08 SCHEDULING:**

- A. Schedule installation so handrails and railings are mounted only on completed walls. Do not support temporarily by any means that does not satisfy structural performance requirements.

## **PART 2 - PRODUCTS**

### **2.01 FERROUS METALS:**

- A. Metal Surfaces, General: Provide metal free from pitting, seam marks, roller marks, stains, discolorations, and other imperfections where exposed to view on finished units.
- B. Steel and Iron: Provide steel and iron in the form indicated, complying with the following requirements:
  - 1. Steel Pipe: ASTM A53; finish, type, and weight class as follows
    - a. Black finish, unless otherwise indicated.
    - b. Galvanized finish for exterior installations and where indicated. Type E, Grade A, standard weight (Schedule 40) for rails and extra heavy weight (Schedule 80) for posts, unless another grade and weight are required by structural loads.
  - 2. Steel Tubing: Cold-formed steel tubing, ASTM A500, Grade A, unless another grade is required by structural loads.
  - 3. Steel Plates, Shapes, and Bars: ASTM A36.
- C. Brackets, Flanges, and Anchors: Cast or formed metal of same type of material and finish as supported rails, unless otherwise indicated.

### **2.02 POLYVINYL CHLORIDE (PVC) FOR NON-CONDUCTIVE RAILINGS:**

- A. Custom colored, fade-resistant PVC pipe and fittings, meeting the structural performance requirements with the following minimum properties:
  - 1. Compressive Strength, ASTM D695: 8,100 psi.
  - 2. Tensile Strength, ASTM D638: 6,500 psi.
  - 3. Flexural Strength, ASTM D790: 11,000 psi.
  - 4. Flexural Modulus, ASTM D790: 350,000 psi.
  - 5. Izod Impact, ASTM D256: 5.0 ft-lb/in minimum.
  - 6. Flamability, ASTM D635: Self-extinguishing.
  - 7. UL Rating: UL 94-V-O, minimum thickness 0.062-inch.
  - 8. Color: Intergrally pigmented PVC in Brown color, FED STD 595B color 20040.

### **2.03 FIBERGLASS REINFORCED PLASTIC (FRP) NON-CONDUCTIVE RAILINGS:**

- A. Fabricated from isophthalic-polyester or vinyl ester resin poltruded fiberglass components with polyurethane UV coating, flame retardant per ASTM E4 Class I, meeting the structural performance requirements and with the following minimum properties:
  - 1. Compressive Stress, ASTM D695: 30,000 psi.
  - 2. Tensile Stress, ASTM D638: 30,0000 psi.
  - 3. Flexural Stress, ASTM D790: 30,0000 psi.
  - 4. Flexural Modulus, ASTM D790: 1.6 x 10<sup>6</sup> psi.
  - 5. Flamability: Self-extinguishing.
  - 6. Color: Manufacturer's standard unless otherwise indicated.

### **2.04 WELDING MATERIALS, FASTENERS, AND ANCHORS:**

- A. Welding Electrodes and Filler Metal: Provide type and alloy of filler metal and electrodes as recommended by producer of metal to be welded and as required for color match, strength, and compatibility in fabricated items.

- B. Fasteners for Anchoring Handrails and Railings to Other Construction: Select fasteners of type, grade, and class required to produce connections suitable for anchoring handrails and railings to other types of construction indicated and capable of withstanding design loads.
  - 1. For steel handrails, railings, and fittings, use plated fasteners complying with ASTM B633, Class Fe/Zn 25 for electrodeposited zinc coating.
- C. Fasteners for Interconnecting Handrail and Railing Components: Use fasteners fabricated from same basic metal as fastened metal, unless otherwise indicated. Do not use metals that are corrosive or incompatible with materials joined.
  - 1. Provide concealed fasteners for interconnecting handrail and railing components and for attaching them to other work, unless otherwise indicated.
  - 2. Provide Phillips flat-head machine screws for exposed fasteners, unless otherwise indicated.
- D. Cast-in-Place and Postinstalled Anchors: Anchors of type indicated below, fabricated from corrosion-resistant materials with capability to sustain, without failure, a load equal to six times the load imposed when installed in unit masonry and equal to four times the load imposed when installed in concrete, as determined by testing per ASTM E488 conducted by a qualified independent testing agency.
  - 1. Cast-in-place anchors.
  - 2. Expansion anchors.
- E. Anchoring Devices:
  - 1. Toggle bolt: FS FF-B-588.
  - 2. Drive Stud: FS FF-S-325, Group 6.
  - 3. Expansion Shield: FS FF-S-325, Group I, Class 2, Style 1; Group II, Type 3, Class 1, Group IV, Type 1; best suited to the purpose.
  - 4. Screw Anchors: Lead or plastic for wood or metal screws.
  - 5. Anchor-bolt sleeve: Corrugated high-density polyethylene plastic.
  - 6. Powder actuated: FS FF-P-395.

## **2.05 COATINGS:**

- A. Shop Primer for Ferrous Metal: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with performance requirements in FS TT-P-664; selected for good resistance to normal atmospheric corrosion, compatibility with finish paint systems indicated, and capability to provide a sound foundation for field-applied topcoats despite prolonged exposure.
- B. Shop Primer for Galvanized Steel: Zinc-dust, zinc-oxide primer formulated for priming zinc-coated steel and for compatibility with finish paint systems indicated, and complying with SSPC-Paint 5.
- C. Galvanizing (zinc-coating by hot-dipped process): ASTM A90, ASTM A123, or ASTM A143, ASTM A153 or ASTM A384, as applicable.
- D. Galvanizing Repair Compound: Stick form, melting point 600-degree F to 650-degree F, GALVABAR or equal.
- E. Bituminous Paint: Cold-applied asphalt mastic complying with SSPC-Paint 12, except containing no asbestos fibers, or cold-applied asphalt emulsion complying with ASTM D 1187.

## **2.06 GROUT AND ANCHORING CEMENT:**

- A. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107. Provide grout specifically recommended by manufacturer for interior and exterior applications.
- B. Erosion-Resistant Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with water at Project site to create pourable anchoring, patching, and grouting compound. Provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating and that is recommended by manufacturer for exterior use.

## **2.07 FABRICATION, GENERAL:**

- A. Fabricate and prepare products required to be galvanized in accordance with recommendations of AGA.
- B. Fabricate handrails and railings to comply with requirements indicated for design, dimensions, member sizes and spacing, details, finish, and anchorage, but not less than that required to support structural loads.
- C. Assemble handrails and railings in the shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation. Use connections that maintain structural value of joined pieces.
- D. Form changes in direction of railing members as follows:
  - 1. By bending.
  - 2. By radius bends of radius indicated on approved shop drawings.
- E. Form simple and compound curves by bending members in jigs to produce uniform curvature for each repetitive configuration required; maintain cylindrical cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of handrail and railing components.
- F. Welded Connections: Fabricate metal handrails and railings for connecting members by welding. Cope components at perpendicular and skew connections to provide close fit, or use fittings designed for this purpose. Weld connections continuously to comply with the following:
  - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
  - 2. Obtain fusion without undercut or overlap.
  - 3. Remove flux immediately.
  - 4. At exposed connections, finish exposed surfaces smooth and blended so no roughness shows after finishing and welded surface matches contours of adjoining surfaces.
- G. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, flanges, miscellaneous fittings, and anchors to interconnect handrail and railing members to other work, unless otherwise indicated.
- H. Provide inserts and other anchorage devices for connecting handrails and railings to concrete or masonry work. Fabricate anchorage devices capable of withstanding loads imposed by handrails and railings. Coordinate anchorage devices with supporting structure.

- I. For railing posts set in concrete, provide preset sleeves of steel not less than 6 inches long with inside dimensions not less than  $\frac{1}{2}$  inch greater than outside dimensions of post, and steel plate forming bottom closure, unless indicated otherwise on approved shop drawings.
- J. For removable railing posts, fabricate slip-fit sockets from steel tube whose ID is sized for a close fit with posts; limit movement of post without lateral load, measured at top, to not more than one-fortieth of post height. Provide socket covers designed and fabricated to resist being dislodged.
  - 1. Provide chain with eye, snap hook, and staple across gaps formed by removable railing sections at locations indicated. Fabricate from same metal as railings.
- K. Shear and punch metals cleanly and accurately. Remove burrs from exposed cut edges.
- L. Ease exposed edges to a radius of approximately 1/32 inch, unless otherwise indicated. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing the Work.
- M. Cut, reinforce, drill, and tap components, as indicated, to receive finish hardware, screws, and similar items.
- N. Provide weep holes or another means to drain entrapped water in hollow sections of handrail and railing members that are exposed to exterior or to moisture from condensation or other sources.
- O. Fabricate joints that will be exposed to weather in a watertight manner.
- P. Close exposed ends of handrail and railing members with prefabricated end fittings.
- Q. Provide wall returns at ends of wall-mounted handrails, unless otherwise indicated. Close ends of returns, unless clearance between end of railing and wall is 1/4 inch or less.
- R. Toe Boards: Where indicated, provide toe boards at railings around openings and at edge of open-sided floors and platforms. Fabricate to dimensions and details indicated on approved shop drawings.

## **2.08 FABRICATION, PIPE RAILINGS AND RAILING GATES:**

- A. Pipe: Black steel, ASTM A53, Type E, Grade A, standard weight (Schedule 40) for rails and extra heavy weight (Schedule 80) for posts, unless another grade and weight are required by structural loads, 1 inch nominal ID unless otherwise shown on approved shop drawings. Fabricated in accordance with NAAMM, "Pipe Railing Manual" and as shown on approved shop drawings.
- B. Plates, shapes and bars: Structural Steel.
- C. Intersections neatly coped, fully welded and ground smooth.
- D. Heated and bent smoothly, without distortion.
- E. Galvanized after fabrication.
- F. Hardware:
  - 1. Hinges: FS FF-H-116, Type 2127H, US2H finish.

2. Cane bolt: FS A-A-462.
3. Double-acting latch:
  - a. Shop fabricated.
  - b. Housing and strike: Steel, ASTM A36.
  - c. Turn piece and bolt: Bronze, US10B
  - d. Spring: Phosphor bronze.

#### **2.09 FABRICATION, HANDRAILS:**

- A. Pipe: Black steel, ASTM A53, Type E, Grade A, standard weight (Schedule 40), 1 inch nominal ID, unless otherwise indicated on approved shop drawings.
- B. Returned to walls at ends with quarter-round bends, with wall flanges welded to bends.
- C. Wall brackets included.
- D. Galvanized after fabrication.
- E. Bonderized and shop primed.

#### **2.10 FABRICATION, PVC NON-CONDUCTIVE RAILINGS:**

- A. Factory manufactured pipe railing assembly consisting of pigmented PVC pipe with prefabricated connections and bends, and with galvanized steel pipe reinforcing inside the posts. Size and arrangement as shown on approved shop drawings and as determined from field measurements.
- B. Deformation Requirement: Support loading required under "Performance Requirements" with a minimum recovery from deflection of 99 percent.
- C. Rails and Posts: Two laminated PVC pipes, one inside the other; inner pipe Schedule 80 and extended to receive tee, cross and end fittings; outer pipe Schedule 40.
- D. Post Reinforcing: Hot-dipped galvanized steel pipe, Schedule 80, of length to reinforce entire height of railing, sized to fit snugly inside inner PVC pipe and extended at floor to anchor into concrete.
- E. Rail Reinforcing: If required for design load, provide hot-dipped galvanized steel pipe, Schedule 40 or Schedule 80 as necessary, of length to reinforce entire length of rail, sized to fit snugly inside inner PVC pipe.
- F. Splice Tubes: Schedule 80 PVC pipe to ensure rigid splices in rails and at end fittings.
- G. Tee, Cross and End Fittings, and Spacers: Schedule 40 PVC pipe matching rail and post diameter and finish.
- H. End Plates: Solid PVC, four-inch diameter  $\hat{A}$ ½-inch thick plate with an integral two-inch long stub of same diameter as splice tube; four pre-drilled countersunk 3/8-inch holes.
- I. Welding Solvent: As recommended by manufacturer.
- J. Color: Metro Brown 20040. Color extending through thickness of PVC.
- K. Grout: Nonshrink as specified, except with 9,000 psi compressive strength.

- L. Source: Safron , Inc. (305)233-5511, or equal.

**2.11 FABRICATION, FRP NON-CONDUCTIVE RAILINGS:**

- A. Factory manufactured tube railing assembly consisting of pigmented FRP tube with prefabricated connections, bends and all fittings. Size and arrangement as shown on approved shop drawings and as determined from field measurements.
- B. Rails and Posts: 2-inch X 2-inch X 1/4-inch square tube manufactured by the pultrusion process. All posts and rails shall use the same tube size. All tubing for handrail to have a minimum 1/4" wall thickness.
- C. Kickplate: Unless indicated otherwise, provide 4-inch pultruded fiberglass shape.
- D. Anchoring devices: Stainless steel anchor bolts or studs, minimum 1/2-inch diameter, extending no less than 2 -1/4 inches into the concrete, or as recommended by railing manufacturer.
- E. Epoxy: As recommended by railing manufacturer.
- F. Color: Manufacturer's standard color unless otherwise indicated.

**2.12 FINISHES, GENERAL:**

- A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- C. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

**2.13 STEEL FINISHES:**

- A. Galvanized Handrails and Railings: Hot-dip galvanize exterior steel and iron handrails and railings to comply with ASTM A123. Hot-dip galvanize hardware for exterior steel and iron handrails and railings to comply with ASTM A153/A153M.
- B. Galvanizing: Hot-dip galvanize items as indicated to comply with applicable standard listed below:
  - 1. ASTM A123, for galvanizing steel and iron products.
  - 2. ASTM A153/A153M, for galvanizing steel and iron hardware.
- C. Fill vent and drain holes that will be exposed in finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.
- D. For galvanized handrails and railings, provide galvanized fittings, brackets, fasteners, sleeves, and other ferrous components.

- E. Preparation for Shop Priming: After galvanizing, thoroughly clean handrails and railings of grease, dirt, oil, flux, and other foreign matter, and treat with metallic-phosphate process.
- F. Preparation for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with minimum requirements indicated below for SSPC surface-preparation specifications and environmental exposure conditions of installed handrails and railings:
  - 1. Exteriors (SSPC Zone 1B): SSPC-SP 6, "Commercial Blast Cleaning."
  - 2. Interiors (SSPC Zone 1A): SSPC-SP 7, "Brush-off Blast Cleaning." Apply shop primer to prepared surfaces of handrail and railing components, unless otherwise indicated. Comply with requirements in SSPC-PA 1, "Paint Application Specification No. 1," for shop painting. Primer need not be applied to surfaces to be embedded in concrete or masonry.
  - 3. Do not apply primer to galvanized surfaces.
  - 4. Stripe paint edges, corners, crevices, bolts, and welds.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION, GENERAL:**

- A. Fit exposed connections together to form tight, hairline joints.
- B. Perform cutting, drilling, and fitting required to install handrails and railings. Set handrails and railings accurately in location, alignment, and elevation; measured from established lines and levels and free from rack.
  - 1. Do not weld, cut, or abrade surfaces of handrail and railing components that have been coated or finished after fabrication and that are intended for field connection by mechanical or other means without further cutting or fitting.
  - 2. Set posts plumb within a tolerance of 1/16 inch in 3 feet.
  - 3. Align rails so variations from level for horizontal members and from parallel with rake of steps and ramps for sloping members do not exceed 1/4 inch in 12 feet.
- C. Adjust handrails and railings before anchoring to ensure matching alignment at abutting joints. Space posts at interval indicated, but not less than that required by structural loads.
- D. Where pipe railing is mounted on concrete, attach by means of bolts and expansion shields. If concrete surface upon which posts are to be set is low, use full-size steel shims to bring railing to correct elevation.
- E. Fastening to In-Place Construction: Use anchorage devices and fasteners where necessary for securing handrails and railings and for properly transferring loads to in-place construction.

#### **3.02 RAILING CONNECTIONS:**

- A. Welded Connections: Use fully welded joints for permanently connecting railing components. Comply with requirements for welded connections in "Fabrication" Article whether welding is performed in the shop or in the field.
- B. Expansion Joints: Install expansion joints at locations indicated but not farther apart than required to accommodate thermal movement. Provide slip-joint internal sleeve extending 2 inches beyond joint on either side, fasten internal sleeve securely to one side, and locate joint within 6 inches of post.

#### **3.03 ANCHORING POSTS:**

- A. Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with the following anchoring material, mixed and placed to comply with anchoring material manufacturer's written instructions:
- B. Form or core-drill holes not less than 5 inches deep and 3/4 inch larger than OD of post for installing posts in concrete. Clean holes of loose material, insert posts, and fill annular space between post and concrete with the following anchoring material, mixed and placed to comply with anchoring material manufacturer's written instructions:
  - 1. Nonshrink, nonmetallic grout.
- C. Cover anchorage joint with flange of same metal as post, attached to post as follows:
  - 1. Welded to post after placing anchoring material.
- D. Leave anchorage joint exposed; wipe off surplus anchoring material; and leave 1/8-inch build-up, sloped away from post.
- E. Anchor posts to metal surfaces with oval flanges, angle type, or floor type as required by conditions, connected to posts and to metal supporting members as follows:
  - 1. For steel pipe railings, weld flanges to post and bolt to metal supporting surfaces.
  - 2. Install removable railing sections, where indicated, in slip-fit metal sockets cast in concrete.

#### **3.04 ANCHORING RAILING ENDS:**

- A. Anchor railing ends into concrete and masonry with round flanges connected to railing ends and anchored into wall construction with postinstalled anchors and bolts.
- B. Anchor railing ends to metal surfaces with flanges bolted to metal surfaces.
  - 1. Weld flanges to railing ends.

#### **3.05 ATTACHING HANDRAILS TO WALLS:**

- A. Attach handrails to wall with wall brackets. Provide bracket with 1-1/2-inch clearance from inside face of handrail and finished wall surface.
- B. Locate brackets not more than four feet on centers, or less if required to support structural loads.
- C. Secure wall brackets to building construction with 3/8-inch bolts and expansion shields, powder actuated fasteners or toggle bolts, as applicable.

#### **3.06 PVC AND FRP NON-CONDUCTIVE RAILINGS:**

- A. Install in accordance with approved shop drawings and manufacturer's printed instructions.

#### **3.07 PAINTING AND REPAIRING COATED SURFACES:**

- A. Before erection or enclosing construction, paint items that support masonry or will be concealed in finish work, except items encased in concrete.
- B. Where shop coat is abraded or burned by welding, clean and touch-up.
- C. Touch-up primed surfaces with same material as coating.

- D. Where aluminum parts come in contact with concrete or steel, coat contact surfaces of aluminum with bituminous coating.
- E. Coat field welds and repair damage to zinc-coated surfaces in accordance with ASTM A780 and as follows:
  - 1. Wire brush areas to be coated to bright metal.
  - 2. Apply galvanizing repair compound at rate of two ounces per-square-foot.

**3.08 PROTECTION:**

- A. Protect finishes of handrails and railings from damage during construction period with temporary protective coverings approved by railing manufacturer. Remove protective coverings at the time of Substantial Completion.
- B. Restore finishes damaged during installation and construction period so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop; make required alterations and refinish entire unit, or provide new units.

**END OF SECTION**

## SECTION 05531

### GRATINGS AND FLOOR PLATES

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section includes providing Adjust list below to suit Project.steel gratings, corrosion-resistant gratings, and underground safety walk gratings and floor plates.
  - 1. Related Work Specified Elsewhere:
    - a. Structural Steel: Section 05120.
    - b. Miscellaneous Metal: Section 05500.
    - c. Metal Stairs: Section 05511.
    - d. Handrails and Railings: Section 05521.

##### 1.02 PERFORMANCE REQUIREMENTS:

- A. Structural Performance: Provide gratings capable of withstanding the following structural loads without exceeding the allowable design working stress of the materials involved, including anchors and connections:
  - 1. Steel gratings: For walkways, ventilation shafts, light wells and other locations subject to possible vehicular traffic: Capable of withstanding AASHTO HS-20-44 load or higher load if required by the jurisdictional authority where the grating is installed.
  - 2. Steel gratings: For track drainage pumping stations and other locations subject to foot traffic only: Capable of withstanding a uniform load of 250 lbf/sq. Ft. Limit deflection to 1/200 of span.
  - 3. Corrosion-resistant gratings: Capable of withstanding a uniform live load as shown or specified.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Product Data: For the following:
    - a. Gratings.
    - b. Clips and anchorage devices for gratings.
    - c. Paint products (if applicable).
  - 2. Shop Drawings: Show fabrication and installation details for gratings. Include plans, elevations, sections, and details of connections. Show anchorage and accessory items. Provide templates for anchors and bolts specified for installation under other Sections.
    - a. For installed products indicated to comply with design loads, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
  - 3. Mill Certificates: Signed by manufacturers of stainless-steel sheet certifying that products furnished comply with requirements.
  - 4. Welding Certificates: Copies of certificates for welding procedures and personnel.
  - 5. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

##### 1.04 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  1. Comply with codes and regulations of the jurisdictional authorities.
  2. ADA: Americans with Disabilities Act.
  3. ASME: B18.21.1, B18.22.1.
  4. ASTM: A36, A90, A123, A143, A153, A242, A307, A384, A510, A570, A536, A563, C633, A653, A780, B633, C1028, D1187, E140, E384, F594.
  5. AASHTO HS-20-44.
  6. AWS: D1.1, D1.3.
  7. FS: RR-G-661.
  8. MS: MIL-P-21305.
  9. NAAMM: MBG 531, MBG 532.
  10. SSPC: PA 1, SP 3, SP 6/NACE No. 3, Paint 12
  
- B. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of gratings that are similar to those indicated for this Project in material, design, and extent.
  
- C. Fabricator Qualifications: A firm experienced in producing gratings similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.
  
- D. Metal Bar Grating Standards: Comply with applicable requirements of the following:
  1. Non-Heavy-Duty Metal Bar Gratings: Comply with NAAMM MBG 531, "Metal Bar Grating Manual for Steel, Stainless Steel, and Aluminum Gratings and Stair Treads."
  2. Heavy-Duty Metal Bar Gratings: Comply with NAAMM MBG 532, "Heavy-Duty Metal Bar Grating Manual."
  
- E. Welding: Qualify procedures and personnel according to the following:
  1. AWS D1.1, "Structural Welding Code--Steel."
  2. AWS D1.3, "Structural Welding Code--Sheet Steel."
  3. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.

**1.05 PROJECT CONDITIONS:**

- A. Field Measurements: Where gratings are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.
  1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating gratings without field measurements. Coordinate construction to ensure that actual dimensions correspond to established dimensions. Allow for trimming and fitting.

**1.06 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Deliver products undamaged.
- B. Store products so as to prevent rust.
- C. Handle products so as to prevent damage.

**1.07 COORDINATION:**

- A. Coordinate installation of anchorages for gratings, grating frames, and supports. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS:**

- A. General Requirements:
  - 1. Insofar as practicable, furnish similar products of a single manufacturer.
  - 2. Metal Surfaces, General: For metal fabrications exposed to view in the completed Work, provide materials with smooth, flat surfaces without blemishes. Do not use materials with exposed pitting, seam marks, roller marks, rolled trade names, or roughness.

### **2.02 FERROUS METALS:**

- A. Steel Plates, Shapes, and Bars: ASTM A36.
- B. High-Strength Low Alloy Structural Steel:
  - 1. ASTM A242.
  - 2. Resistance to atmospheric corrosion: Four times that of carbon steel, minimum.
- C. Wire Rod for Grating Crossbars: ASTM A510.
- D. Uncoated Steel Sheet: ASTM A570, Grade 33.
- E. Galvanized Steel Sheet: ASTM A653, structural quality, Grade 33, with G90 coating.
- F. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy to be welded.
- G. Ductile Iron: ASTM A536.
- H. Grating: Steel, bar and crossbar type as shown, hot-dipped galvanized after fabrication and sizing, FS RR-G-661, Type , Class 1 or 2.

### **2.03 COATINGS:**

- A. Shop Primer for Ferrous Metals: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with performance requirements in FS TT-P-664; selected for good resistance to normal atmospheric corrosion, compatibility with finish paint systems indicated, and capability to provide a sound foundation for field-applied topcoats despite prolonged exposure.
- B. Zinc-rich paint: MS MIL-P-21305.
- C. Galvanizing (zinc-coating by hot-dipped process): ASTM A90, ASTM A123, or ASTM A143, ASTM A153 or ASTM A384, as applicable.
- D. Galvanizing Repair Compound: Stick form, melting point 600-degree F to 650-degree F, GALVABAR or equal.

- E. Bituminous Coating: Cold-applied asphalt mastic complying with SSPC Paint 12, except containing no asbestos fibers, or cold-applied asphalt emulsion complying with ASTM D1187.

#### **2.04 FASTENERS:**

- A. General: Provide Type 304 or 316 stainless-steel fasteners for exterior use and zinc-plated fasteners with coating complying with ASTM B 633, Class Fe/Zn 5, where built into exterior walls. Select fasteners for type, grade, and class required.
- B. Bolts and Nuts: Regular hexagon-head bolts, ASTM A307, Grade A; with hex nuts, ASTM A563; and, where indicated, flat washers.
- C. Plain Washers: Round, carbon steel, ASME B18.22.1.
- D. Lock Washers: Helical, spring type, carbon steel, ASME B18.21.1.
- E. Expansion Anchors: Anchor bolt and sleeve assembly of material indicated below with capability to sustain, without failure, a load equal to six times the load imposed when installed in unit masonry and equal to four times the load imposed when installed in concrete, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.
  - 1. Material: Carbon-steel components zinc-plated to comply with ASTM B 633, Class Fe/Zn 5.
  - 2. Material: Alloy Group 1 or 2 stainless-steel bolts complying with ASTM F593 and nuts complying with ASTM F594.

#### **2.05 FABRICATION:**

- A. Shop Assembly: Fabricate grating sections in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.
- B. Form from materials of size, thickness, and shapes indicated, but not less than that needed to support indicated loads.
- C. Shear and punch metals cleanly and accurately. Remove burrs.
- D. Ease exposed edges to a radius of approximately 1/32 inch, unless otherwise indicated.
- E. Fit exposed connections accurately together to form hairline joints.
- F. Welding: Comply with AWS recommendations and the following:
  - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
  - 2. Obtain fusion without undercut or overlap.
  - 3. Remove welding flux immediately. Provide for anchorage of type indicated; coordinate with supporting structure. Fabricate and space anchoring devices to secure gratings, frames, and supports rigidly in place and to support indicated loads.
  - 4. Fabricate toeplates at height indicated to fit grating units and weld to units in shop, unless otherwise indicated.

#### **2.06 STEEL GRATINGS:**

- A. Angles or other structural shapes as supports for grating: Structural steel.

- B. Grating manufactured by electro-pressure welding or pressure-locking process, forming sound welded or pressure-locked joints at intersection of bars and having bars in the same plane.
- C. For walkways, ventilation shafts, light wells and other locations subject to possible vehicular traffic:
  - 1. Traffic Surface: Plain.
  - 2. Gratings: Rectangular type subject to loadings identified under "Performance Requirements.
- D. For track bed drainage pumping stations and other locations subject to foot traffic only:
  - 1. Traffic Surface: Serrated.
  - 2. Gratings: Rectangular type, unless otherwise shown, subject to loadings identified under "Performance Requirements." Fabricated of 1-1/4-inch by 1/8-inch bearing bars at 1-3/16-inch o.c. and crossbars at 4 inches o.c.
- E. Steel Finish: As follows:
  - 1. Shop primer applied according to manufacturer's standard practice.
  - 2. Hot-dip galvanized with a coating weight of not less than two ounces per-square foot of coated surface.
- F. Fabricate removable grating sections with banding bars attached by welding to entire perimeter of each section. Include anchors and fasteners of type indicated or, if not indicated, as recommended by manufacturer for attaching to supports.
  - 1. Provide not less than four weld lugs for each heavy-duty grating section, with each lug shop welded to two bearing bars.
  - 2. Provide not less than four saddle clips for each grating section composed of rectangular bearing bars 3/16 inch or less in thickness and spaced 15/16 inch or more o.c., with each clip designed and fabricated to fit over two bearing bars.
  - 3. Furnish removable steel gratings equipped with locking lugs and provision for bolting to supporting members with stainless steel bolts.
- G. Fabricate cutouts in grating sections for penetrations indicated. Arrange cutouts to permit grating removal without disturbing items penetrating gratings.
  - 1. Edge-band openings in grating that interrupt four or more bearing bars with bars of the same size and material as bearing bars.
- H. Do not notch bearing bars at supports to maintain elevation.

**2.07 CORROSION-RESISTANT GRATINGS:**

- A. Fabricate from high-strength low alloy structural steel.
- B. Grating manufactured by electro-pressure welding or pressure-locking process, forming sound welded or pressure-locked joints at intersection of bars and having bars in the same plane.
- C. Grating system shall be fabricated to mechanically secure units in place and of such size to permit one-man operation.
- D. Traffic Surface: As shown.
- E. Gratings: Rectangular type, unless otherwise shown, subject to loadings identified under "Performance Requirements." Fabricated of 2-inch by 3/16-inch bearing bars at 5-inch o.c. and with crossbars at end of six-foot long units.

- F. Subject to compliance with requirements, products are manufactured by Blaw-Knox Company, Irving Grating Company, Reliance Steel Products Company or equal.

## **2.08 UNDERGROUND SAFETY WALK GRATINGS:**

- A. Angles or other structural shapes as supports for grating: As shown.
- B. Grating bearing bars and end-bearing bar of material shown manufactured by electro-pressure welding or pressure-locking process, forming sound welded or pressure-locked joints at intersection of bars and having bars in the same plane, size and design as shown.
  - 1. Designed to provide for hinged section of grating bolted to walls. Grating of such size to permit one-man operation and manual position vertically or horizontally.
  - 2. Structural steel plate hinges bolted to supporting construction with holes and slots as shown.

## **2.09 FLOOR PLATES:**

- A. Steel Floor Plates: Form to configurations shown from abrasive-surface floor plate of thickness necessary to support indicated loads, but not less than 1/4 inch.
  - 1. Abrasive-Surface Floor Plate: SLIP-NOT as manufactured by the W. S. Molnar Company or approved equal:
    - a. Surface Texture: Grade 1, fine.
    - b. Surface: All metal plasma stream deposition process bonds surface to substrate. Anti-slip primarily martensitic steel surface consisting of a random hatch matrix.
    - c. Surface Hardness, Rockwell C Scale, ASTM E 140 and E 384: Minimum of 55.
    - d. Bond Strength, Surface to Substrate, ASTM C 633: Minimum of 4,000 psi.
    - e. Coefficient of Friction, Anti-Slip Surface: Minimum of 0.6.
    - f. UL Listed: Slip-resistant.

## **2.10 GRATING FRAMES AND SUPPORTS:**

- A. Steel Frames and Supports: Fabricate from structural-steel shapes, plates, and bars of welded construction to sizes, shapes, and profiles indicated and as necessary to receive gratings. Miter and weld connections for perimeter angle frames. Cut, drill, and tap units to receive hardware and similar items.
- B. Equip units with integrally welded anchors for casting into concrete or building into masonry.
  - 1. Unless otherwise indicated, space anchors 24 inches o.c. and provide minimum anchor units in the form of steel straps 1-1/4 inches wide by 1/4 inch thick by 8 inches long.
  - 2. Galvanize frames and supports unless otherwise indicated.

## **2.11 FINISHES:**

- A. General:
  - 1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
  - 2. Finish gratings, frames, and supports after assembly.
- B. Galvanizing:
  - 1. Clean ferrous metal thoroughly before applying zinc coating.

2. Apply zinc coating to products after fabrication, by the hot-dip method, using coating weighing not less than two ounces per-square-foot.
- C. Preparation for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with minimum requirements indicated below for SSPC surface-preparation specifications and environmental exposure conditions of installed items:
  1. Exteriors (SSPC Zone 1B): SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning".
  2. Interiors (SSPC Zone 1A): SSPC-SP 3, "Power Tool Cleaning."
- D. Apply shop primer to uncoated surfaces of gratings, frames, and supports, except those with galvanized finishes and those to be embedded in concrete or masonry, unless otherwise indicated. Comply with SSPC-PA 1, "Paint Application Specification No. 1," for shop painting.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION, GENERAL:**

- A. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing gratings to in-place construction. Include threaded fasteners for concrete and masonry inserts, through-bolts, lag bolts, and other connectors.
- B. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing gratings. Set units accurately in location, alignment, and elevation; measured from established lines and levels and free from rack.
- C. Provide temporary bracing or anchors in formwork for items that are to be built into concrete or masonry.
- D. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade the surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.
- E. Field Welding: Comply with the following requirements:
  1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
  2. Obtain fusion without undercut or overlap.
  3. Remove welding flux immediately.
- F. Corrosion Protection: Coat concealed surfaces of aluminum that will come into contact with grout, concrete, masonry, wood, or dissimilar metals with a heavy coat of bituminous paint.

### **3.02 INSTALLING GRATINGS:**

- A. General: Install gratings to comply with recommendations of referenced metal bar grating standards that apply to grating types and bar sizes indicated, including installation clearances and standard anchoring details.
- B. Attach removable units to supporting members with type and size of clips and fasteners indicated or, if not indicated, as recommended by grating manufacturer for type of installation conditions shown.
- C. Use bolts, screws or locking lugs to secure safety walk gratings; do not weld.
- D. Consecutively number walkway plate covers with steel stamp after screwed to support channels.

**3.03 PAINTING AND REPAIRING COATED SURFACES:**

- A. Before erection or enclosing construction, paint items that support masonry or will be concealed in finish work, except items encased in concrete.
- B. Where shop coat is abraded or burned by welding, clean and touch-up.
- C. Touch-up primed surfaces with same material as coating.
- D. Where aluminum parts come in contact with concrete or steel, coat contact surfaces of aluminum with bituminous coating.
- E. Coat field welds and repair damage to zinc-coated surfaces in accordance with ASTM A780 and as follows:
  - 1. Wire brush areas to be coated to bright metal.
  - 2. Apply galvanizing repair compound at rate of two ounces per-square-foot.

**END OF SECTION**

## SECTION 05581

### FORMED METAL FABRICATIONS - STATION KIOSKS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies the fabrication and installation of steel cladding and insulated panels for station kiosks.
- B. Related Work Specified Elsewhere:
- C. Cast-in-Place Structural Concrete: Section 03300.
- D. Structural Steel: Section 05120.
- E. Structural Steel Metal Decking: Section 05310.
- F. Seals and Sealants: Section 07900.
- G. Finish Hardware: Section 08710.
- H. Glass and Glazing: Section 08800.
- I. Metal Doors and Frames: Section 08810.
- J. Acoustical Snap-In Metal Pan Ceilings: Section 09520.
- K. Field Painting: Section 09920.
- L. Kiosk Mechanical Work: Section 15736.
- M. Grounding and Bonding: Section 16060.
- N. Wire and Cable: Section 16120.
- O. Wire Connection Accessories: Section 16125
- P. Raceways, Boxes and Cabinets: Section 16130.
- Q. Wiring and Control Devices: Section 16145.
- R. Circuit Breakers, Panelboards and Load Centers: Section 16440.
- S. Lighting Fixtures: Section 16525
- T. Kiosks Systems: Section 16733.

##### 1.02 SUBMITTALS:

Submit the following samples for approval in accordance with the Special Conditions and with the additional requirements as specified for each:

- A. Shop Drawings:
  - 1. Details of construction and installation of fabricated items including materials, dimensions, methods of joining, welding, fastening and anchoring.
  - 2. Obtain approval for minor variations in detail for the purpose of improving fabrication and installation procedures, but not affecting general design for structural stability.
- B. Samples: Three of each of the following in each finish to be used in the work:
  - 1. Sheet metal: Four inches square.
  - 2. Tubing and extension: Six inch lengths.
  - 3. Insulated panels: Six inches square. Fabricate to show typical metal panel with fasteners on two edges, opened to expose core material on two edges. Furnish with required finish material on one face and unfinished on other face.

### **1.03 QUALITY ASSURANCE:**

- A. Reference Codes and Specifications:
  - 1. Codes and regulations of the jurisdictional authorities.
  - 2. ASTM: A36, A501, A526, B221, C272, C518, D696, D1621, E84, E96.
  - 3. FED STD: 595A.
  - 4. AWS: D1.1.
  - 5. MS: MIL-P-21035
  - 6. SSPC: SP-2, SP-3, SP-10
- B. Qualification of Welders:
  - 1. Employ operators, who have been qualified previously by the test as described by the American Welding Society's Standard D1.1, to perform welding.
  - 2. Furnish certificates that each operator has passed the tests.

### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Deliver products in good conditions
- B. Store products so as to prevent corrosion, deterioration, and damage.
- C. Handle products so as to prevent damage.
- D. Deliver fabricated insulated panels to the site individually wrapped and packed to avoid damage. Protect from water, dirt, and other potentially harmful substances.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS:**

- A. General: Insofar as practicable, furnish products of a single manufacturer.
- B. Steel Sheet (Steel Cladding): ASTM A526, coating G235, thickness of sheet as shown.
- C. Steel Rods, Bars, and Shapes: ASTM A36.
- D. Aluminum Bars: ASTM B221, alloy 6063-T52.
- E. Screws: Corrosion resistant, finished to match adjacent material.
- F. Pop Rivets: Stainless steel with mandrel head, series 4.
- G. Rigid Insulation: Extruded polystyrene rigid foam, Styrofoam HI-115 by DOW Chemical Company, or approved equal, with the following additional requirements:

Flame Spread	ASTM E84	Less than 25.
Compressive strength	ASTM D1621	115-psi minimum at five percent deflection.
Water absorption	ASTM C272	1.0 percent maximum.
Water vapor transmission	ASTM E96	1.0 perm maximum for one-inch thickness
Linear coefficient of thermal expansion	ASTM D696	3.5 times 10 <sup>-5</sup> inches per degree Fahrenheit in a range of minus 260°F to plus 70°F.
Thermal conductivity at 40°F mean	ASTM C518	0.185 BTU/hr/ft <sup>2</sup> /degree F/inch, maximum.

- H. Adhesive: Rubber-based, solvent-dispersed type, compatible with the insulation and meeting AFG-01 and HUDFHA UM60 Standards.
- I. Polyurethane Finish: Polane System by Sherwin-Williams, or approved equal.
  - 1. Shop primer: Rust-inhibitive vinyl epoxy, Wash Primer Green, P60.
  - 2. Intermediate high-build coat: Title Clad II Primer, B62.
  - 3. Finish color coat: Polane, semi-gloss sheen, FED STD 595A Color No. 20040.
  - 4. Spatter surface texture: Polane T, semi-gloss sheen, Spatter Surface Texture, FED STD 595A, Color No. 20040.
- J. Lifting Hardware: Stanley No. 1215, No. 2, or approved equal, minimum 3-1/2 inches by 3-3/4 inches with 2-1/4 inch outside diameter of lifting ring, 19/32-inch overall depth. Thickness of steel minimum 0.083 inches, zinc-plated finish.
- K. Miscellaneous fasteners, clips, and angles: Type and size as shown, galvanized and finished to match adjacent material.
- L. Galvanizing Repair Compound: Zinc-dust zinc-oxide primer conforming to MS MIL-P-21035.
- M. Bituminous Paint, Preformed Tape: Material as approved.

**2.02 FABRICATION, GENERAL:**

- A. Do not start work prior to approval of shop drawings.
- B. Verify dimensions before proceeding with work. Obtain measurements at structure.
- C. Match mark shop-prepared work to ensure proper assembly and fit in the field.
- D. Match exposed work to produce continuity of line and design. Accurately fit and rigidly secure joints in exposed work with hairline contacts. Wherever possible, position holes for fasteners in concealed areas.

- E. Coat welds and repair damage to zinc-coated surfaces as follows:
- F. Wire brush areas to be coated to bright metal.
- G. Apply galvanizing repair compound at a rate equal to two ounces of zinc per square foot. Feather edges of the application.
- H. Use only material free from mill scale, flake rust and mill pitting.
- I. form and finish items to shape and size with sharp angles and lines. Provide cut-outs to sizes and in locations required.
- J. Countersink metalwork to receive the required hardware, and provide proper bevels and clearances.
- K. Weld plates on for mounting hardware. Drill or punch holes for bolts and screws. Conceal fastenings wherever practicable.
- L. Grind exposed edges of work smooth. Construct joints exposed to weather to exclude water.
- M. Provide brackets, lugs, and similar accessories, required for installation, as part of the metal item.
- N. Fasteners, Anchors, and Inserts: Use sizes and types shown on approved shop drawings.
- O. Bituminous Paint, Preformed Tape: Material as approved.

**2.03 FABRICATION, INSULATED PANELS:**

- A. Steel sheet: Brake-form or die-form as required, free from oil-canning, bends, warps, and other defects. Drill or punch as required for assembly and installation. Continuously weld corners and connections, and grind smooth and flush.
- B. Rigid insulation core: One layer for total thickness required. Cut to size and shape to fit over core of panels to thickness shown, tight around perimeter.
- C. Assembly: Apply adhesive to steel sheet faces according to manufacturer's recommendation. Provide full adhesive contact between core and face sheets for wall and roof panels. Provide full adhesive contact between core and lower face sheet at floor panels.
- D. Glazing members: Screw aluminum bar sections to insulated panels as shown.
- E. Install pass-through with door or inside and trim secured on exterior as shown.
- F. Install lifting hardware with sheet metal screws, one at each corner of hardware plate.

**2.03 FABRICATION, STEEL CLADDING:**

- A. Form as shown, free from oil-canning, bends, warps and other defects.
- B. Drill or punch for attachment to structural members so that fasteners will not be visible after installation of monitoring cabinets.

**2.04 FINISH, GENERAL:**

- A. Prepare surface for priming as follows:

- B. Clean bare steel surfaces according to SSPC SP-10 (Near-White Metal Blast Cleaning).
- C. Clean galvanized steel surfaces according to SSPC SP-2 (Hand Tool Cleaning) or SP-3 (Power Tool Cleaning) and the recommendation of the paint manufacturer, so as to remove white rust (zinc oxide) but not to remove the galvanizing.
- D. Coat welds and repair damage to zinc-coated surfaces as follows:
  - 1. Wire brush areas to be coated to bright metal.
  - 2. Apply galvanizing repair compound at a rate equal to two ounces of zinc per square foot. Feather edges of the application.
- E. Apply minimum coating as follows to all metals:
  - 1. First coat, primer: 0.3 mils DFT.
  - 2. Second coat, intermediate high-build coating: 4.0 mils DFT.
  - 3. Third coat, finish color coat: 2 mils DFT in brown color, FED STD 595A Color No. 20040. Omit on totally concealed surfaces only.
  - 4. Fourth coat, spatter surface texture: Texture matching approved sample, in brown color, FED STD 595A Color No. 20040. Omit on totally concealed surfaces only.
- F. Apply finish on exposed areas and edges of each insulated panel.
- G. Separate dissimilar metals at surfaces of contact with one coat of alkali-resistant bituminous paint or other protective coating to prevent galvanic action.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION, GENERAL:**

- A. Provide anchors and inserts in sufficient number for proper fastening of metal items.
- B. Set metalwork accurately, level, plumb, and in true alignment with adjoining work.
- C. Drill holes as required for bolts and screws in supports, steel cladding and in insulated panels when in different locations from hole prepared in shop fabrication. Conceal fasteners where possible. Where exposed fasteners are necessary, match fasteners to adjacent metals.
- D. Use fastenings and anchors of size and type as shown on approved shop drawings. Conceal fasteners wherever practicable.
- E. Provide sealant material as required to seal panels against moisture infiltration, in accordance with Section 07900.
- F. Coordinate installation of ornamental metal work with work of other trades.
- G. Provide protection against galvanic action between dissimilar metals by completely covering contact surfaces with heavy brush coat of bituminous paint or by separating contact surfaces with preformed tape.
- H. Protect exposed metal work throughout work to prevent scratches, stains, discoloration and other damage.
- I. Set metal items level, plumb, and in true alignment with adjoining work. Set built-up parts true to line and without sharp bends, twists or kinks.
- J. Fasten metal work in place so that items will not be distorted, finish will not be impaired, nor fasteners overstressed from expansion and contraction of metal.

**3.02 INSTALLATION, STEEL CLADDING:**

- A. Apply to structural members by securing in position with sheet metal screws or pop rivets, fastener selections as best suited for purpose intended to provide secure anchorage and stability of cladding material. Locate fasteners at points not visible from the interior or exterior of the kiosk after installation of cabinets.

**3.03 CLEAN-UP:**

- A. Upon completion of installation, clean surfaces of metalwork by procedures recommended by metalwork manufacturer.
- B. Clean-up rubbish and debris caused by this work and remove from the site
- C. Leave areas surrounding the work in broom-clean condition.

**3.04 PAINTING AND REPAIR OF SURFACES:**

- A. Where finish coat is damaged during shipment or installation, field touch-up damaged areas with air-dry paint of type to fuse with finish material as recommended by manufacturer of finish material/

**3.05 ACCEPTANCE TEST/INSPECTION:**

- A. The table below shall be utilize to preform the acceptance test/inspection for the kiosk construction.

ITEM	PASS	FAIL
Compliance with all requirements in Section 4 and Kiosk Enclosure Fabrication Contract drawings.		
Check for proper structural fit and finish (no sharp metal edges, proper fit at corners etc.)		
Check for proper operation of door and door lock		
Check for proper fit of glass		
Check paint for nicks, scratches and proper application.		
Test and measure to ensure proper voltages (AC) is $\pm$ 5% of specified voltage.		
Test AC circuit breakers proper operation.		
Test all lights.		
Test all air conditioning controls and calibrate temperature setting with a thermometer and provide calibration chart.		
Test all heater controls for proper operation.		

**END OF SECTION**

## SECTION 05651

### GENERAL TRACK CONSTRUCTION

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This section specifies general track construction procedures and requirements including laying continuous welded rail, joining CWR strings, final alignment and inspection. The Contractor shall comply with all **safety and health regulations** identified in **Section 01450**. Associated train control and traction power Sections are located elsewhere in this Specification.
- B. Track construction shall include main/primary track and storage track as indicated on the Drawings, and specified herein.

##### 1.02 RELATED SECTIONS

- A. Section 05091 - Rail Welding
- B. Section 05652 - Ballasted Track Construction
- C. Section 05653 - Direct Fixation Track Construction
- D. Section 05654 - Special Trackwork Construction - Ballasted
- E. Section 05655 - Special Trackwork Construction - Direct Fixation
- F. Section 05656 - Running Rail
- G. Section 05658 - Track Appurtenances and Other Track Material
- H. Section 05660 - Restraining Rail and Lubricators
- I. Section 06130 - Timber Ties
- J. Section 06131 - Composite (Plastic) Ties
- K. Section 06132 - Timber Grade Crossings

##### 1.03 REFERENCES

- A. Pertinent provisions of the following listed standards and publications shall apply to the Work, except as they may be modified herein, and are hereby made part of these Specifications to the extent required.
  - 1. American Railway Engineering and Maintenance-of-Way Association, Manual for Railway Engineering, herein referred to as the AREMA Manual, **latest edition**.
  - 2. American Railway Engineering and Maintenance-of-Way Association, Portfolio of Trackwork Plans, herein referred to as the AREMA Portfolio.
  - 3. American Society of Testing and Materials (ASTM).

##### 1.04 SUBMITTALS

- A. Submittals shall be in accordance with Section 01300, Submittals of these Specifications.

- B. Submittals shall include certificates of compliance, codes and regulations of the jurisdictional authorities as well as other submittals stipulated in these Specifications.
- C. Provide five each AREMA approved rail thermometers. Two of the five shall be a quick reading digital type. The thermometers shall become WMATA property.
- D. Provide four Geismar RCAT-A1 two-piece combination track levels and gauges, or approved equal, with current calibration. They shall become WMATA property.
- E. Provide three Aldon AL-102 combination rolling track gauge readers and digital track levels, equipped with distance counters and carrying cases, or approved equal, with current calibration. They shall become WMATA property.
- F. Submit method and equipment for transport of rail.
- G. Submit rail end-hardening procedure and the personnel who will perform the end-hardening of the rails in the field.
- H. Submit test reports on two samples of field end-hardened rail which shall be tested by an approved independent laboratory.
- I. Submit for approval detailed procedures of the following items required in connection with laying and joining CWR strings:
  - 1. String schedule showing length and location of strings.
  - 2. Equipment to be used.
  - 3. Procedure for positioning CWR strings in track, setting gaps between strings and initial fastening.
  - 4. Procedure for lining, gauging and profiling of rails, and tightening of anchor bolts.
  - 5. Procedure for joining CWR strings, including method of obtaining correct gap if joined at a different temperature than at which it was laid.
  - 6. Procedure for destressing/anchoring CWR strings to zero thermal stress temperature, including control of rail movement and installing rail clips for fastening of rail to plates or D.F. fasteners.
  - 7. Special procedure for closing last string with previously anchored rail or special trackwork.
- J. **Completed and signed Record of CWR Laying Form provided in Section 05651 (Exhibit 05651-C / Part 2 of 2).**

## **1.05 QUALITY ASSURANCE**

- A. Perform all measures necessary to assure quality of the Work. This shall include source quality control and field quality control requirements specified in these Specifications.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS**

- A. General: All trackwork materials required by the specifications for the track construction, except those furnished by the Authority, shall be furnished by the Contractor.

- B. Metal tags to mark the superelevation on curved track shall be made of a corrosive resistant metal such as anodized aluminum or brass. Tags shall be placed at start of superelevation and at every 1/8 inch change until full superelevation is reached.

### **PART 3 - EXECUTION**

#### **3.01 CONSTRUCTION EQUIPMENT**

- A. Track gauge, guardrail, flangeway width, curve radii, rail sections and special trackwork components are designed for WMATA Metro Rail Vehicle and Crane Car operation. Modify on-track equipment, as required, to operate over this track without causing damage to the track structure. Damages to the track structure shall be repaired by Contractor at his own expense.
- B. Clearance for the on-track equipment shall conform to the requirements for vehicle clearances.
- C. Contractor's equipment shall not exceed the design loads. Further information concerning vehicle characteristics will be provided by the Authority upon request by Contractor. Verify that proposed equipment meets these requirements.

#### **3.02 MONUMENTATION**

- A. Monuments will be furnished and installed by other trades to establish the centerline of both the outbound and inbound main track.
- B. Monuments will be set at all points of change in horizontal alignment including TS, SC, CS, ST, PC, PT, PCC and SS and on tangents and within curves as needed to provide monuments not more than 1,000 feet apart throughout the work. All adjacent monuments will be intervisible. The location of the monuments will be as stated below:
  - 1. Aerial Structure: On or near track centerline.
  - 2. Underground Sections: Offset outside the track invert section.
  - 3. At-grade Sections: Offset outside the track invert section.
- C. The **WMATA** Engineer will provide the Contractor with identifications and elevations to one thousandth of a foot for all monuments.
- D. The use of controls for survey other than the monumentation described above shall be at the Contractor's risk.

#### **3.03 ALIGNMENT AND PROFILE DATA**

- A. Track shall be constructed conforming to the alignment and profile data shown on the drawings as modified by the requirements in these specifications.
- B. Alignment information shown on the drawings refers to geometric control points for the track. Alignment is based on the centerline of track, equidistant between gauge sides of the running rails. Profile refers to top of the lower rail in final position.
- C. Construction of direct fixation track shall not begin until final alignment data is available.

#### **3.04 ENGINEERING STATIONING**

- A. Engineering stationing is not continuous and is subject to equations.

- B. Engineering stationing is used to reference all geometric control points.
- C. Mathematized alignment data for each track is included in drawings.

### **3.05 TRACK GAUGE**

- A. Track gauge will be measured between points 5/8 inch below top of rail on the inside faces of the running rails.
- B. Track gauge, except as shown in special trackwork, shall be as follows:
  - 1. Tangent and curves with radius greater than or equal to 1,425 feet:
    - a. Mainline Track: 4 feet, 8-1/4 inches.
    - b. Yard Tracks: 4 feet, 8-1/2 inches.
  - 2. Curve of radius greater than or equal to 755 feet and less than 1,425 feet:
    - a. Mainline Track: 4 feet, 8-1/4 inches.
    - b. Yard Tracks: 4 feet, 8-1/2 inches.
  - 3. Curve of radius greater than or equal to 350 feet and less than 755 feet:
    - a. Yard Track: 4 feet, 8-1/2 inches.
  - 4. Curve of radius less than 350 feet:
    - a. Yard Track: 4 feet, 9 inches
    - b. Yard Track with restraining rail: 4 feet, 9-1/4 inches.

### **3.06 TRACK GAUGE TRANSITIONS**

- A. Gauge widening at spiraled curves shall begin at the junction of the spiral curve and tangent, proceed toward the circular curve and be completed at the junction of the spiral curve and the circular curve or before. Gauge widening at unspiraled curves shall be done on the tangents and shall be completed at the junction of the tangent and the circular curve.
- B. Gauge transitions at special trackwork shall be accomplished by suitable adjustment of the rail on the diverging route side.

### **3.07 SUPERELEVATION**

- A. Track curves shall be superelevated as indicated on the drawings.
- B. The outer rail shall be elevated above the inner rail, which shall be at the required profile grade line as indicated on the drawings.
- C. The superelevation at the tangent-to-spiral point shall be zero and shall increase uniformly through the length of the spiral to full elevation of the outer rail at the spiral-to-curve point. Provide this spiral and superelevation at the ends of simple curves and segments of compound curves as indicated. Attain the superelevation on curves without spirals over equal lengths on the tangent and curve, and increase linearly throughout the rate of change length.
- D. Turnouts and crossovers shall not be superelevated, unless specifically noted on the drawings.
- E. Track curve information shall be as indicated on the drawings. Shop pre-curved rail shall be marked by the manufacturer for proper installation by the Contractor.

### 3.08 TRACK TOLERANCES

- A. The final gauge, cross level, superelevation, horizontal and vertical alignment of all tracks shall be as specified within the tolerances as shown in **Exhibit 05651-A** for each specific type and class of track.
- B. Variations of gauge, cross level and superelevation with respect to tolerances shall be at a rate of change not exceeding 1/8 inch per 31 feet of track.
- C. Strings of high strength rail shall be located within plus or minus 20 feet of the locations shown on the drawings.
- D. Prior to start of rail installation the Contractor shall furnish to the Engineer three Aldon AL - 102 Combination Rolling Track Level and Gauge Readers equipped with optional distance counters and carrying cases, or approved equal. Also furnish to the **WMATA** Engineer four Geismar RCAT-A1 two-piece combination track levels and gauges.

### 3.09 CLEARANCE ENVELOPE

- A. The transit car outline in the design of the Metro system is shown in **Exhibit 05651-C** for information.
- B. Equipment proposed for use by the Contractor for performance of work under this Contract shall be submitted for approval. The submittal shall include a drawing showing the outline of the proposed equipment superimposed on the transit car outline.

### 3.10 TYPES OF RAIL

- A. Rail for use as running rail shall be 115 RE tee rail in all main/primary tracks and yard/storage tracks.
- B. Running rail shall be either standard carbon, head hardened or premium/high strength rail as indicated on the Contract Drawings.
- C. Restraining rail shall be 132 RE head hardened or high strength rail in accordance with AREMA requirements. **Reference Section 05656 for specific WMATA requirements for running rail.**
- D. Emergency guard rail: Structural angle, cover plates and base plates shall be as indicated on the Contract Drawings and shall comply with ASTM A36.
- E. Special trackwork components, closure rails and ladder track rails shall have premium rails.
- F. 115 RE tee rail will be used in the following locations:
  - 1. Ballasted Main/Primary Track
  - 2. Ballasted Yard/Storage Track
  - 3. Direct Fixation Track

### 3.11 RUNNING RAIL REQUIREMENTS

- A. Running rail procurement is covered under Section 05656, Running Rail.
- B. Running rail for use in continuous welded rail (CWR) track shall be welded in accordance to Section 05091, Rail Welding.

- C. Transport and distribute rail:
1. Rail shall be transported and distributed in such a manner and by use of such equipment that bumping or striking of the rail will be avoided. The method and equipment used by the Contractor shall be subject to approval by the Engineer. Continuous welded rail (CWR) shall be transported and laid in place in an efficient, expeditious manner that will prevent damage to fasteners, rail and structures.
  2. Rail should not be dropped or dragged on the track bed. The use of rollers is required to facilitate transporting and reduce the risk of damage to rail, track fasteners, track appurtenances and facilities.
- D. Procedure of laying and joining CWR strings: Submit for Engineer's approval the detailed procedure of the following items of work required in connection with laying and joining CWR strings.
1. String schedule showing length and location of strings.
  2. Equipment to be used.
  3. Procedure for positioning CWR strings in track, setting of gaps between strings and initial fastening.
  4. Procedure for lining, gauging, profiling of rails and tightening of anchor bolts.
  5. Procedure for joining CWR strings including method of obtaining correct gap if joined at a different temperature than at which it was laid.
  6. Procedure for destressing/anchoring strings to zero thermal-stress temperature, including control of rail movement and installing rail clips for fastening of rail to D.F. Fasteners.
  7. Special procedure for closing last string with previously anchored rail/special trackwork units.
- E. Cutting and drilling of rails:
1. No holes or cuts in the CWR shall be permitted except as shown and specified. Rails shall be cut square and clean by means of rail saws or abrasive cutting disks. **No rail is to be cut for** the installation of a bonded joint within 5 feet of an electric weld.
  2. For joints, 500 KCMIL negative return cables and restraining rail separator blocks, holes shall be located as shown and as directed by the Engineer. Holes shall be cylindrical, of the proper diameter for the bolt required and drilled directly through the web of the rail with an approved rail drill. Holes associated with the restraining rail shall have the additional requirement of split sleeve - cold expansion as specified in Section 05660, Restraining Rail and Lubricators. An approved template shall be used as a guide for drilling holes. In no case shall a joint bar be used for this purpose. All rejected rail holes must be saw-cut from the rail. All holes shall be reamed smooth, ends beveled and burrs removed. Cutting rail or burning holes in rail by use of a torch is prohibited. Accurately space holes for bolting of rail and drill with a rail drill in accordance with the current requirements of AREMA Manual for Railway Engineering, Specifications for Rail Drilling, Bar Punchings and Track Bolts.
- F. Beveling of Rail Ends:
1. Bevel rail ends at non-bonded insulated joints in accordance with current AREMA Standard Plan No. 1005.
  2. Rail ends in bonded joints shall be beveled in accordance with the joint manufacturer's written specifications. Unless otherwise stated manufacturer's written specifications, rail ends shall be beveled in accordance with AREMA page 4-M-2 "Where rail is to be beveled, it is recommended that such beveling extend 1/16 inch back from the rail end and to a depth of 1/8 inch plus, from the surfaces."

G. End-Hardening

1. In bonded joints, rail ends that are not of head hardened or high strength rail shall be end-hardened in the field. Joints bars and their insulating material shall be removed from rail ends during the end-hardening process.
  - a. The end-hardening procedure and the personnel who perform the end-hardening of the rails in the field shall be subject to approval by the **WMATA** Engineer, which will depend upon the acceptance of two samples of field end-hardening performed according to the approved procedure and by the personnel who will perform the field end-hardening. The two samples of field end-hardened rail shall be tested by an approved independent laboratory. The Contractor shall notify the Engineer 48 hours prior to the performance of field end-hardening of rails.
2. End Hardening Tests:
  - a. The two samples shall be tested for Brinell hardness in accordance with ASTM E10, in a grid pattern on the rail head surface of 1/8 inch increments for a distance of six inches from the end of the rail.
  - b. The hardness number and location shall be recorded.
  - c. After the hardness test is performed, one sample shall be sectioned for one foot along the centerline of rail and the other sample shall be sectioned transversely 1/2 inch from the end of rail. These cross sections shall be etched to enable the observation of the hardness pattern.
3. Acceptance Criteria:
  - a. The hardness measured at a spot on the centerline of the head 1/4 inch to 1/2 inch from the end of the rail shall show a Brinell hardness number range of 341 to 401 when decarburized surface has been removed.
  - b. The heat-affected zone defined as the region in which the hardness is above that of the parent metal shall cover the full width of the rail head and extend longitudinally a minimum of 1-1/2 inch from the end of the rail. The effective hardness zone 1/2 inch from the end of the rail shall be at least 1/4 inch deep.
  - c. A report of hardness determination shall be given to the **WMATA** Engineer.
  - d. The hardness pattern shall be uniform across the top surface of the rail head.
  - e. The etched cross sections of the rail shall exhibit a uniformly distributed hardness pattern.

### 3.12 LAYING CONTINUOUS WELDED RAIL

A. CWR String:

1. At the time each string of CWR is laid on the installed tie plate or D.F. Fastener to its final line and profile in accordance with the approved working drawings submitted under Section 05091, Rail Welding. The temperature of the string and other data shall be measured and recorded. Information to be recorded shall be as shown on **Exhibit 05651-C (Part 1 of 2)**.
2. The strings shall be laid with a gap between them to permit joining and destressing without unnecessary cutting of rail. Each gap shall be based on the temperature of the rail, the length of the string and as specified below.
  - a. Only the gap required for the joint shall be provided between the end of the existing rail and the first adjacent CWR strings.
  - b. The destressing gap shall be located at the other end of the string, the free end.
  - c. Each succeeding string shall be laid with its beginning end even with the end of the gap computed for the previous string, and shall have its corresponding destressing gap located at its free end. See **Exhibit 05651-C (Part 2 of 2)** for record of CWR laying.

- B. Rail Temperature and Rail Thermometer:
1. Rail temperature shall be determined by means of reliable AREMA standard rail thermometers as specified in Chapter 5 of the AREMA Manual (**latest edition**).
    - a. Place two (2) rail thermometers on the shaded side of the rail base next to the web and leave in place until no change in the readings are detected, but not less than ten minutes.
    - b. Take the average of the two temperature readings at the time of adjusting the gap between rail ends.
  2. If the rail temperature deviates from the specified zero thermal stress range, fastening or anchoring of rail shall cease until the rail temperature returns to within the specified range and the rail has been vibrated to relax localized stress build-up.
  3. Deliver five (5) each AREMA approved rail thermometers to the Engineer within 30 days after NTP.
  4. Two of the five thermometers shall be a quick reading digital type. Thermometers shall become Authority Property.

- C. Determining Gap Between Rail Ends:
1. The gap between CWR strings or between CWR and bolted rail shall be determined by the equation:  $G=(t-T)(L)(K)+Q$

Where: G=rail gap in inches;  
t=zero thermal stress temperature for type of track construction (Sections 05652 and 05653);  
T=Average actual rail temperature at time of laying degrees F.;  
L=One-half the sum of the length of the rail being laid and the length of the preceding rail;  
K=Coefficient of thermal expansion for rail steel, (0.000078 inch per foot per degree F.); and  
Q=Rail gap as required by manufacturers of field weld kit in inches. For bonded standard joints, as recommended by the respective manufacturer. For bonded insulated joints, Q equals the end post thickness.

### 3.03 LINING, GAUGING, AND PROFILING CWR

- A. Each CWR string shall be brought to approximate final line, gauge and profile before joining, destressing and anchoring. The procedures specified for ballasted or direct fixation track construction, as appropriate, shall be used
- B. Use of Dutchman (Short Rails Between Rail Ends):
1. The Contractor shall insert a dutchman between the ends of all CWR strings, a short piece of rail equal in length to the rail gap (G) minus ½ inch where the rail gap (G) is determined by the formula above. This requirement does not apply if the calculated rail gap (G) is less than 1-1/2 inches. The dutchman shall be inserted at the time the rail is laid to prevent damage to the rail ends during rail laying or other operations requiring the passage of on-track equipment over the rail joints.
  2. The short rail shall be removed prior to anchoring, and when the rail temperature results in a calculated closure of the rail gap.
- C. Initial Fastening of Rail
1. Prior to use by on-track equipment, newly laid rail shall be fastened at proper gauge at not less than every fifth fastener on tangents and curves of radius greater than 1,900 feet and at every third fastener for curves of radius of 1,900 feet or less.

2. The method of preventing damage due to thermal expansion shall be submitted for approval.

### 3.14 JOINING CWR STRINGS

- A. Before destressing/anchoring each string of CWR, its beginning end shall be joined to the previously anchored string.
- B. Main/primary track CWR strings shall be joined in the field by ~~field welding bonded standard joints~~.
- C. Yard and secondary track CWR shall be joined by ~~field welding bolted standard joints~~.
- D. Joints shall not be placed in the following locations unless specifically shown or specified otherwise:
  1. Within 19 feet from the center of bonded or bolted joints in the same rail.
  2. Within eight feet of joints in the opposite rail.
  3. Within eight feet of shop welds in the same rail.
- E. Standard Joint Requirements: Standard joints shall be installed in accordance with Section 05658, Track Appurtenances and Other Track Material.

### 3.15 DESTRESSING/ANCHORING OF CWR

- A. After the beginning end of a string of CWR has been joined to the previously destressed/anchored string, it shall be destressed and immediately thereafter anchored. Installation of the Pandrol e2056 Spring Clips shall be considered as anchoring the rail.
- B. Each string shall have its length adjusted for the zero thermal stress temperature, vibrated to relieve internal stresses and be fully anchored.
- C. When a CWR string closes on a fully anchored string the fully anchored string shall have its anchors removed for 300 feet and shall be readjusted to zero thermal-stress temperature at the time it is joined.
- D. Adjusting Rail for Zero Thermal Stress:
  1. Rail shall be adjusted for zero thermal-stress by either heating, cooling or pulling the rail, the adjustment shall be monitored by observing the movement of the rail at its quarter points and free end. The required movement to achieve zero thermal stress shall be computed using the formula given in Article 3.12.C ~~of this specification section~~.
  2. The rail temperature shall be taken as close to the time of destressing as practicable and as specified in Article 3.12.B.
  3. The destressing and closing of the gaps shall be obtained by uniformly expanding or contracting the rail string throughout its entire length. The Contractor shall verify this by computing and measuring the required movement at the quarter points and free end of the string. The actual movement shall not differ from the computed required amount of movement equivalent to a temperature difference of 10 degrees F for the length of rail being monitored.
  4. At the time of destressing/anchoring the second rail in a track shall be within 5 degrees F (3 degrees C) of the temperature at which the first rail was destressed/anchored.

- E. Anchoring: Immediately following the destressing of the rail it shall be anchored by the installation of Pandrol Spring Clips. If the rail moves beyond the allowable range specified herein before it is anchored, the destressing operation shall be repeated and the rail reanchored.
- F. Record of Laying, Joining, Destressing/Anchoring: A record of rail laying, joining, and destressing/anchoring data shall be made by the Contractor and be witnessed and approved by the Authority Inspector, for each installed string of CWR. The record shall be made on and include the data shown on **Exhibit 05651-C (Part 1 of 2)**.

### **3.16 FINAL ALIGNMENT AND TRACK INSPECTION**

- A. The final horizontal and vertical alignment, gauge cross level and superelevation shall be within the specified tolerances.
- B. In order to determine the acceptability of finished track, the Authority will make an inspection of the track.
- C. Track deviations, as disclosed by the inspection, which exceed specified tolerances shall be corrected by the Contractor at no additional cost to the Authority.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.01 MEASUREMENT:**

- A. Measurement of work specified in this section will be made in the following manner:
  - 1. General Track Construction: No separate measurement.

### **4.02 PAYMENT:**

- A. Compensation for work specified in this section will be made in the following manner:
  - 1. General Track Construction: Included in the price of work of which it is a part.



TRACK CONSTRUCTION TOLERANCES

TYPE AND CLASS OF TRACK	GAUGE VARIATION	CROSS LEVEL AND SUPERELEVATION VARIATION	VERTICAL TRACK ALIGNMENT		HORIZONTAL TRACK ALIGNMENT	
			TOTAL DEVIATION	MIDDLE ORDINATE IN 62' CHORD	TOTAL DEVIATION	MIDDLE ORDINATE IN 62' CHORD
DIRECT FIXATION, MAIN	±1/8"	±1/8"	±1/4"	±1/8"	±1/4"*	±1/8"
BALLASTED, MAIN	±1/8"	±1/8"	±1/2"	±1/8"	±1/2"*	±1/8"
DIRECT FIXATION, YARD & SECONDARY	±1/8"	±1/8"	±1/2"	±1/8"	±1/4"	±1/8"
BALLASTED, YARD & SECONDARY	+1/4" -1/8"	±1/4"	±1/2"	±1/4"	±1/2"	±1/8"

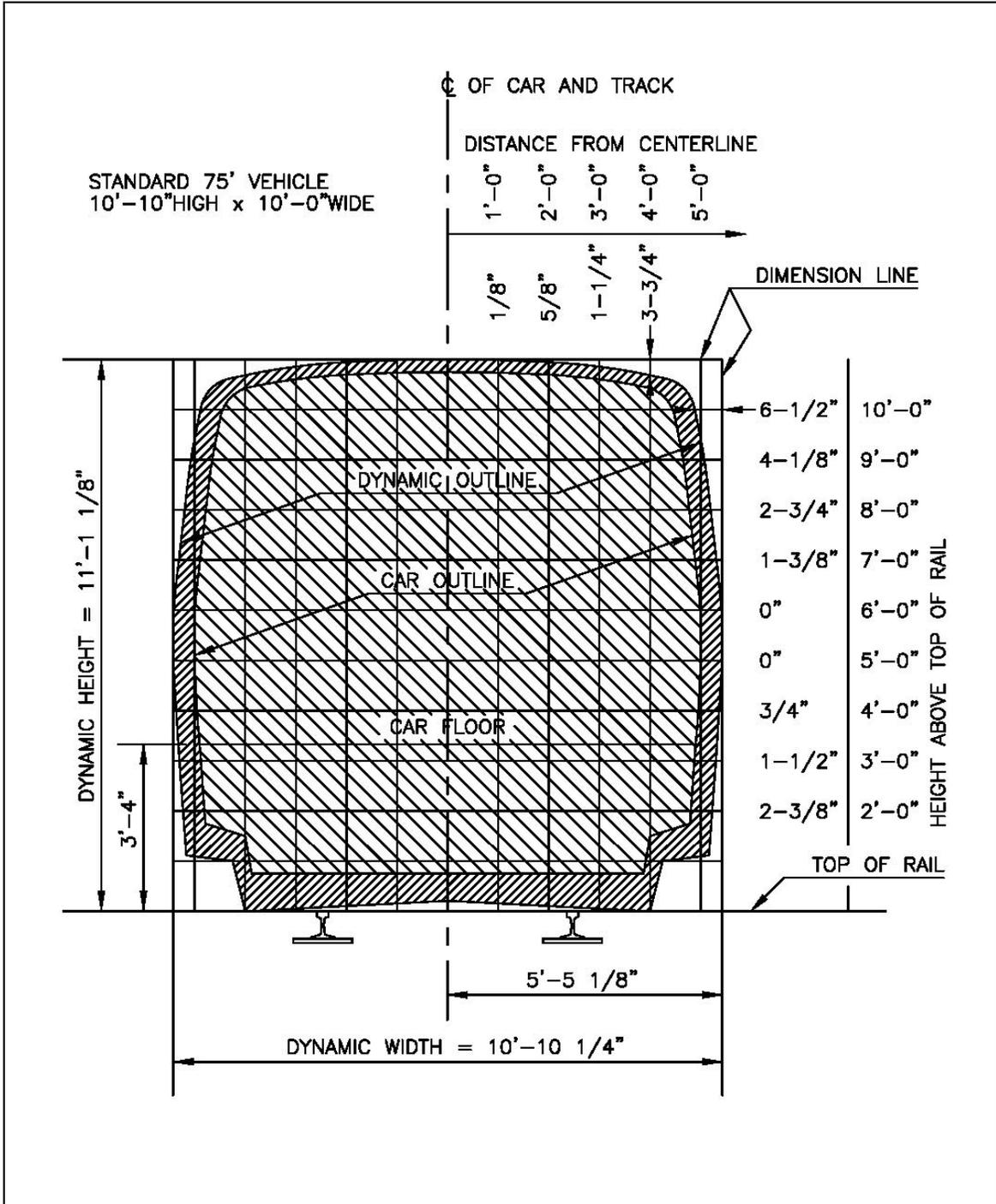
TOTAL DEVIATION IS MEASURED BETWEEN THE THEORETICAL AND ACTUAL ALIGNMENTS AT ANY POINT IN THE TRACK.

\* TOTAL DEVIATION IN STATION AREAS SHALL BE 0" TOWARD PLATFORM AND 1/4" AWAY FROM PLATFORM.

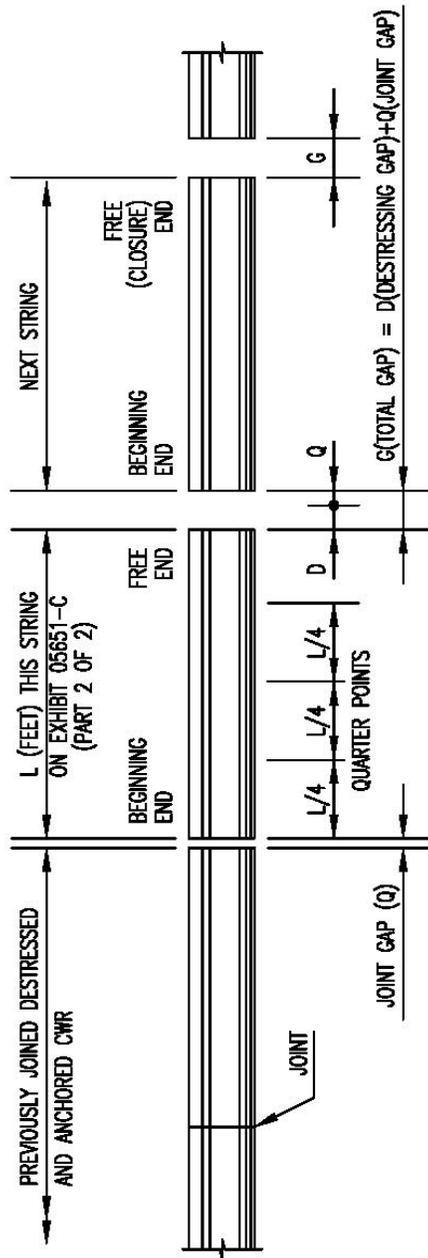
WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

DEPARTMENT OF  
TRANSIT SYSTEM DEVELOPMENT  
OFFICE OF  
ENGINEERING & ARCHITECTURE

TRACK CONSTRUCTION TOLERANCES  
EXHIBIT 05651-A



<b>WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY</b>	
<p>DEPARTMENT OF TRANSIT SYSTEM DEVELOPMENT OFFICE OF ENGINEERING &amp; ARCHITECTURE</p>	<p>DESIGN VEHICLE DYNAMIC OUTLINE DIAGRAM TANGENT TRACK EXHIBIT 05651 -B</p>



$$D = (60-T) (0.000078L)$$

- D = DESTRESSING GAP IN INCHES
- T = RAIL TEMP, DEGREES F
- L = STRING LENGTH IN FEET
- Q = JOINT GAP IN INCHES

ACCURACY

- L = NEAREST FOOT
- D,G,Q = NEAREST 1/16 INCH
- T = NEAREST DEGREE F

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

DEPARTMENT OF  
TRANSIT SYSTEM DEVELOPMENT  
OFFICE OF  
ENGINEERING & ARCHITECTURE

RECORD OF C.W.R. LAYING  
EXHIBIT 05651-C (PART 1 OF 2)

GENERAL INFORMATION

STRING: (String Number) \_\_\_\_\_  
TRACK: (Inbound or Outbound) \_\_\_\_\_  
RAIL: (Right or Left) \_\_\_\_\_  
BEGINNING STATIONING: \_\_\_\_\_  
ENDING STATION: \_\_\_\_\_  
STRING LENGTH (L): \_\_\_\_\_

LAYING DATA

DATE LAID: \_\_\_\_\_  
TIME LAID: \_\_\_\_\_  
AIR TEMP: \_\_\_\_\_  
CWR STRING TEMP (T): \_\_\_\_\_  
COMPUTED GAP REQUIRED AT FREE END (G): \_\_\_\_\_  
ACTUAL GAP LEFT AT BEGINNING END (G OR Q): \_\_\_\_\_  
JOINT TYPE TO BE INSTALLED AT BEGINNING END (Q): \_\_\_\_\_

JOINING DATA

	BEGINNING END	CLOSURE END (WHEN NEEDED)
DATE JOINED:	_____	_____
TIME JOINED:	_____	_____
AIR TEMP:	_____	_____
CWR TEMP:	_____	_____
GAP AT START:	_____	_____
METHOD OF ADJUSTING GAP FOR BEGINNING END JOINT: _____ (A = CUT IN/OUT PIECE; B = MOVE ENTIRE STRING)		

DESTRESSING/ANCHORING DATA

DATE DESTRESSED/ANCHORED: \_\_\_\_\_  
TIME DESTRESSING STARTED: \_\_\_\_\_  
AIR TEMP AT START: \_\_\_\_\_  
CWR TEMP (T) AT START: \_\_\_\_\_

	COMPUTED	MEASURED (ACTUAL)
1/4 POINT:	_____	_____
1/2 POINT:	_____	_____
3/4 POINT:	_____	_____
FREE END:	_____	_____

CWR TEMP AT COMPLETION: \_\_\_\_\_  
AIR TEMP AT COMPLETION: \_\_\_\_\_  
TIME ANCHORING COMPLETED: \_\_\_\_\_  
CONTRACTOR'S REPRESENTATIVE: \_\_\_\_\_  
ENGINEER'S REPRESENTATIVE: \_\_\_\_\_  
DATE SUBMITTED: \_\_\_\_\_

**WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY**

**DEPARTMENT OF  
TRANSIT SYSTEM DEVELOPMENT  
OFFICE OF  
ENGINEERING & ARCHITECTURE**

RECORD OF C.W.R. LAYING  
EXHIBIT 05651 -C (PART 2 OF 2)

END OF SECTION

## SECTION 05652

### BALLASTED TRACK CONSTRUCTION

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. The work in this Section shall include the construction of ballasted track as indicated on the drawings and as specified in these specifications.
- B. The construction of ballasted track shall include:
  - 1. Preparation of subgrade and placement of sub-ballast and ballast.
  - 2. Hauling of construction materials.
  - 3. Distribution and spacing of ties.
  - 4. Laying, destressing and joining of continuous welded rail (CWR) strings
  - 5. Construction of ballasted track
- C. The above construction is encompassing and includes all pertinent trackwork related items associated with track construction such as the standard and insulated joints; rail cutting and stress adjustment; tamping, surfacing lining and gauging and all other operations necessary to construct an acceptable completed track structure.
- D. Unless otherwise shown or specified, trackwork within limits of ballasted special trackwork units is not included in this Section.

##### 1.02 RELATED SECTIONS

- A. Section 02726 - Sub-Ballast.
- B. Section 02727 - Ballast.
- C. Section 05091 - Rail Welding.
- D. Section 05651 - General Track Construction.
- E. Section 05654 - Special Trackwork Construction - Ballasted.
- F. Section 05656 - Running Rail.
- G. Section 05658 - Track Appurtenances and Other Track Material.
- H. Section 05660 - Restraining Rail and Lubricators.
- I. Section 06130 - Timber Ties.
- J. Section 06131 - Composite (Plastic) Ties.
- K. Section 06132 - Timber Grade Crossing.

##### 1.03 REFERENCES

- A. Codes and regulations of the jurisdictional authorities.

- B. American Railway Engineering and Maintenance-of -Way (AREMA), Manual for Railway Engineering (**latest edition**), herein referred to as the AREMA Manual are as follows:
1. Chapter 4, Part 1, Rail Drilling, Bar Punching and Track Bolts.
  2. Chapter 5, Part 4, Specifications for Track Construction.
- C. **American Society of Testing and Materials (ASTM).**

#### 1.04 SUBMITTALS

- A. Submittals shall be specified in Section 01300, Submittals. The following submittals shall be made **and submitted** by Contractor:
1. Detailed descriptions of construction procedures required for the work specified in this Section.
  2. Samples required for the work specified in this Section.
  3. Test results required for the work specified in this Section.
  4. Working Drawings showing the proposed method for temporary fastening of rail during installation.
  5. Required rail temperature record forms for rail laying and rail fastening operations.
  6. Five (**5 each AREMA approved**) thermometers as specified in Section 05651, General Track Construction, Article 3.12, Laying Continuous Welded Rail.
  7. **Method and equipment for transport of rail.**
  8. **Submit for approval detailed procedures of the following items required in connection with laying and joining CWR strings:**
    - a. **String schedule showing length and location of strings.**
    - b. **Equipment to be used.**
    - c. **Procedure for positioning CWR strings in track, setting gaps between strings and initial fastening.**
    - d. **Procedure for lining, gauging and profiling of rails.**
    - e. **Procedure for joining CWR strings, including method of obtaining correct gap if joined at a different temperature than at which it was laid.**
    - f. **Procedure for destressing/anchoring CWR strings to zero thermal stress temperature, including control of rail movement and installing rail anchors and spiking rail down.**
    - g. **Special procedure for closing last string with previously anchored rail or special trackwork.**
  9. **Completed and signed Record of CWR Laying Form provided in Section 05651 (Exhibit 05651 C / Part 2 of 2).**

#### 1.05 QUALITY ASSURANCE

- A. In order to determine the acceptability of the installation, the Contractor shall make a survey of the completed track, and provide the Engineer with a copy for review. Deviations from the drawings which exceed tolerances specified in Section 05651, General Track Construction, shall be corrected by the Contractor at no additional cost to WMATA.

## PART 2 - PRODUCTS

### 2.01 MATERIALS

- A. The following track materials shall be furnished by the Contractor and any additional items necessary to construct an acceptable, completed track structure.
1. Sub-ballast
  2. Ballast

3. Ties
4. Special Trackwork
5. Running Rail
6. Track Appurtenances and Other Track Material
7. Metal Tags (to mark superelevation)
8. Restraining Rail and Lubricators (as required)
9. Bumping Posts (as required)

## **PART 3 - EXECUTION**

### **3.01 GENERAL**

- A. All ballasted main/primary track shall be constructed with Pandrol spring clips, elastic fastener tie plates punched for four 7/8 inch screw spikes and four 7/8 inch screw spikes.
- B. Track within the limits of ballasted special trackwork units shall be constructed as specified for Special Trackwork Construction.
- C. Ballasted track construction includes realignment of existing tail tracks to meet with the new track alignments to be extended.
- D. Ballasted track construction includes placing sub-ballast and ballast, distributing and lining ties; installing, anchoring, and joining CWR strings, raising and lining track; and other incidentals as required and as specified for General Track Construction as modified

### **3.02 TOLERANCES FOR BALLASTED TRACK**

- A. Deviation from the gauge, cross level, superelevation, horizontal alignment and vertical alignment shall not exceed the tolerance specified.

### **3.03 PLACEMENT OF SUB-BALLAST**

- A. Subballast shall be distributed, placed and compacted in accordance with Section 02726, Subballast.
- B. Prior to placement of subballast all trash and debris shall be removed from subgrade.
- C. Subgrade shall be clear and void of tire ruts, large stone or other deleterious objects before placement of subballast.
- D. Subgrade shall be dry before placement of subballast.

### **3.04 INITIAL LAYER OF BALLAST**

- A. **Ballast shall be distributed, placed and compacted in accordance with Section 02727, Ballast.**
- B. An initial layer of ballast shall be uniformly distributed over the finished subballast and compacted before tie distribution. The ballast shall not be distributed on the roadbed until the subballast has been approved. Subballast fouled or distributed by the Contractor's operations shall be repaired by the Contractor at no additional cost to the Authority.
- C. The initial layer of ballast shall be limited to a total compacted depth that will establish the track surface at least four inches below final grade, with further provision that each compacted lift shall be a maximum depth of four inches.

- D. The ballast depth shall conform to the cross sections shown. Each lift of ballast shall be uniformly spread. Each lift of ballast shall be fully compacted by a self-propelled pneumatic-tired roller or a vibrating compactor.
- E. The self-propelled pneumatic-tired roller shall have a minimum gross weight of nine tons and the vibratory compactor shall have a minimum weight of 5,000 pounds capable of applying a dynamic load of 18,000 pounds or more. The equipment selected by the Contractor shall be subject to approval by the Engineer.

### **3.05 DISTRIBUTION AND SPACING OF TIES**

- A. All ties shall be carefully distributed and properly spaced on the initial layer of ballast with every fourth tie being a contact rail tie unless otherwise specified or shown.
- B. Care shall be exercised in the placement of contact rail ties to ensure the proper offset for contact rail supports.
- C. Unnecessary handling, distribution and reloading of ties shall be avoided. To the extent practicable, ties shall be distributed in proper position for use without further handling. They shall be unloaded in a manner that will not damage the ties. In no case shall ties be dropped. Ties shall be moved only with tie tongs or by leverage with a bar.
- D. Ties shall be installed radially on curves and at right angles to the centerline of tangent track at the designed spacing prior to rail installation. The lined side shall be the outside of each track for all main and yard/storage lead tracks. Main track shall be considered double track regardless of separation.
- E. Contact rail ties shall be installed to properly support the contact rail on the side of the track as shown. The line end shall be lined with the adjacent ties.
- F. Ties damaged as a result of improper handling by the Contractor and rejected by the Engineer shall be removed and replaced with new ties.
- G. Timber ties shall be adzed only with the Engineer's approval and shall be installed with the heartwood face down.
- H. Tie Boring:
  - 1. All timber or composite (plastic) ties shall be bored in the field. Timber tie boring shall be performed with the heartwood face down. For cut spikes, the holes shall be 9/16 inch in diameter and not less than five inches nor more than six inches deep. For screw spikes, the ties shall be bored as directed by the manufacturer or as directed by the Engineer. The location and number of holes shall conform to the location and number of spikes required for the type of track or special trackwork unit in which the tie is to be installed. Boring of holes in excess of the number of spikes used will not be permitted.
  - 2. A tolerance of plus or minus 1/16 inch will be permitted in the distance between spike holes. The spike holes shall be located in such a manner that each tie plate will be centered on the tie at a right angle to the rail when the spikes are driven into place. A tolerance of 1/8 inch in the centering of the holes across the width of the tie will be permitted. Timber tie holes shall be treated with pentachlorophenol oil or creosote immediately after boring.
- I. Tie Spacing
  - 1. Ties shall be spaced on an average of 27 inch centers, for main track unless otherwise shown.

2. Tie spacing at approach slabs shall be as shown.
3. Tie spacing on restraining rail track shall be on an average of 24 inch centers.
4. Tie spacing shall be as specified or shown with a tolerance of plus or minus 1 inch.

### **3.06 LAYING CONTINUOUS WELDED RAIL (CWR)**

- A. Laying, anchoring and joining CWR shall be as specified.
- B. Zero Thermal Stress Temperature
  1. The rail shall be anchored at a temperature of 85 deg. F plus 5 deg. for minus 10 deg. F (30 deg. C plus 3 deg. C or minus 6 deg. C).
  2. The temperature of opposite rails when anchored shall be within 5 deg. F (3 deg. C) of each other.
- C. Fastening Rail To Ties
  1. Materials for fastening rail to ties shall be as specified for Track Appurtenances and OTM.
  2. Tie plates shall be installed under running rails on all ties. Spiking pattern shall be as follows:
    - a. Pandrol Tie Plates - 4 screw spikes
  3. Prior to installing tie plates, the contact surfaces of the tie plates shall be cleaned to allow full bearing of the tie plate upon the tie. Tie plates shall be centered on the tie and placed normal to the centerline of the rail so that the outside shoulder of the plate will have full bearing against the base of rail.
  4. Spikes shall be started vertically and square and driven straight. Straightening of spikes will not be permitted. Spikes bent during driving shall be withdrawn and the holes plugged with treated tie plugs as specified for Track Appurtenances and OTM.
- D. Rail Anchoring: Installation of Pandrol spring clips shall be considered as anchoring the rail.

### **3.07 SURFACING AND LINING**

- A. Ballasting
  1. Following the assembly of the track, ballast shall be unloaded in the tie cribs and shoulders of the track structure to restrain movement or buckling of the track due to temperature changes.
  2. Such ballast unloading shall provide an adequate amount of ballast for the track raise with sufficient surplus to continue to hold the track after the raise.
- B. Surfacing
  1. Track surfacing shall be done by methods which will prevent undue bending of the rail or straining of the joints.
  2. The amount of track lift shall not exceed four inches nor endanger the horizontal or vertical stability of the track. The track shall be given at least two raises of not less than one inch nor more than three inches each raise.
  3. All ties pulled loose during surfacing shall be replaced to full bearing against the rail and properly secured.
  4. Track surfacing will not be permitted until the cribs are filled with ballast nor will surfacing be permitted when the ambient temperature is higher than 95 deg. F.
- C. Tamping
  1. Tamping of ballast shall be done with approved power tamping equipment of the vibratory squeeze type. Control or cycling of the power tamper shall provide the maximum proper compaction of ballast uniformly along the track.

2. The ballast shall be thoroughly tamped on both sides of the tie from a point 15 inches inside the rails to the ends of the tie, with the exception of contact rail ties where tamping shall be only to a point opposite the ends of the adjacent cross tie. Tamping will not be permitted at the center of the tie outside of the above stated limits. For each tie, tamping shall proceed simultaneously inside and outside both running rails on both sides of the tie.
- D. Final Surface and Alignment
1. The final surface and alignment of all track shall be within the specified ballasted track construction tolerances, executed by machines with automatic lining equipment or with combined lifting, lining and tamping equipment. Final tamping and lifting shall be effected by equipment fitted with tamping heads between axles or of arch -bar construction.
  2. After the final surfacing and alignment of track is completed the ballast shall be dressed to conform to the ballast section shown and as directed by the Engineer. The portion of sub-ballast outside the toe of slope of the ballast shall have a smooth, even surface, sloped as shown.
  3. A manual dressing, as directed by the Engineer will be required to ensure a one inch clearance between the base of rail and top of ballast.
- E. Ballast Compaction
1. Following tamping and lining, but prior to installation of contact rail and insulators, the crib and shoulders of all track shall be compacted by a machine specifically designed to compact the crib and shoulders simultaneously. The compactor shall operate on all shoulders and in those cribs where special trackwork components do not interfere with the operation of the machine. After compaction of ballast no further shaping of the ballast section will be permitted except as directed by the Engineer.
  2. The crib compacting tool work faces shall measure nine inches by 14 inches with the nine-inch dimension parallel to the rail. Crib compacting tool work faces shall appear as flattened V's when viewed normal to the nine-inch dimension and the depth of the V shall be 3/4-inch plus or minus 1/16-inch. There shall be a minimum of eight crib compacting tools, two on each side of each rail. The shoulder compacting tool work faces shall conform to the designed ballast section outline from 1-1/2 inches beyond the tie ends horizontally to the beginning of the 2:1 shoulder slope, continuous to within six inches of the ballast toe at the sub-ballast. The length of work faces in the direction of travel shall not be less than 33 inches, with flared ends in the direction of travel to avoid plowing of ballast shoulders. For superelevated and spiraled sections, the shoulder tools shall be adjustable such that the 2:1 ballast shoulder slope will be maintained as shown.
  3. The compacting tool work faces shall vibrate with a frequency between 2200 and 3000 Hertz. The vibrational amplitude shall be between 0.058 inch and 0.117 inch. The vibrating work faces shall apply a pressure between 14 psi and 21 psi to the surface of the ballast. The pressure applied shall be the same for all operations and remain constant throughout the job and shall be monitored by a permanently affixed calibrated pressure gauge. The compacting tools shall be applied to both crib and shoulders for a period of between three and six seconds duration at each crib successively.
- F. Ballast Inspection: The Contractor, shall remove a maximum of one percent of the ties, selected at random by the WMATA Engineer, to allow inspection of the ballast compaction beneath the ties to determine the variables of each piece of tamping and compaction equipment and for spot checking of the production work.
- G. Superelevation Marker Tags
1. The required amount of superelevation in ballasted tracks shall be shown on metal marker tags affixed to the tops of ties.

2. Tags shall be placed at start of superelevation to show zero superelevation and at every 1/8 inch change until full superelevation is reached.
3. Tags shall be fastened with two nails to the top of the nearest tie approximately one foot inside the high rail and shall be placed so they can be read while facing against the traffic, on tracks of assigned direction. Tags shall be placed at the point of full superelevation so that they may be read facing the high rail, to plainly indicate the authorized full superelevation.
4. Tags shall be made of a corrosive-resistant metal such as anodized aluminum or brass. Fastening nails shall be of the same material as the tags.
5. Tags shall be stamped in 1/8 inch increments from zero superelevation to maximum superelevation. Whole numbers and fractions shall be stamped in characters ½ inch minimum in height.
6. Tags shall be a minimum of .050 inches thick, 1-1/4 inches wide and two inches long.

#### **PART 4 - MEASUREMENT AND PAYMENT**

##### **4.01 MEASUREMENT:**

- A. Measurement of work specified in this section will be made in the following manner:
  1. Ballasted Track Construction: No separate measurement.

##### **4.02 PAYMENT:**

- A. Compensation for work specified in this Section will be made in the following manner:
  1. Ballasted Track Construction: Included in the price of work it is a part.

**END OF SECTION**

## SECTION 05653

### DIRECT FIXATION TRACK CONSTRUCTION

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. The work specified in this Section shall include the construction of direct fixation (DF) track, as indicated on the Drawings. Direct fixation track construction (DFTC) includes the requirements for qualifying the construction methods; surface preparation of existing concrete and stirrups; forming, placing, and curing reinforced track concrete; installing DF rail fasteners; and installing continuous welded rail (CWR).
- B. Direct fixation track construction is comprised of the installation of grout pads and direct fixation rail fasteners, installing running rail, anchoring, joining CWR strings and other incidentals as specified. The track shall be constructed as specified for General Track Construction (GTC) and as specified herein.
- C. Direct fixation track construction shall use resilient spring clip direct fixation fasteners, vibration attenuating direct fixation fasteners and "Stiff" direct fixation fasteners with slip-in Pandrol shoulders within Special Trackwork where shown. Type of fastener to be installed at a given location shall be as indicated on the contract drawings.
- D. Prior to start of DFTC all under track drains and invert conduits shall be proofed with a mandrel. Following completion of DFTC all under track drains and invert conduits shall again be proofed with a mandrel to demonstrate that the Contractor's operations have not plugged the drains or conduits.
- E. Prior to the second proofing of track drains, but after all other work is complete, the underground portions of direct fixation track shall be thoroughly washed two separate times, including inbound and outbound tracks, overhead, sidewalls and invert. Washing equipment shall be capable of attaining at least 2500 psi nozzle pressure and shall be approved by the Engineer prior to start of washing.

##### 1.02 RELATED SECTIONS

- A. Section 05651 - General Track Construction
- B. Section 05091 - Rail Welding
- C. Section 05655 - Special Trackwork Construction - Direct Fixation
- D. Section 05656 - Running Rail
- E. Section 05657 - Direct Fixation Rail Fasteners
- F. Section 05660 - Restraining Rail and Lubricators

##### 1.03 REFERENCES

- A. American Railway Engineering and Maintenance-of-Way Association (AREMA), Volumes I and II (**latest edition**). Items particularly noted in the AREMA Manual are as follows:
  - 1. Chapter 4, Part 1, Rail Drilling, Bar Punching, and Track Bolts.
  - 2. Chapter 5, Part 4, Specifications for Track Construction.

- B. American Association of State Highway and Transportation Officials (AASHTO):
  - 1. AASHTO M148
  - 2. AASHTO T277
  
- C. American Society for Testing and Materials (ASTM):
  - 1. ASTM A325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
  - 2. ASTM A449 - Standard Specification for Quenched and Tempered Steel Bolts and Studs.
  - 3. ASTM C33 - Standard Specification for Concrete Aggregates.
  - 4. ASTM C39 - Standard Specification for Compressive Strength of Cylindrical Concrete Specimens.
  - 5. ASTM C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2 inch Cube Specimens).
  - 6. ASTM C150 - Standard Specification for Portland Cement.
  - 7. ASTM D2240 - Standard Test Method for Rubber Property - Durometer Hardness.
  - 8. ASTM D2936 - Standard Test Method for Direct Tensile Strength of Intact Rock Core Specimens (C900 - STM for Pullout Strength of Hardened Concrete).
  
- D. Steel Structures Painting Council (SSPC):
  - 1. Specification SP1 - Solvent Cleaning
  - 2. Specification SP5 - White Metal Blast Cleaning.

#### 1.04 SUBMITTALS

- A. A work plan shall be submitted for approval prior to the beginning of construction. The work plan shall include a step-by-step construction sequence accompanied by descriptions and sketches as needed to describe the following:
  - 1. The method of laying out the work including grout pads, inserts and fasteners, to result in finished track meeting alignment requirements within the specified tolerances.
  - 2. The method of preparing concrete invert surfaces to obtain the specified bond of grout pad to invert.
  - 3. The method of locating and drilling insert holes and setting inserts to specified position and elevation. Include hole diameter and depth.
  - 4. The details for securing the fastener inserts in the trackbed invert including the following:
    - a. Brand/manufacturer of each component.
    - b. Temperature range of substrate for setting inserts and curing anchor material supported by test data.
    - c. Wetness range for placing and curing anchor material.
    - d. Packing, storing, handling, proportioning, mixing and placing details.
    - e. Hole cleaning, brushing, blowing and drying details.
    - f. Insert cleaning and degreasing details.
    - g. Method for measuring and controlling substrate temperature during setting and curing of material.
  - 5. Details of the insert including shop drawings or catalog cuts and certification of chemical composition and physical characteristics to verify compliance with these specifications.
  - 6. The details of the grout pad sizes, and procedures for forming, mixing, placing and curing including items 4. a. thru d. and g. above.
  - 7. The grout mix design identifying materials, proportions and additives.
  - 8. Curing materials for grout pads.

9. Required rail temperature record forms for rail laying and rail fastening operations.
10. Five (5) each AREMA approved thermometers as specified in Section 05651, General Track Construction, Article 3.12, Laying Continuous Welded Rail.
11. Method and equipment for transport of rail.
12. Submit for approval detailed procedures of the following items required in connection with laying and joining CWR strings:
  - a. String schedule showing length and location of strings.
  - b. Equipment to be used.
  - c. Procedure for positioning CWR strings in track, setting gaps between strings and initial fastening.
  - d. Procedure for lining, gauging and profiling of rails.
  - e. Procedure for joining CWR strings, including method of obtaining correct gap if joined at a different temperature than at which it was laid.
  - f. Procedure for destressing/anchoring CWR strings to zero thermal stress temperature, including control of rail movement and installing rail anchors and spiking rail down.
  - g. Special procedure for closing last string with previously anchored rail or special trackwork.
13. Completed and signed Record of CWR Laying Form provided in Section 05651 (Exhibit 05651 C / Part 2 of 2).

#### 1.05 QUALITY ASSURANCE

- A. The Contractor shall make the following submittals and tests before constructing direct fixation track.
- B. Submit a Preliminary Work Plan for approval containing the information specified.
  1. Perform grouting material tests.
  2. Perform grout pad qualification tests.
  3. Perform anchoring material tests.
  4. Upon approval of the work plan, DFTC shall proceed using the material, methods and procedures stated in the plan.
  5. Quality control tests in the plan shall be performed in the manner and to the intervals specified and the results furnished to the Engineer within 14 days after performing each test.
  6. No track construction shall commence prior to approval of the final work plan.
- C. Testing of Grouting Materials
  1. Test specified shall be conducted on specimens of the proposed materials by an approved independent laboratory. Results of the test shall be submitted for approval.
  2. Compressive Test:
    - a. Compressive test shall be made on three 3-inch by 6 inch cylinders in accordance with the requirements of ASTM C39.
    - b. To be acceptable, the average compressive strength shall not be less than 3500 psi nor more than 6000 psi at 28 days.
- D. Grout Pad Qualification Testing
  1. The Contractor shall prepare four 1-1/4 inch thick grout pads in each of two areas of the existing trackbed designated by the Engineer. The preparation of the invert, and the placement of grout pads shall be as proposed in the Contractor's work plan. Each area shall exhibit differing invert conditions.

2. The grout pads shall be allowed to cure for 28 days, after which core specimens from grout pads shall be taken of a size as required by ASTM D2936. The perimeter of any hole shall be six inches minimum from any adjacent hole and a maximum of two inches from an edge of the grout pad.
3. The specimens shall be taken at locations as directed by the Engineer. Cores shall be taken using diamond core drills and shall be oriented normal to the grout pad surface with a tolerance of plus or minus one degree.
4. The cores shall be tested in direct tension using methods specified in ASTM D2936. All cores shall be tested to failure. To be acceptable the minimum tensile strength, including the bond shall not be less than 125 psi. If failure occurs in the invert concrete at less than 125 psi an additional core shall be tested.
5. Grout pads from which cores were removed may be used for the final installation providing the cores pass the specified test and the pads are otherwise acceptable. Holes shall be filled with specified grout and the top surface shall be finished to the tolerances of the surrounding grout pad.
6. Grout pads that fail to pass the test shall be completely removed and the holes in the invert shall be patched as specified.
7. The Contractor shall perform insert drilling tests on the grout pads (full depth of insert) to determine optimum insert drilling period. Hole(s) shall be drilled 24 hours, 48 hours, 72 hours, 7 days, 14 days, and 28 days after pads are placed. Pads shall be placed in such a manner that insert drilling tests can be performed without affecting adjacent portions of the grout pad to be used for qualification testing. All holes to be filled full depth after test with specified grout. Test results shall be submitted for approval.

E. Fastener Insert Pull-Out Testing

1. Inserts shall be installed according to the work plan in each of two areas of existing concrete trackbed exhibiting different invert conditions as directed by the Engineer. The sites selected **and witnessed** by the Engineer will be chosen to demonstrate the temperature and wetness limits of the anchoring material.
2. A restrained test shall be performed in each area, in which a 3-1/2 inch square by 1/2 inch thick steel plate, with a 0.9687 inch diameter hole in the center shall be placed over insert on the concrete trackbed. The insert bolt shall be installed and then have an upward vertical load applied, bearing against the steel plate, until a load of 40,000 pounds occurs. The load shall then be released. Six inserts and bolts in each area shall be tested in this manner.
3. For the unrestrained test, the steel plate shall be removed. The insert bolt shall again have an upward vertical load applied, in such a manner that no vertical load is applied to the concrete trackbed within a radius of six inches from the insert until a load of 6,000 pounds is attained.
4. Testing shall be no additional cost to the Authority.
5. Acceptance Criteria for Insert Pull-Out Testing
  - a. During the restrained test there shall be no evidence of failure of the insert anchoring system before a load of 40,000 pounds is attained.
  - b. During unrestrained test there shall be no evidence of failure by slippage or cracking of the insert anchoring material before a load of 6,000 pounds is attained.

F. Quality Control Requirements

1. The Contractor's Work Plan shall include the Contractor's quality control plan for DFTC. As a minimum, the following quality control measures shall be included:
  - a. Three 3-inch by 6-inch cylinders of grout shall be taken from the production mix and cured under the same conditions as the grout pads. At the end of 28 days the cylinders shall be tested in accordance with ASTM C109.

The average compressive strength shall not be less than 3,500 psi nor more than 6,000 psi. Samples shall be taken from each 200 feet of track constructed or each days work, whichever is less.

- b. The grout pad qualification test shall be performed on three cores each 200 feet of track or each day if less than 200 feet of grout are placed per day. The test procedure and acceptance criteria shall be the same as specified in the qualification test.
- c. The unrestrained insert pull-out test shall be performed on one insert on each rail every 200 feet. Should the insert or the bond fail, the Contractor shall test every insert in both directions to define, to the Engineer's satisfaction, a zone of defective inserts. All inserts in such a zone shall be made and labeled as directed by the Engineer.
- d. All materials or installation determined to be defective in accordance with the quality control program shall be removed and new materials installed and tested in accordance with the quality control program. In the event of a second failure during any retest, the Contractor shall modify his work plan to include corrective actions to be taken before any further work with the failed material is to continue. All removal and replacement shall be at no additional cost to the Authority.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS**

- A. Grout
  1. Grout shall have a design strength of 4,000 psi and shall be premeasured, prepackaged, requiring only the addition of water, and shall consist of Portland cement, fine aggregate, coarse aggregate and additives.
  2. Grout shall be low-shrink, contain no expansive cement, metallic particles or air entraining agents.
  3. Grout shall have been used in like application for not less than three years and perform successfully as specified under quality assurance.
  4. The components of grout selected shall meet the following requirements, listed below.
    - a. Portland Cement: ASTM C150, Type I or II.
    - b. Fine Aggregates: ASTM C33.
    - c. Coarse Aggregates: ASTM C33, 3/8 - inch maximum.
    - d. Water: Potable
      - 1) Additives: As recommended by manufacturer and approved
      - 2) Curing compound: Conforming to AASHTO M148, Type I-D and as recommended by grout manufacturer.
- B. Insert Anchoring Material
  1. Fox Industries FX-830, polyester resin, Fox Industries FX-816 or equal.
  2. Ramset/Red Head EPCON System, Ceramic C Formula with static mix nozzle, two-part epoxy or approved equal.
- C. Fastener Anchorage Assembly
  1. Insert:
    - a. Steel conforming to mechanical requirements of ASTM A449 and chemical composition of ASTM A325, Type 3, or equal, with chromium, nickel and copper in such combination to achieve maximum corrosion resistance consistent with strength and hardness requirements.
      - 1) Threaded to 1-1/2 inch depth to receive ASTM A325 7/8-inch bolt.

- 2) Designed and tested to meet 40,000 - pound bolt load without yielding.
  - 3) Washer face bearing against fastener equal to bearing area of A325 heavy hex nut for 7/8-inch bolt.
  - 4) Length and anchorage configuration designed and tested to withstand 12,000 pounds unrestrained pull-out and 250 foot - pounds torque without yielding and with four to five inches embedment in concrete exclusive of grout pad thickness.
  - 5) Each insert furnished with a firmly fixed and easily removable plug or nylon or plastic material to exclude concrete or other materials from entry during transport, handling and installation. Plugs shall be capable of re-insertion and, if re-inserted, shall still exclude concrete or other materials from entry.
  - 6) Inserts shall be coated with an epoxy resin insulating coating, 100-percent dry powder epoxy resin, Scotch Kote Brand Protective Resin No. 206N, Minnesota Mining and Manufacturing Company; Corvel Epoxy ECB - 1363A, Polymer Corporation; or equal. The coating application shall be in accordance with the coating manufacturer's recommendations and as approved, with the following additional requirements:
    - a) Remove oil, grease and other foreign matter shall be removed by solvent, caustic degreasing or by steam cleaning in accordance with SSPC Specification SP 1.
    - b) Prepare surface to white metal in accordance with SSPC Specification SP 5.
    - c) Preheat the inserts to a uniform temperature of not less than 325 deg. F, checking and recording temperature every hour.
    - d) Dip inserts into fluidized bed of proper temperature and density to provide complete and uniform coverage of surfaces except interior threads when provided.
    - e) Immediately oven cure at a temperature between 400 deg. F and 425 deg. F for a time which will ensure complete cure of the epoxy resin.
    - f) The epoxy coating shall be not thinner than 10 mils nor thicker than 20 mils when tested by a magnetic mil gauge at not less than two areas of the insert; epoxy coating having runs, sags or chips will not be acceptable. When tested in accordance with ASTM D2240, epoxy coatings shall have a hardness not less than 85 nor more than Shore D.
2. Bolt:
    - a. Furnished with Standard D.F. Fasteners: ASTM A449 for Mechanical Properties; A325 Type 3 for Chemical Properties .
  3. Washer:
    - a. Furnished with Standard D.F. fasteners.
  4. Methyl Methacrylate
    - a. Silikal R41si primer by Silikal North America, Inc., FX-821 (mma) by Fox Industries, Inc., or approved equal.
  5. **Elastomeric (Stiff) Direct Fixation Fastener, F-20 Type, produced by L. B. Foster, or approved equal.**

**PART 3 - EXECUTION**

**3.01 INSTALLATION**

A. Direct fixation rail fastener

1. Direct fixation rail fasteners shall be installed in pairs, opposite each other within a tolerance of one inch, at right angles to the centerline of track, one fastener under each running rail. Fastener shall be spaced as follows:

Fastener Spacing (Inches)		
All tracks except those listed below.	Average Individual Spacing (Design Spacing)	30
	Average of 20 consecutive fasteners(20 spaces, plus or minus three inches	30
	Maximum Individual Spacing	33
Special Track-work and Joints	Average Individual Spacing (Design Spacing)	As shown
	Maximum Individual Spacing	As shown plus 3 inches

2. The fasteners inserts shall be located 5-1/4 inches from the centerline of rail measured normal to the rail and 1-3/4 inches from the centerline of fastener measured parallel to the rail. The fastener inserts shall be symmetrically located in the upper right quadrant and lower left quadrant of the fastener as referenced along the centerline of rail.
3. A transverse, four-inch, heavy-duty cast-iron pipe, connecting Type 1 drain inlets to the main track drain is located in the concrete invert below the running rail. Where the top of the connecting pipe is less than six inches below the concrete surface at the running rail, the fastener shall be located to provide not less than three inches clearance between the fastener insert holes and the nearest surface of the pipe.
4. The fasteners are designed with a lateral adjustment feature having a range of plus or minus 1/2 -inch. The range of adjustment is for both construction tolerances and re-gauging, but may not include gauge widening for curves and special trackwork. The Contractor shall install fasteners in such a manner that after final gauging and aligning of the track not less than 1/2-inch of the lateral adjustment range of each fastener remains for tightening of the gauge.

B. Chipping of Concrete Trackbed

1. Trackbed surfaces where grout pads are to be installed shall be chipped to a depth of approximately 1/4-inch to expose aggregate and provide a surface suitable for grout bonding. Chipping equipment and procedures shall be approved by the Engineer.
2. The Contractor shall submit for approval computations for the actual amount of chipping required and the proposed method. No chipping shall be done without prior approval.
3. In areas chipped in excess of that required for the installation of grout pads, the Contractor shall restore the invert to its original grades by filling chipped surface with grout pad material from which the coarse aggregate has been removed, or by filling with approved patching mortar.

4. The Contractor shall, immediately upon completion of the chipping work, clean-up and remove debris and any water resulting from the chipping.

C. Grout Pads

1. Grout pads shall be installed in direct fixation track to provide an even surface for the support of the rail fastener. The pad shall be located and its surface leveled to provide the fastener full bearing support at all positions of lateral adjustment of the fasteners along the entire length of grout pad.
2. Grout pads shall be 20 inches wide, not less than nine feet nor more than 10 feet long. There shall be a minimum of six inches of the existing trackbed exposed between grout pads.
3. Grout pads shall not be constructed over construction joints. Where grout pads overlap as-built drainage troughs, the Contractor shall proceed as directed by the Engineer. For special trackwork, the grout pad shall extend no less than 1/2-inch beyond the elastomer pad and shall be configured to provide adequate trackbed drainage.
4. The grout pad thickness shall be a minimum of 3/4-inch. Contractor shall be responsible for providing grout quantities as needed to a maximum of 3 inches at no additional cost to the Authority. Additional thickness of rail grout pads on curved track shall be computed from invert dimensions shown in typical sections for superelevated track. Grout exceeding the 3-inch maximum on the high rail for superelevation purposes will also be at no additional cost to the Authority.
5. Grout pads over two inches thick shall be reinforced as shown,
6. Except within the limits of special trackwork and unless otherwise directed by the Engineer, grout pads shall be laid to provide the running rails a 40:1 cant toward the center of the track. Cant may vary from 33:1 to 50:1. Pads within the limits of special trackwork shall provide no cant to the rail and shall be flat to plus-or-minus 0.3 degrees.
7. The difference in elevation of two adjacent grout pads on the same rail, adjusted for grade, shall not exceed 1/16 inch.

D. Grout Installation

1. Preparation
  - a. The surface shall be clean, sound and free of standing water. Foreign substances and laitance shall be removed to expose firmly embedded coarse aggregate.
  - b. Divert running water temporarily to achieve water free area to install grout pad.
  - c. If a bonding agent is used, the recommendations of the manufacturer of the bonding agent shall be submitted for approval; and once approved, strictly followed in handling, mixing, placing and curing.
2. Forms
  - a. Forms shall be constructed of coated wood, metal, or equal, and anchored securely. They shall be leakproof and strong enough to retain grout in place. Provision shall be made to give the top of grout pads the specified cant.
  - b. Slip forming of grout pads may be used provided the finished grout pad meets all other requirements of the specifications and drawings.
3. Mixing
  - a. The components of Portland cement grout, in the approved proportion, shall be mixed thoroughly to ensure even distribution of components.
  - b. Mixing shall be done as near the grouting site as possible.
  - c. Water added shall be the maximum required to achieve the design water content, including the moisture entrained in the aggregate. Water is not available in the tunnels /cut and cover box structures.

Water for mixing grout and all other purposes shall be provided from sources outside of the tunnels/cut and cover box structures.

- d. Material temperature shall be within the approved limits set by the manufacturer. Once mixed, grout not placed within its working time shall be discarded.

4. Placing and Curing

- a. The placing of grout shall be as recommended by the grout manufacturer.
- b. The grout shall be kept wet and curing compound shall be applied as recommended by the manufacturer of the curing compound.

E. Fastener Insert Installation

1. Drilling Insert Holes

- a. Inserts shall be located with sufficient accuracy to ensure compliance with specified tolerances and as required by the rail fastener design.
- b. Holes shall be drilled to a depth not greater than 5-1/2 inches in the concrete trackbed below the grout pad and the diameter shall not be greater than 2-1/4 inches. Holes shall be drilled normal, plus-or-minus one degree to the plane of the rail base.
- c. The Contractor's method of drilling the concrete trackbed for D.F. inserts shall not spall the concrete, delaminate the grout pads nor compromise structural integrity of the tunnel/cut and cover box structure.
- d. Spacing for transverse reinforcing bars in the concrete trackbed is as shown on the Drawings. To decrease the possibility of interference with the drilling of the insert holes, exposed vertical fender studs welded to the transverse reinforcing bars have been provided in all underground D.F. track at longitudinal intervals of 10 feet. As a further aid in locating reinforcement bars, a pacometer is available for loan from the Authority. Special care shall be taken on aerial structures to prevent damage to tensioning cables.
- e. In the event any of the following occur, the Contractor shall immediately notify the Engineer and under his direct supervision proceed as follows:
  - 1) If a longitudinal reinforcing bar is encountered while drilling an insert hole, drilling shall be continued until the hole has reached design depth.
  - 2) If a transverse reinforcing bar is encountered while drilling an insert hole before reaching the design depth, the hole shall be relocated a minimum distance of three inches or as directed by the Engineer. Whenever a hole is relocated, the original hole shall be filled with approved insert anchoring material.
  - 3) If the hole is drilled to a depth greater than 5-1/2 inches, it shall be filled with grout or anchor material to the design depth.
- f. Insert holes shall be free of dust and debris prior to installation of the inserts. All debris from drilling insert holes shall be removed from the work site without damage to existing facilities. The Contractor shall take measures to prevent clogging of permanent drainage facilities. Prior to completion of the Contract, **the Contractor** shall ensure that permanent drainage facilities are left free of foreign matter.

2. Setting Inserts

- a. Insert holes shall be installed in accordance with the approved procedure and shall be embedded not less than four inches in the concrete trackbed below the grout pad.
- b. Before the installation, inserts shall be free of rust, dirt and other deleterious substances.
- c. Inserts shall be set normal plus-or-minus one degree to the plane of the rail base. The insert and anchoring material surface shall be no higher than zero inch and not lower than 1/32 inch from the top plane of the grout pad.

3. Setting Fasteners
  - a. Fasteners shall be placed on grout pads and secured by the use of bolts. Anchoring of a string of CWR in direct fixation track shall be accomplished by installing devices furnished by the fastener manufacturer, which are for the purpose of holding the rail on the fastener. The installation of the direct fixation fastener shall be in accordance with the fastener manufacturer's recommended installation procedure.
  - b. Rail fasteners shall be kept clean and free of dirt, grout and other substances which could reduce the electrical-insulating characteristics of the fastener. Inserts shall be kept free of rust, dirt and other substances. The use of shims is prohibited unless specifically approved by the Engineer on a case by case basis.
  
- F. Laying Continuous Welded Rail on Direct Fixation Rail Fasteners
  1. Laying, anchoring and joining of CWR shall be as specified for General Track Construction with the following additional requirements:
    - a. Zero Thermal Stress Temperature
    - b. The rail in underground direct fixation track shall be installed, joined and anchored to produce zero thermal-stress in the rail at 60 deg. F plus-or-minus 10 deg. F (16 deg. C plus-or-minus 6 deg. C).
      - 1) Aerial, at-grade and approach slab rail shall be anchored at a temperature of 85 deg. F plus 5 deg. F or minus 10 deg. F (30 deg. C plus 3 deg. C or minus 6 deg. C).
      - 2) The temperature of opposite rails when anchored shall be within 5 deg. F (3 deg. C) of each other.
    - c. Lining Direct Fixation Track
      - 1) Rail shall be brought to final line and grade with the rail bearing against the field side shoulder (TPI Fastener) or centered between the rail clamps (Lord Fasteners) of the fastener; the rail or fastener shall then be moved laterally to obtain corrected line and gauge. The anchor bolts shall then be tightened.
      - 2) Anchor bolts on all direct fixation rail fasteners under a string of CWR shall be fully tensioned in accordance with the approved installation procedure before anchoring of CWR string is begun.
    - d. Tensioning Anchor Bolts
      - 1) Bolts shall be in tightening motion when the torque is measured. Torque wrenches shall be accurate within plus-or-minus 10 foot-pounds. Calibration of a torque wrench in order to translate the tension requirement into the foot-pound setting shall be determined by laboratory test in an accurate device capable of indicating actual bolt tension from each lot to be installed.
      - 2) Final bolt tension shall be 30,000 pounds with a tolerance of plus 10 percent and minus 20 percent.
      - 3) Calibration of wrenches shall be by tightening, in a device capable of indicating actual bolt tension, not less than three bolts taken from each lot to be installed.
      - 4) Power wrenches shall be adjusted to stall or cut out at the required tension.
      - 5) If manual torque wrenches are used, the torque indication corresponding to the calibrated tension shall be noted and used for the installation of the tested lot.
      - 6) Calibrate wrenches immediately prior to bolt tensioning operation and every six months thereafter, including two (2) Authority owned torque wrenches.

- e. Joining and Anchoring CWR Strings
    - 1) After lining the CWR in underground, aerial, at-grade or approach slab direct fixation track it shall be joined, de-stressed and anchored as specified in General Track Construction.
- G. Sealing Aerial Structure Grout Pads
1. Description: All direct fixation aerial structure grout pads shall be sealed with two coats of methyl methacrylate.
  2. Surface Preparation
    - a. Complete within 24 hours prior to sealing of pads.
    - b. Clean existing sides of grout pads and 6 inches of invert adjacent to pads of loose materials, oils, greases, and other foreign substances.
    - c. Use high pressure (minimum 500 psi) water blast to clean pad sides and surrounding perimeter of invert.
    - d. Remove water and debris with compressed air from which the oil has been removed.
    - e. Dry surface around pad by torch when directed by the Engineer. The pad and surrounding area shall be surface dry.
  3. Application
    - a. Apply to previously prepared surface.
    - b. Apply only during dry weather and not sooner than 48 hours after precipitation ceases. Do not perform work when ice crystals are present in concrete voids.
    - c. Apply primer with brushes on the dry clean surface. Apply primer evenly to obtain a closed, sealing film on the four sides of each pad and on a three inch perimeter of invert adjacent to the pad.
    - d. Apply primer quickly and continuously, without returning to areas already primed.
    - e. Apply first primer coat to sides of pads and invert in liberal quantities, especially at bond line.
    - f. Apply second primer coat not sooner than 30 minutes after the first application.
  4. Safety Precautions
    - a. The uncured primer is flammable. Take appropriate precautions. After curing, the primer will not support combustion.
    - b. The primer may present a minimal dermatological hazard to certain individuals. Persons involved in mixing and application of the primer must wear protective clothing such as, but not limited to, rubber gloves and goggles.
    - c. In general, all accident prevention regulations with respect to flammable materials, presently in force, must be observed. A dry chemical ABC fire extinguisher shall be on hand while products are in use.
    - d. Component B is flammable and a strong irritant. Handle with appropriate precautions. Protective gear, not limited to goggles, rubber gloves and rubber boots must be worn.
    - e. Provide an eyewash facility.
    - f. Smoking is prohibited on the job site.
    - g. If contact with skin occurs, wash immediately with soap and water, and contact a physician. If contact with eyes occurs, immediately flush with water for 15 minutes and contact a physician.
    - h. Wash contaminated clothing before reuse; discard contaminated shoes.
  5. Quality Control
    - a. Surface Seal Test
      - 1) The **WMATA** Engineer will visually inspect the surface of the treated pads and invert **with the Contractor**.

- 2) Acceptance Criteria: No voids or cracks which could absorb water are allowed.
- 3) Remedial Measures: Repair pads showing insufficient treatment with additional coat (s) of methyl methacrylate.

#### **PART 4 -MEASUREMENT AND PAYMENT**

##### **4.01 MEASUREMENT**

- A. Measurement of work specified in this Section will be made in the following manner:
  1. No separate measurement.

##### **4.02 PAYMENT**

- A. Compensation for work specified in this Section will be made in the following manner:
  1. Included in the price of the work of which it is a part.

**END OF SECTION**

**SECTION 05654**  
**SPECIAL TRACKWORK CONSTRUCTION - BALLASTED**

**PART 1 - GENERAL**

**1.01 SECTION INCLUDES**

- A. The work in this Section shall include the construction of ballasted special trackwork as indicated on the Contract Drawings and as specified.

**1.02 RELATED SECTIONS**

- A. Section 02726 - Sub-Ballast
- B. Section 02727 - Ballast
- C. Section 05091 - Rail Welding
- D. Section 05651 - General Track Construction.
- E. Section 05652 - Ballasted Track Construction
- F. Section 05656 - Running Rail
- G. Section 05658 - Track Appurtenance and Other Track Material
- H. Section 05659 - Special Trackwork
- I. Section 06130 - Timber Ties
- J. Section 06131 - Composite (Plastic) Ties

**1.03 REFERENCES**

- A. Pertinent provisions of the following listed standards and publications shall apply to the Work, except as they may be modified herein, and are hereby made part of these Specifications to the extent required.
  - 1. American Railway Engineering and Maintenance-of-Way Association (AREMA), Manual for Railway Engineering herein referred to as AREMA Manual (**latest edition**).
  - 2. American Railway Engineering and Maintenance-of-Way Association (AREMA), Portfolio of Trackwork Plans, herein referred to as the AREMA Portfolio (**latest edition**).

**1.04 SUBMITTALS**

- A. The Contractor shall develop and submit for the Engineer's approval a detailed installation plan, including sketches, for all special trackwork installation. Particular emphasis should be placed on alignment and clearances, and methods of checking each.
- B. Submittals shall be as specified in Section 01300, Submittals. The following submittals shall be made by the Contractor:
  - 1. The name(s) of the suppliers and manufacturers for the special trackwork components.

2. Shop drawings for the various types of special trackwork and supporting drawings.
3. Installation and maintenance instructions by the manufacturer for the various trackwork components.
4. Detailed description of construction procedures required for the work specified in this Section submitted at least 30 calendar days before beginning the work.
5. Test results required for the work specified in this Section and related work specified elsewhere.

C. Shop Drawings for all Special Trackwork Construction (Ballasted Track) shall be transmitted with paper copies and CADD (latest version) to WMATA as per the requirements of the contract.

#### **1.05 QUALITY ASSURANCE AND SAFETY**

- A. In order to determine the acceptability of the installation, the Contractor shall make a survey of the special trackwork and provide the Engineer with a copy of the report. Deviations from the drawings or specifications which exceed tolerances specified shall be corrected by the Contractor at no additional cost to the Authority.
- B. Switch points shall mate and rest under the undercut stock rail and provide a continuous contact with stock rail the length of the machined point rail face adjacent to the stock rail.
- C. Switch points shall bear on all slide plates as shown by grease marks and feeler gauges in the thrown operating position.
- D. Operation of switch point shall be unrestricted and allow for smooth switch machine operation with current draw to suit WMATA's standard switch machine.
- E. Contractor's Work Trains:
  1. Contractor shall not operate his work trains over special trackwork until it has been assembled and secured in place to the satisfaction of the Engineer.
  2. Switch points shall be secured to the satisfaction of the Engineer before work trains or other on-track equipment are passed over turnouts.
- F. WMATA, or its representatives, reserve the right to visit the producers facility during usual business hours unscheduled to: a) observe panel or special trackwork assemblies and material, b) observe sampling and inspection procedures, b) obtain samples of the prepare material being produced and shipped, and c) review plant inspection methods, quality control procedures, equipment and examine inspection test results of current and previous tests.

#### **1.06 DELIVERY, STORAGE AND HANDLING**

- A. The Contractor shall handle all special trackwork materials in such a manner as to prevent damage during loading, transporting, unloading, storing and installing.

### **PART 2 - PRODUCTS**

#### **2.01 MATERIALS**

- A. The Contractor shall supply the special trackwork turnouts and crossings as listed on the Contract Drawings, including all materials necessary to provide a complete installation.

- B. The following materials in accordance with the bills of materials on the drawings for special trackwork and general track construction shall be furnished as described, including but not limited to:
1. Sub-Ballast
  2. Ballast
  3. Running Rail
  4. Track Appurtenances and Other Track Material
  5. Special Trackwork
  6. Timber Ties / Composite (Plastic) Ties
- C. Other materials:
1. Switch stands, connecting rods and associated hardware as shown on the Drawings.
  2. Furnish a dry graphite lubricant for application to the riser plates. The lubricant shall have low electrical conducting properties.
  3. Furnish switch machines, operating rods and switch machine mountings for power operated turnouts, as described in Division 16 of the Contract Specifications.
  4. Furnish all additional track materials required within the special trackwork limits to construct an acceptable, completed special trackwork structure as specified herein.

### **PART 3 - EXECUTION**

#### **3.01 GENERAL**

- A. Construction of special trackwork on ballasted track shall be as specified and shall comply with the applicable portions of Ballasted Track Construction (BTC), Section 05652.
- B. Ballasted special trackwork will be factory assembled on all switch ties. After Authority inspection and approval, the switch will be shipped in one piece, except for long ties.
- C. The remainder of the unit will be disassembled and the switch ties banded into bundles identified as to turnout, crossing and location in accordance with the special trackwork installation drawings prepared by the fabricator.
- D. Tracks through the center diamond of crossovers shown as CWR shall be high strength rail. Through main line tracks between turnouts of crossovers shown as CWR shall be standard rail.
- E. Lubrication
1. At the time of installation all sliding surfaces of special trackwork assemblies shall be lubricated with an approved dry-film graphite lubricant.
  2. Vertical switch rod clips shall be greased in accordance with the manufacturer's recommendations.
  3. The specified lubrication shall be maintained as necessary to ensure proper operation of all components throughout the duration of this Contract.
- F. Adjustments
1. The Contractor shall make all mechanical adjustments, including those required for train control and switch machine installation, as directed by the Engineer prior to the final acceptance of special trackwork to ensure that special trackwork units are in alignment to their plates and proper operating condition.
- G. Switch Machine: Switch machines and operating rods will be furnished and installed by other trades.
- H. Switch Rods: Adjust for throw **as illustrated in the contract documents**.

- I. Rail Ends: Rail ends to be connected to CWR will be drilled in the field.
- J. Joints
  - 1. All furnished joints required to assemble the turnout shall be installed by the Contractor. **All rail joint bolts are to be torqued as per specifications.**
  - 2. All joints, standard or insulated, connecting a turnout to other trackage shall be furnished and installed by the Contractor. This normally consists of one pair of joints ahead of the point of switch and two pairs of joints beyond the frog; one pair on the through track and one pair on the turnout track.

### **3.02 SUB-BALLAST**

- A. Sub-Ballast shall be as specified in Section 02726, Sub-Ballast.

### **3.03 BALLASTING**

- A. Ballast shall be uniformly tamped under both sides of each tie, directly under each running rail and for a distance of 15 inches on both sides of the rail.
- B. The top of the ballast section shall be one inch below the base of rail throughout special trackwork units except in the cribs between the point and heel of the switch rails, where the ballast level shall be three inches below the base of the rail.
- C. Additional clearance at vertical switch rods shall be provided as needed to allow unrestricted movement. The width and slope of the shoulders shall be as shown.

### **3.04 SWITCH TIES**

- A. Switch ties shall be spaced and lined as shown.
- B. Ties shall be lined at right angles to the centerline of the thru-main line tangent track.
- C. The line side for all turnout units is the side on which the straight stock rail is located. The line side for diamond units is designated by the special trackwork fabricator and indicated on his installation drawings. Tie end on the line side are the line ends.
- D. Switch tie spacing shall have a tolerance of plus or minus ½ inch with the exception of the switch machine ties which shall have a tolerance of plus or minus 1/4 inch.
- E. Ties shall be added only with approval of the Engineer.
- F. All ties will be bored for 7/8" screw spikes.
- G. The Contractor will adz switch timbers to compensate for minor warpage and thereby provide correct rail surfacing only at the Engineer's direction. Adzing shall be at no additional cost to the Authority.

### **3.05 PLATES**

- A. All plates shall be located as shown.
- B. Elastic Fastener (Pandrol) tie plates shall be used at all support locations not having special frog or switch plates or AREMA standard-gauge switch plates.

- C. All plates shown within the limits of ballasted special trackwork will be factory assembled on the switch ties.
- D. Ties will be bored to accommodate all spike locations in all plates.
- E. Where plates span two or more ties, spikes will not be installed and the plates will be shipped separate from the ties.
- F. All plates occupying one tie including standard tie plates shall be spiked to the tie.

### **3.06 SPIKING**

- A. Spiking of ballasted special trackwork shall be as specified for BTC with the following additional requirements:
  - 1. All spikes holes shall be pre-bored.
  - 2. A sufficient number of 7/8 " screw spikes are to be furnished with each turnout to complete its field assembly.

### **3.07 ANCHORING**

- A. Upon installation of the Pandrol spring clips, special trackwork units shall be considered anchored.

### **3.08 TOLERANCE**

- A. Tolerances shall conform to the AREMA Portfolio and Manual, unless modified by these specifications and drawings.
- B. The gauge, cross level, superelevation, and horizontal and vertical alignment of ballasted special trackwork shall be as shown and specified.
- C. Tolerances shall be as specified for ballasted track construction.
- D. Switch points in normal position shall be square within 5/8 inch.
- E. At the Engineer's direction, the Contractor shall be required to provide some spike lining in the pre-plated tolerances. Minor spike lining will be allowed only after the Contractor has demonstrated that the switch points and frogs have been correctly oriented. This shall be at no additional cost to the Authority.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.01 MEASUREMENT**

- A. Measurement of work specified in this Section will be made in the following manner:
  - 1. No separate measurement.

### **4.02 PAYMENT**

- A. Compensation for work specified in the Section will be made in the following manner:
  - 1. Included in the price of work of which it is a part.

**END OF SECTION**

## SECTION 05655

### SPECIAL TRACKWORK CONSTRUCTION - DIRECT FIXATION

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. The work specified in this Section shall include: the construction of direct fixation special trackwork as indicated on the Contract Drawings and as specified.

##### 1.02 RELATED SECTIONS

- A. Section 05091 - Rail Welding
- B. Section 05651 - General Track Construction
- C. Section 05653 - Direct Fixation Track Construction
- D. Section 05656 - Running Rail
- E. Section 05657 - Direct Fixation Rail Fasteners
- F. Section 05658 - Track Appurtenances and Other Track Material
- G. Section 05659 - Special Trackwork

##### 1.03 REFERENCES

- A. Pertinent provisions of the following listed standards and publications shall apply to the Work, except as they may be modified herein, and are hereby made part of these Specifications to the extent required.
  - 1. American Railway Engineering and Maintenance-of-Way Association (AREMA), Manual for Railway Engineering herein referred to as AREMA Manual (**latest edition**).
  - 2. American Railway Engineering and Maintenance-of-Way Association (AREMA), Portfolio of Trackwork Plans, herein referred to as the AREMA Portfolio (**latest edition**).

##### 1.04 SUBMITTALS

- A. The Contractor shall develop and submit for the Engineer's approval a detailed installation plan, including sketches, of all special trackwork installation. Particular emphasis should be placed on alignment and clearances, and methods of checking each.
- B. Submittals shall be as specified in Section 01300, Submittals. The following submittals shall be made by the Contractor:
  - 1. The name(s) of the suppliers and manufacturers for the special trackwork components.
  - 2. Shop drawings for the various types of special trackwork and supporting drawings.
  - 3. Installation and maintenance instructions by the manufacturer for the various trackwork components
  - 4. Detailed description of construction procedures required for the work specified in this Section submitted at least 30 calendar days before beginning the work.
  - 5. Test results required for the work specified in this Section and related work specified

- elsewhere.
- 6. Copies of AWS welder qualification certificates.

C. Shop Drawings for all Special Trackwork Construction (Direct Fixation Track) shall be transmitted with paper copies and CADD (latest version) to WMATA as per the requirements of the contract.

## 1.05 QUALITY ASSURANCE AND SAFETY

- A. In order to determine the acceptability of the installation, the Contractor shall make a survey of the special trackwork and provide the Engineer with a copy of the report. Deviations from the Drawings which exceed tolerances specified shall be corrected by Contractor at no additional cost to the Authority.
- B. Switch points shall mate and rest under the undercut stock rail and provide a continuous contact with stock rail the length of the machined point rail face adjacent to the stock rail
- C. Switch points shall bear on all slide plates as shown by grease marks and feeler gauges in the thrown operating position.
- D. Operation of switch point shall be unrestricted and allow for smooth switch machine operation with current draw to suit WMATA's standard switch machine.
- E. Contractor's Work Trains
  1. Contractor shall not operate his work trains over special trackwork until it has been assembled and secured in place to the satisfaction of the Engineer.
  2. Switch points shall be secured to the satisfaction of the Engineer before work trains or other on-track equipment are passed over turnouts.
- F. WMATA, or its representatives, reserve the right to visit the producers facility during usual business hours unscheduled to: a) observe special trackwork assemblies and material, b) observe sampling and inspection procedures, b) obtain samples of the prepare material being produced and shipped, and c) review plant inspection methods, quality control procedures, equipment and examine inspection test results of current and previous tests.

## 1.06 DELIVERY, STORAGE AND HANDLING

- A. The Contractor shall handle all special trackwork materials in such a manner as to prevent damage during loading, transporting, unloading, storing and installing.

## PART 2 - PRODUCTS

### 2.01 MATERIALS

- A. The Contractor shall supply the special trackwork turnouts and crossings as listed on the Contract Drawings, including all materials necessary to provide a complete installation.
- B. The following materials in accordance with the bills of materials on the drawings for special trackwork and general track construction shall be furnished as described, including but not limited to:
  1. Running Rail
  2. Direct Fixation Rail Fasteners
  3. Track Appurtenances and Other Track Material
  4. Special Trackwork

- C. Other materials:
  - 1. Switch stands, connecting rods and associated hardware as shown on the Drawings.
  - 2. Furnish a dry graphite lubricant for application to the riser plates. The lubricant shall have low electrical conducting properties.
  - 3. Furnish switch machines, operating rods and switch machine mountings for power operated turnouts, as described in Division 16 of the Contract Specifications.
  - 4. Furnish all additional track materials within the special trackwork limits to construct an acceptable completed special trackwork structure as specified herein.

## **PART 3 - EXECUTION**

### **3.01 GENERAL**

- A. Construction of special trackwork on direct fixation track shall be as specified and shall comply with the applicable portions of Direct Fixation Track Construction (DFTC), Section 05653.
- B. Direct fixation special trackwork will be factory pre-assembled in accordance with Special Trackwork, Section 05659, for Authority inspection and approval. The special trackwork will then be packaged and shipped in accordance with the specifications.
- C. Tracks through the center diamond of crossovers shown as CWR shall be high strength rail. Through main line tracks between turnouts of crossovers shown as CWR shall be standard rail.
- D. Lubrication
  - 1. At the time of installation all sliding surfaces of special trackwork assemblies shall be lubricated with an approved dry-film graphite lubricant.
  - 2. Vertical switch rod clips shall be greased in accordance with the manufacturer's recommendations.
  - 3. The specified lubrication shall be maintained as necessary to ensure proper operation of all components throughout the duration of this Contract.
- E. Adjustments
  - 1. The Contractor shall make all mechanical adjustments, including those required for train control and switch machine installation, as directed by the Engineer prior to the final acceptance of special trackwork to ensure that special trackwork units are in alignment to their plates and proper operating condition.
- F. Switch Machine: Switch machines and operating rods will be furnished and installed by others.
- G. Switch Rods: Adjust for throw **as illustrated in the contract documents**.
- H. Rail Ends: Rail ends to be connected to CWR will be drilled in the field.
- I. Joints
  - 1. All furnished joints required to assemble the turnout shall be installed by the Contractor. **All rail joints are to be torqued as per specifications**.
  - 2. All joints, standard or insulated, connecting a turnout to other trackage shall be furnished and installed by the Contractor. This would usually be one pair of joints ahead of the point of switch and two pairs of joints beyond the frog; one pair on the through track and one pair on the turnout track.

### **3.02 CHIPPING**

- A. Chipping of the concrete trackbed shall be as specified for DFTC.

### **3.03 PLACING OF GROUT PADS**

- A. Grout pads shall be cast in place and shall conform to the requirements shown and specified for DFTC.
- B. Grout pads shall be coordinated with the Engineer to provide clearance for ATC wayside equipment.
- C. Grout pads shall be placed prior to installation of special trackwork.

### **3.04 DRILLING ANCHOR HOLES**

- A. Anchor stud holes for special plate anchorage assemblies shall be drilled at the locations shown within a tolerance of plus or minus 1/16 inch.
- B. Insert holes for direct fixation rail fasteners within special trackwork units and holes for special plate anchorage assemblies shall be as specified for DFTC and as follows.
  - 1. Special plate anchorage assembly holes shall be drilled 4-1/2 to 5-1/2 inches deep, 1-1/8 to 1-3/4 inches in diameter, and normal to the concrete surface plus or minus one degree.
  - 2. The base plate may be used as a guide for drilling anchor bolt holes.
  - 3. All debris shall be removed.

### **3.05 SETTING ANCHOR ASSEMBLY**

- A. The Anchor Assembly for special plates shall be specified in Section 05658, Track Appurtenances and Other Track Material, and as shown. They shall be set normal to the concrete surface plus or minus one degree and shall be installed using the bolt anchoring material and procedures as specified, tested and approved for DFTC.

### **3.06 SECURING SPECIAL PLATES**

- A. During installation of special plates, anchor bolts shall be fitted with protective sleeves to prevent thread damage. Anchorages for special plates shall be assembled as shown.
- B. After the grout pads and anchoring material have attained sufficient strength as determined by the Engineer, anchor bolts shall be tightened until the spring washer coils have a gap of 0.075 inch, plus or minus 0.005 inch. The tightening shall be verified to the satisfaction of the Engineer by the use of a feeler gauge.
- C. Rail clamp bolts shall be torqued to 21,000 pounds tension. The Contractor shall furnish and calibrate torque wrenches and feeler gauges to check the torquing of anchor bolts and rail clamp bolts. Torque wrenches shall be accurate within plus or minus 10 foot-pounds. The feeler gauges and the calibration of torque wrenches shall be subject to approval.
- D. Frog guard rail plates shall be field-welded to frog plates by an AWS qualified welder.

### **3.07 DIRECT FIXATION RAIL FASTENERS**

- A. Direct fixation rail fasteners of the type shown (standard or stiff) shall be installed in special trackwork at all support locations where special plates are not shown. The installation shall comply with the requirements for DFTC.

### **3.08 TOLERANCES**

- A. Tolerances shall conform to the AREMA Portfolio and Manual, unless modified by these specifications and drawings.
- B. The final gauge, cross level, superelevation, horizontal alignment and vertical alignment of direct fixation special trackwork shall be as specified for direct fixation track construction for GTC.
- C. Tolerances shall be as specified for direct fixation track construction.
- D. Switch points in normal position shall be square within 5/8 inch.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.01 MEASUREMENT**

- A. Measurement of work specified in this Section will be made in the following manner:
  - 1. No separate measurement.

### **4.02 PAYMENT**

- A. Compensation for work specified in the Section will be made in the following manner:
  - 1. Included in the price of work of which it is a part.

**END OF SECTION**



## SECTION 05656

### RUNNING RAIL

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies manufacture and delivery of standard and head hardened (high strength) 115RE steel running rail for use in transit track.

##### 1.02 RELATED SECTIONS

- A. Section 05091 - Rail Welding
- B. Section 05651 - General Track Construction
- C. Section 05652 - Ballasted Track Construction
- D. Section 05653 - Direct Fixation Track Construction
- E. Section 05654 - Special Trackwork Construction - Ballasted
- F. Section 05655 - Special Trackwork Construction - Direct Fixation
- G. Section 05658 - Track Appurtenances and Other Track Material (OTM)
- H. Section 05659 - Special Trackwork

##### 1.03 REFERENCE STANDARDS

- A. Work shall be performed in accordance with the following applicable Codes, Regulations, Reference Standards and Specifications.
  - 1. The American Railway Engineering and Maintenance-of-Way Association (AREMA), Manual for Railway Engineering, herein referred to as the AREMA Manual, Volume 1, Chapter 4, Rail (latest edition).
  - 2. American Society for Testing and Materials (ASTM)
    - a. ASTM E10 Standard Method of Brinell Hardness for Metallic Materials
    - b. ASTM A578 Ultrasonic Testing

##### 1.04 SUBMITTALS

- A. Submit to the Engineer a description of the method of transport for approval prior to shipment.
- B. Mill Inspection:
  - 1. Make specified tests and inspections at the mill prior to shipment.
  - 2. **Submit to the WMATA Engineer all information required of the Steel Rail Inspection Form shown in Exhibit A.**
  - 3. Provide free access for the **WMATA** Engineer to all fabrication and test facilities where work is being performed for this Contract.
- C. Provide rail test records, including mechanical properties tests, hardness measurements, ultrasonic test records and all other required test documentation, for informal review during the in-plant inspection.

## 1.05 QUALITY CONTROL

- A. Develop and maintain a quality control program regulating methods, procedures, and processes to ensure compliance with standards of quality required by the Contract Documents.
- B. Within 30 days after the effective date of the Notice of Proceed, submit for approval of the WMATA Project Manager a detailed narrative explaining the Quality Control program and procedures to be utilized for the work and a description of the organization to be used on the Contract.
- C. Records of all inspection work by the Contractor shall be kept complete and available to the Engineer during the performance of the Contract; and to such other agencies and for longer periods as may be specified elsewhere in the Contract.
- D. Perform all tests and analyses specified in Chapter 4 of the AREMA Manual and submit the results in accordance with this Section.
- E. Ultrasonically test all rail for internal defects in accordance with ASTM A578.
- F. Testing shall conform to the requirements of the AREMA Specifications for Steel Rails
- G. Make all rail tests and inspections at the mill prior to shipment. Assume full responsibility for all testing indicated. Give the Engineer sufficient notice when testing in any form is proposed so he may witness the tests.
- H. Provide the Engineer free entry at all times to the manufacturer's mill to inspect the processing and testing of rail while work on this Contract is being performed.
- I. Perform all tests specified herein at no additional cost.
- J. Testing must be witnessed and certified by a qualified independent testing firm or individual.
- K. **Qualification of Testing Personnel:**
  - 1. Personnel performing tests and inspections shall be qualified for such work by virtue of prior experience or training.
  - 2. Personnel performing nondestructive testing shall be qualified and certified in accordance with SNT-TC-1A. Only persons certified for NDT Level I and working under a NDT Level II person or persons certified for NDT Level II shall perform nondestructive testing.
- L. **Testing Equipment.** Testing equipment shall be in good operating condition, of adequate capacity and range, and accurately calibrated. Testing equipment calibration shall be certified and traceable to recognized national standards such as the National Institute of Standards and Technology. Such certified calibration test reports must be made available to the Engineer upon request.
- M. **Test Report.**
  - 1. A report of test results of each test shall be submitted which includes rail section, rail type, heat number, test name, identity of test sample, test procedure references, specified requirements, actual test results, non-conformance if any, and interpretation of the results. The format for the test report shall be arranged so that the data is presented in an orderly manner.
  - 2. The rail mill's standards, computer generated, test reports may be used.

3. Copies of calibration certificates shall be submitted with the initial test reports. If test equipment is recalibrated while work is being performed, calibration certificates shall be submitted for the recalibrated test equipment with test reports of the first tests performed after recalibration. In lieu of submitting calibration certificates, the manufacturer may maintain the certificates at its facility available to the Engineer at all times during the performance of the contract and for a three year retention period thereafter.
- N. The Engineer shall be notified in writing not less than ten (10) business days in advance of dates scheduled for any tests or inspections. The Engineer retains the right to witness the tests or conduct visual inspection prior to rail loading at the plant.

## 1.06 DELIVERY, HANDLING AND STORAGE

- A. Handle rails carefully to avoid damage.
- B. Load rail head up with the branding on all rails facing in the same direction.
- C. Sort and load rails together according to their markings. Do not intermix rails of different markings in loading. If there are not sufficient rails of one marking for a full car, smaller groups consisting of tiers of different markings may be loaded onto one car.
- D. Load all rails of the same radius together in the same or adjacent tiers.
- E. Load rails with adequate wood strips between the tiers or rail to prevent damage in transit.
- F. Delivery shall be F.O.B. job site in the Washington Metropolitan Area as directed by the Engineer.

## PART 2 - PRODUCTS

### 2.01 RAIL

- A. Standard Rail
  1. Rail Section and Weight shall be new 115 RE rail section, and shall be in conformance with AREMA Recommended Rail Sections, 115 RE Rail Section and Specifications for Steel Rails, **latest edition**.
  2. Rail shall be suitable for joining into continuous welded strings using both electric flashbutt and exothermic welding methods.
  3. The steel shall be cast by a continuous casting process, or by other methods approved by the Engineer.
  4. Length:
    - a. The standard length of rails shall be either 78 or 80 feet, **or as specified**.
    - b. Up to 10 percent of the total tonnage accepted for each individual rolling will be accepted for each individual rolling will be accepted in shorter lengths of 79, 78, 77, 75, 70, 65 and 60 feet.
- B. High Strength (Head Hardened) Rail
  1. High strength rail shall meet all of the requirements of Standard Rail and as follows:
    - a. High strength rail shall be either head hardened or fully heat treated.
    - b. High strength rail shall conform to all requirements for high strength rail specified in the AREMA Manual for Railway Engineering, Chapter 4 (**latest addition**).

- c. Rails shall have a Brinell Hardness between 341 and 397 BHN. A maximum hardness of 410 BHN may be exceeded in accordance with AREMA rail standards; however, if 410 BHN is exceeded, the manufacturer must examine the microstructure in the head, at 100X or higher, and confirm that a fully fine pearlitic microstructure is maintained and demonstrated in the head with certified test results. The manufacturer is to provide certified test results, prior to shipment and acceptance, for any BHN Brinell Hardness exceeding 410 BHN.
- d. Minimum tensile strength: 140,000 psi.
- e. Minimum yield strength: 95,000 psi.
- f. No untempered martensite shall be present within the rail.

### **PART 3 - EXECUTION**

#### **3.01 GENERAL**

- A. A mill certificate shall be furnished to the Engineer containing the following data:
  - 1. The identity of each rail in a charge by heat, ingot and letter.
  - 2. The identity of each equivalent sample by heat.
  - 3. The dates of all phases of heat treatment for each charge.
  - 4. A listing of the accepted and rejected rail in each charge.
  - 5. Rail section and type.
  - 6. Number of pieces in each heat.
  - 7. Chemical analysis.
  - 8. List of Brinell Hardness readings.
  - 9. Ultrasonic test results.
  - 10. Macrotech test results.
  - 11. Submit a storage procedure covering, as a minimum, the following subjects for storage of running rail at the manufacturer's facility:
    - a. Handling methods in and out of storage, including crane and details of lifting rig.
    - b. Environmental conditions.
    - c. Inventory control procedures.
    - d. Security of stored materials.
- B. Product Data and Test Program. Submit the following for review and approval by the Engineer prior to rail production in accordance with the approved schedule:
  - 1. Steel manufacture process description for making and casting or teaming the steel.
  - 2. Hydrogen elimination process description for hydrogen elimination.
  - 3. Production records and production test results. Submit the following for review and approval by the engineer at the time of each shipment.
  - 4. Rail inspection results for each test and inspection specified by AREMA and herein.

### **PART 4 - MEASUREMENT AND PAYMENT**

#### **4.01 MEASUREMENT**

- A. Measurement of work specified in this Section will be made in the following manner:
  - 1. No separate measurement.

#### **4.02 PAYMENT**

- A. Compensation for work specified in the Section will be made in the following manner:
  - 1. Included in the price of work of which it is a part.

**END OF SECTION**



## SECTION 05657

### DIRECT FIXATION RAIL FASTENERS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. Work under this Section covers furnishing all labor, materials, and equipment for the manufacture, testing, fabrication and delivery of direct fixation rail fasteners for installation in underground box structures, aerial structures and at-grade slabs. **Specification and supply of these fasteners does not include rail clips and anchor bolt assemblies.**

##### 1.02 RELATED SECTIONS

- A. Section 05651 - General Track Construction
- B. Section 05653 - Direct Fixation Track Construction
- C. Section 05655 - Special Trackwork Construction - Direct Fixation
- D. Section 05656 - Running Rail

##### 1.03 REFERENCES

- A. American Society for Testing and Materials (ASTM)
  - ASTM A325
  - ASTM A536
  - ASTM A563
  - ASTM A615
  - ASTM B117
  - ASTM B633
  - ASTM C31
  - ASTM C39
  - ASTM C172
  - ASTM D257
  - ASTM D297
  - ASTM D395
  - ASTM D412
  - ASTM D429
  - ASTM D471
  - ASTM D518
  - ASTM D570
  - ASTM D573
  - ASTM D624
  - ASTM D1149
  - ASTM D1229
  - ASTM D2084
  - ASTM D2240
  - ASTM E10
  - ASTM E18
  - ASTM E23
  - ASTM E162
  - ASTM E320

- B. Rubber Manufacturers Association (RMA) Handbook  
RMA Publication Rubbers Handbook
- C. Society of Automotive Engineers (SAE)  
SAE J434

#### 1.04 SUBMITTALS

- A. Contractor's Shop Drawings and Data
  - 1. Submittals shall be as specified in Section 01300: Submittals
  - 2. Submit Shop Drawings and other data, including design calculations, which are required by the Specifications or which are necessary to adequately perform the work. Shop Drawings are to be complete and detailed.
  - 3. Submit all drawings, data and schedules in accordance with the specified time requirements. If time requirements are not specified, submit in timely manner to permit no less than 21 days for appropriate review by the WMATA Engineer.
  - 4. Contractor submittals shall be checked, coordinated, and approved by the Contractor before they are submitted for the approval of the Engineer. Submittals lacking Contractor's approval may be returned to the Contractor for resubmission.
- B. Samples:
  - 1. Unless otherwise indicated, submit not less than two identical samples of the direct fixation fastener.
  - 2. Label each sample indicating:
    - a. Contract Name and Number.
    - b. Name of Contractor and Subcontractor.
    - c. Material or equipment represented.
    - d. Source.
    - e. Name of producer and brand.
    - f. Reference Specifications Section and Article Number.
- C. Quality Control Program Plans
  - 1. Quality assurance/control plan as specified herein.
  - 2. Test program plan as specified herein.
- D. Qualification Test Results
  - 1. Submit the following for review and approval prior to commencing fastener manufacture.
    - a. Certification of the elastomer samples used in the qualification testing.
    - b. Elastomer qualification test results for each test specified herein.
    - c. Fastener body metal qualification test results for each test specified herein.
  - 2. Submit qualification test results within 14 days after completing of testing. Submit elastomer certification with the elastomer qualification test results.
- E. Production Test Results
  - 1. Submit the following for review and approval prior to shipping each fastener production lot.
    - a. Certification of the elastomer samples used in the production testing of each production lot as detailed herein.
    - b. Elastomer production test results for each test specified herein.
    - c. Fastener production test results for each test specified herein.
- F. Submit the method and materials of packaging for shipment and storage no later than 60 days prior to the initial shipment.

## 1.05 QUALITY CONTROL

- A. Develop and maintain a quality control program regulating methods, procedures, and processes to ensure compliance with standards of quality required by the Contract Documents.
- B. Within 30 days after the effective date of the Notice to Proceed, submit for approval of the Project Manager a detailed narrative explaining the Quality Control Program and procedures to be utilized for the work and a description of the organization to be used on the Contract. All work undertaken by the Contractor before approval of his quality control program will be at the Contractor's risk. The Project Manager will monitor the Contractor's methods, procedures, and processes for compliance with the approved program.
- C. Keep complete records of all inspection work by the Contractor available to the Project Manager during the performance of the Contract; and to such other agencies and for longer periods as may be specified elsewhere in the Contract.
- D. **WMATA, or its representatives, reserve the right to visit the producers facility during usual business hours unscheduled to a) observe sampling and testing procedures, b) obtain samples of the prepare material being produced and shipped, and c) review plant inspection methods, quality control procedures, equipment and examine test results of current and previous tests.**

## 1.06 DESIGN REQUIREMENTS

- A. The direct fixation rail fasteners shall have the following primary functions:
  - 1. Support the running rail and secure it to the concrete trackbed using the minimum number of parts possible.
  - 2. Provide vertical, lateral and longitudinal stability, and provide for vertical and lateral adjustments.
  - 3. Provide a specific longitudinal restraint.
  - 4. Provide electric insulation for the rail, thus isolating it from the concrete trackbed.
  - 5. Isolate vibrations and attenuate noise generated by the moving wheel of the vehicles on the rails.
- B. Fastener and Its Components:
  - 1. The fastener shall be for 115 RE Rail section.
  - 2. The rail hold-down spring clips shall be considered part of the fastener.
  - 3. The body of the fastener is a metal base element and a metal top element with an elastomeric pad bonded between them. Bonding shall occur during the vulcanization process.
  - 4. **The fastener body anchorage assembly shall be comprised of two female type anchorage inserts for embedment into the epoxy grout on a concrete track bed and two anchor bolts for securing the fastener body to the anchor inserts and to the concrete track bed.**  
**The fastener body anchorage design shall not pass through the top plate and shall anchor thru the bottom plate only.**
  - 5. **The rail hold down assemblies shall be designed so that when removed, the rail may be lifted vertically until it is completely free of the rail fastener without disturbing the horizontal or vertical alignment of the rail fastener body.**
  - 6. **The rail fastener body design shall provide on each side of the rail base a positive means of preventing more than 1/8 inch total lateral movement of the rail base relative to the fastener in event of failure or loosening of one or both rail hold-down assemblies.**

The design feature shall be integral cast into the top plate component at a minimum height of 9/32 inches from the top of the rail seat and shall extend across the entire width of the fastener body in the direction longitudinal to the running rail on both field and gage sides.

7. The rail hold-down assembly device shall not be dependent on elastomeric components in torsion.
8. Bonding of any part of the rail fastener to the grout pad will not be permitted.
9. Longitudinal and lateral restraint properties of the rail fastener shall be identical in both directions
10. The stability of the rail fastener in the lateral direction shall not be dependent solely upon the strength of the bond of the elastomer to metal.
11. Molding:
  - a. Contractor's name or trademark shall be molded into the elastomer.
  - b. Each cavity in a mold shall have a cavity identification mark which is molded into the elastomer. If more than one mold is used, then each cavity in a mold shall have a mold identification mark which is molded into the elastomer.
  - c. Each molding cycle which produces one or less fasteners from each cavity in a mold is a heat.
  - d. Consecutive heats from a mold shall be numbered consecutively.
  - e. The elastomer's production batch number and the heat number shall be marked on each fastener in a permanent manner. The marking shall be visible in the installed position.
  - f. The location and method of marking of identification data shall be shown on a shop drawing.
  - g. In an orderly manner, each mold/heat/cavity permutation shall be assigned a unique sequential part number and part numbers shall be assigned to lots.
  - h. A tabulation of lot, part, batch, mold, heat and cavity shall be developed as part of the Quality Assurance Program.
12. Welding shall not be used.
13. The base of the fastener is parallel to the rail seat so as to provide no cant to the rail. The slope tolerance is plus and minus 0.37%. The rail seat area is flat having maximum convexity and concavity of less than 0.001 inch per inch when measured from a straight edge.
14. Anchor bolts
  - a. The fastener includes anchor bolts, 7/8 inch in diameter, for securing the fastener to the concrete trackbed under a tension of 30,000 pounds per anchor bolt.
  - b. The anchor bolts will be threaded into female threaded inserts set in the concrete trackbed.
  - c. Anchor bolts, including washers, and threaded inserts shall be considered parts of the fastener.
  - d. The fastener is also capable of being anchored by placement over 7/8 - inch threaded studs.
  - e. The anchor bolts engage not less than one inch and not more than one and one -half inches of the threaded insert in the installed position.
  - f. Other than the standard protective coating applied by the bolt and insert manufacturers, no oil, sealant or other compound shall be applied to the threads.
15. The bottom of the base element shall be free of elastomer except that minimal flashing will be acceptable providing it does not interfere with retention of proper anchor bolt tension.

16. Except as required to meet other requirements specified herein, elastomer surfaces shall be smooth with a finish and appearance equal to or better than an F-3 designation in accordance with the RMA Handbook.
17. The rail fastener shall be comprised of as few components as is economically and technically feasible for ease of assembly, disassembly and maintenance, and shall be designed to permit installation and replacement of the entire assembly or any of its components by one man using standard, ~~conventional hand tools~~ **by one man using conventional hand tools.**
18. ~~The overall distance between the base of the rail fastener and the base of the rail with the rail fastener in the installed position shall be 1-1/2 inches (desired) with 1-3/8" minimum and 1-3/4" maximum distances.~~
19. ~~When completely assembled, the overall dimension of the rail fastener, including the elastomer, shall stay within a design envelope of 10 inches maximum in width measured parallel to the rail and 18 inches in length measured normal to the rail.~~
20. ~~The fastener body anchorage assembly shall provide for two anchor bolts, each 7/8 inch in diameter, for securing the fastener to the epoxy grout pad and concrete track bed. The anchor bolts shall be symmetrically located as shown in Figure A with respect to the rail fastener body center lines. As shown in **Exhibit A** the anchorage assembly bolts shall be located in the upper right-hand quadrant and low left-hand quadrant of the rail fastener as referenced along the centerline of rail. The rail fastener shall also be designed to be capable of being anchored by placement over existing 7/8-inch threaded stud bolts in lieu of the anchor bolts and female anchor inserts. The adjustment washers shall be designed so that they can be used for either the anchor bolts or the threaded studs.~~
21. ~~The underside of the rail fastener body shall be a flat, continuous plane with no projections below the top of the grout pad.~~
22. ~~No portion of the completely assembled rail fastener, including the rail clips and anchor bolts, shall extend any higher than 3-1/2 inches measured vertically from the base of the rail centerline.~~
23. ~~Recesses in the rail fastener shall be free draining in all positions of lateral adjustment up to a maximum actual superelevation of 4-1/2 inches.~~
24. ~~The rail fastener body shall provide an electrical leakage distance of not less than 1-1/8 inch measured from the grounded portion of the fastener to the charged portion by the most direct path that does not pass through an insulating material. The minimum distance of separation between any point of the top plate to the bottom plate shall be 1/2 inch and shall contain a full and complete section of elastomer material. The entire top and side surfaces of the metal plates of the fastener body shall contain a minimum coating of 1/16 inch, exclusive of the serrated area of the fastener body anchorage location.~~

C. Damping of Force

1. The direct fixation rail fastener shall be designed to provide damping of lateral and vertical forces transferred to anchor bolts
2. The fastener plates shall have full bearing on the elastomer in all positions of lateral adjustment and shall have a means of preventing displacement of the elastomer under operating conditions
3. The stability of the fastener in any direction shall not be dependent solely upon the strength of any bonding of the elastomer to metal.

D. Adjustment Requirement.

1. Lateral Adjustment:
2. ~~The rail fastener shall provide a minimum of plus or minus 1/2 inch rail lateral adjustment in 1/8 inch increments. All lateral adjustment shall be provided at the anchor bolts.~~

The rail fastener body shall provide a means of 1" total lateral adjustment having a range of plus or minus ½ inch via a serrated mechanism at each anchor location. Serration shall be vertical, a minimum of 5/32" high, and integrally cast into the bottom plate. The bottom of the vertical serration shall be raised a minimum of 1/8 inches above the top of the bottom plate. Together with a serrated adjustment washer, the system shall allow adjustment in either lateral direction in increments of 1/8". Friction alone as a means of adjustment will not be permitted. The serration shall have not less than three interlocking serrations engaged in any position of lateral adjustment. The adjustment feature shall be integral with the rail anchorage assemblies.

2. Friction shall not be used as a means for adjustment or for preventing lateral movement.
3. If lateral adjustment employs serrations on any component, each serrated interface shall have at least three engaged serrations. There shall be a minimum of three linear inches of serration engagement per fastener. Serrations shall be machined or cast to a minimum depth of 1/16 inch. Cap plates, if used, shall cover the opening to any ground potential in every position of adjustment and form a reasonable seal to prevent the intrusion of dirt, metallic particles, and other material.
4. Each rail fastener shall be furnished with all components required for all specified increments of lateral adjustment. Components of the rail fastener shall not be replaced or added to the basic configuration in order to laterally adjust the rail.

E. Vertical Adjustment:

1. Vertical rail adjustment capability shall be a minimum of ½ inch in 1/16 inch increments, provided by shims.
2. All requirements of these Specifications shall be satisfied for all increments of fastener adjustment.

## 1.07 FASTENER QUALIFICATION TESTING

A. General:

1. The qualification tests specified herein shall be performed by an independent testing facility approved by the WMATA Engineer and shall be a member of the American Council of Independent Laboratories. Qualification testing may be performed at any test facility, including such facilities at the contractor's plant, provided they meet the approval of the WMATA Engineer and satisfy the requirements of the American Council of Independent Laboratories "Manual of Practice, Quality Control System" - Requirements for Testing and Inspection Laboratory, and ASTM E320. Testing equipment shall be in good repair, of adequate capacity and shall be accurately calibrated. Copies of calibration certificates shall be submitted to the WMATA Engineer. The WMATA Engineer shall be notified not less than 14 days in advance of dates scheduled for quality control tests. All testing shall be performed at no additional cost to the Authority and is to be performed post-award and prior to manufacture of production quantities. Previously approved and supplied product design meeting the requirements of this specification shall be exempt from the Qualification Testing. Production Testing as specified shall be performed.
2. Prior to testing, the Contractor shall submit shop drawings detailing the rail fastener components and a detailed description of the steps required for its complete installation as well as the replacement of individual components. Upon approval by the WMATA Engineer of the shop drawings and installation description, rail fasteners shall be fabricated for testing.
3. Before beginning any tests, a detailed description of all tests shall be submitted to the WMATA Engineer for approval. The description shall completely detail the test procedure and shall include drawings showing the relationship of the fastener and all significant components of the testing equipment, including the test block and anchor bolts.

4. From a lot of not less than twenty standard direct fixation fasteners, sixteen will be selected at random by the WMATA Engineer. If additional fasteners are necessary to meet these test requirements they shall be furnished at no additional cost to the Authority.
5. Each of the fasteners selected for testing shall be carefully measured and examined to determine the compliance with these specifications and the approved shop drawings.  
Upon satisfactory completion of this examination eight fasteners will be retained by the Authority and the remaining eight fasteners shall be returned to the Contractor for execution of the Qualification Performance Tests by an independent laboratory.
6. Except as otherwise specified herein, each test shall be performed on two completely assembled rail fasteners at thirty inch center-to-center spacing, with a section of 115RE rail not less than 42 inches long mounted and clipped thereon. Before assembly, all parts shall be cleaned and dried. The fastener shall be assembled as shown in the approved shop drawings and installation description, and all threaded elements shall be tensioned as specified. The test fasteners shall be mounted on a concrete test block and anchored with 7/8 inch diameter ASTM A325, "Standard Specifications for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength", threaded stud bolts to simulate field installation. The anchorage shall not fail under loadings imposed by any test specified below.
7. The concrete test block shall be reinforced concrete with dimensions as shown on **Exhibit D**.  
The concrete shall have a minimum 28 day strength of 4,000 pounds per square inch as determined by ASTM C39, "Compressive Strength of Cylindrical Concrete Specimens". The reinforcing steel shall be Grade 60 per ASTM A615, "Standard Specifications for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement".
8. Two pairs of threaded stud bolts shall be drilled and epoxied into the concrete test block. The stud bolts shall project 3-1/2 inches out from the top surface of the concrete. The stud bolts shall be positioned as they would be in track for two fasteners 30 inches apart measured parallel to the rail. The holes for the dowels shall be 1-1/8 to 1-3/4 inch diameter and 5-1/2 inches deep. The epoxy to be used shall provide a minimum unrestrained pullout strength of 20,000 pounds. As an alternate, the stud bolts may be replaced with 7/8 inch anchor bolts and female inserts epoxy grouted into the concrete block.
9. Before commencing any tests the rail fastener(s) shall be stabilized at a temperature of 24 degrees C, plus or minus 6 degrees C for a minimum of four hours.
10. Should any fastener assembly fail a test, perform the entire sequence of test on the eight new fastener assemblies. Should a fastener assembly from a sample lot fail a test, the entire lot is rejected and the Contractor is to provide a new random sample lot to the WMATA Engineer, from which a sample of eight fasteners will be returned to the Contractor for testing by the independent laboratory. If the design of the fastener must be modified to pass any test, shop drawings of the new design shall be submitted to and approved by the WMATA Engineer before retesting is continued. Manufacture at least ten fastener assemblies of the new design and perform all tests on the new fastener design. Continue the revision, approval and test cycle until the fastener assemblies are accepted. Four (4) weeks is allotted for redesign, approval, and testing commencement. The Authority reserves the right to terminate the contract for default should the Contractor fail to develop an approved fastener within a reasonable amount of time after award so as to prevent their capability of complying with the delivery schedule.

#### **1.08 ELASTOMER QUALIFICATION TESTING**

1. Each test listed below shall be performed on two specimens.
2. The specimens used for the test shall be certified by the Contractor to have been taken from the production size batch used for making the fastener and to have cured in a manner equivalent to the cure used for the fastener.

3. Prior to the testing, all elastomer specimens shall be conditioned for not less than two days at 23 degree C plus or minus 2 degree C and 50% plus or minus 5% relative humidity
4. Tests performed on specimens are:
  - a. **Hardness Test** - The Durometer A hardness shall be between 45 and 55 as measured in accordance with ASTM D2240, "**Indentation Hardness of Rubber and Plastics by Means of a Durometer**".
  - b. **Tensile Strength and Ultimate Elongation Test** - When tested in accordance with ASTM D412, "**Tension Testing of Vulcanized Rubber**", the tensile strength shall be 2,350 psi or greater and the ultimate elongation shall be ~~500-~~ 400 percent or greater.
  - c. **Compression Test** - The elastomer shall be tested for 22 hours in accordance with ASTM D395, Method B **to determine the percent of compression set**. The test shall be conducted at 70 degree C. And the set shall not exceed 25 percent.
  - d. **Accelerated Aging of Rubber Test** - In accordance with ASTM D573, "**Accelerated Aging of Vulcanized Rubber**", the test sample shall be aged for 70 hours at 70 degree C. The percentage of decrease of tensile strength shall not exceed 25 percent; the percentage of decrease of ultimate elongation shall not exceed 25 percent; and the change in hardness, measured on the Durometer A scale, shall not exceed 10 points.
  - e. **Resistance to Ozone Cracking Test** - Test specimens shall be prepared in accordance with **Procedure A of ASTM D518, "Resistance to Surface Cracking of Stretched Rubber Components"**. The test specimens shall be tested in accordance with ASTM D1149, "**Accelerated Ozone Cracking of Vulcanized Rubber**", at a temperature of 40 degree C and at an ozone partial pressure of 50 mPa. The elastomer shall not exhibit any cracking when examined in accordance with ASTM D1149 at the end of a 100-hour exposure.
  - f. **Compression Set at Low Temperature Test** - When tested at minus 10 degree C for 70 hours in accordance with ASTM D1229, "**Low Temperature Compression Set of Vulcanized Elastomers**", the compression set at 30 minutes after release (t@30 reading) shall not exceed 37 percent
  - g. **Oil Absorption Test** -
    - 1) One test shall be conducted with **IRM 903** (No. 3) oil at 23 degree C for 70 hours. The volume change for the No. 3 oil shall not exceed 60 percent.
    - 2) A second test using a different sample shall be conducted with **IRM 903** (No. 1) oil at 23 degree C for 70 hours in accordance with ASTM D471, "**Change in Properties of Elastomeric Vulcanizates Resulting from Immersion in Liquids**", to determine the volume change of the elastomer. The volume change for the No. 1 oil shall not exceed 10 percent.
  - h. **Adhesion to Metal Test** - This test shall be performed on specimens of elastomer which are to be bonded in the finished fastener in accordance with ASTM D429, **Method A, "Adhesion of Vulcanized Rubber to Metal"**, the failure must be entirely Type R (eg. **Elastomer tears before bond fails**). The metal substrate, preparation, adhesive and bonding process shall be the same as that used for the manufacture of the direct fixation rail fastener.
  - i. **Resistance to Tearing Test** - When tested in accordance with ASTM D624, "**Standard Test Method for Rubber Property - Tear Resistance**", the resistance to tearing shall be not less than 100 pounds per inch.
  - j. **Flame Spread and Smoke Generation Test** - The elastomer shall be tested in accordance with ASTM E162, "**Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source**", to determine the Flame Spread Index<sub>s</sub>.

The elastomer shall be tested in accordance with NFPA No. 258-1982, Smoke Generated by Solid Materials Test, in both the flaming and nonflaming modes to determine the Smoke Generation Specific Optical Index,  $D_s$ . The elastomer shall not exhibit any flaming drippings when tested. No acceptance criteria are specified for the Flame Spread Index,  $L_s$  and the Smoke Generation Specific Optical Index,  $D_s$ . These indices shall be reported to the Authority for information only.

k. **Electrical Resistivity Test - Prepare a fully assembled fastener and apply 500 V dc. to the rail head for three minutes with all anchor bolts and metal base elements grounded. The elastomer shall be tested and measured in accordance with ASTM D257 "Standard Test Method for D-C Resistance or Conductance of Insulating Materials", to determine the resistivity of the elastomer. Next, remove the fastener from the test block and immerse it in potable water for 70 hours at 70 degrees C. Immediately after removal from the water immersion, without drying and with no portion of the fastener less than 35 degrees C, reinstall the fastener on the test block and test for electrical resistance and impedance. For testing under wet conditions, immerse elastomer in potable water with a resistivity of 1,000 to 1,500 ohm-cm. Adjust resistivity of potable water if required by addition of sodium chloride. The minimum volume resistivity under dry condition shall be  $10^{12}$ -ohm-cm and  $10^{11}$ -ohm-cm under wet condition.**

l. **Water Absorption Test - The elastomer shall be tested in accordance with ASTM D570, "Standard Test Method for Water Absorption of Plastics", to determine the change in weight of elastomer due to absorption of water. Immerse specimens in distilled water for 24 hours at a temperature of 23 degree C prior to testing. The elastomer shall have a maximum increase in weight of 1.0 percent.**

~~5. When tested in a Monsanto Oscillating Disk Rheometer the rheology data shall fall within the limits shown on Exhibit H~~

~~6. When tested with a Fisher-Young Gravitometer, the specific gravity shall be 1.19 plus or minus 0.2.~~

l. **Rheology (Cure and Strength Indicator) Test -**

- 1) Test the elastomer in accordance with ASTM D2084.
- 2) During qualification testing a cure curve shall be developed based on the rheology test results for approval by the WMATA Engineer. Specification limits shall be established at several points along the curve for approval by the WMATA Engineer.
- 3) During production testing the cure curves shall be compared to the qualification test cure curve. The production test curve shall be within the specification limits.

m. **Specific Gravity Test -**

- 1) Test the elastomer in accordance with ASTM D297
- 2) During the qualification testing the specific gravity of the elastomer shall be determined. During the production testing the specific gravity shall be plus or minus 0.02 of the specific gravity determined during the qualification testing.

## **1.09 FASTENER BODY METAL QUALIFICATION TESTING**

A. Prepare three Charpy impact test specimens in accordance with ASTM E23, "Standard Method for Notched Bar Impact Testing of Metallic Materials", from the same metal used for the top and bottom plates of the fastener body. Each metal sample shall have met the minimum impact requirements and be approved by the WMATA Engineer before fastener assembly qualification testing proceeds.

- B. Conduct a Charpy impact test on each specimen at a temperature of 21 degree C in accordance with ASTM E23. The fracture energy shall be greater than three foot-pounds. The test report shall include all the information required by ASTM E23. The fracture energy shall be greater than 3 foot-pounds for irons and 15 foot-pounds for steel.
- C. High Frequency Resonance Test
  - 1. Suspend the top plate with a nylon, hemp, polyethylene or cotton rope, or an elastomer band of sufficient strength to support the top plate without failure. Mount an accelerometer of mass not greater than 0.05 kg at the center of the rail seat area, with an axis of sensitivity normal to the rail seat. The accelerometer signal shall be appropriately conditioned with a charge amplifier or voltage preamplifier and analyzed with a minimum 400 line spectrum analyzer, while striking an end of the top plate with a hammer in a direction normal to the rail seat plane.
  - 2. The frequencies of the top plate's modes of vibration, identified by maxima in the spectrum of the response of the top plate to hammer impacts, shall be greater than 600 Hz.

## 1.10 FASTENER ASSEMBLY TESTING

- A. Test Sequence:
  - 1. Eight (8) complete rail fastener assemblies are required to conduct the tests. Assemble and mount two fasteners on each concrete block designated as A, B, C, and D. The set of fasteners shall be subjected to the following tests as specified below. All fasteners shall be subjected to each of the static tests as specified below:
  - 2. Fasteners A shall undergo the Vertical and Lateral Repeated Load Test and then undergo the Repeated Load Test With One Anchor Bolt. Fasteners A shall then again undergo each Static Test without replacement of any component. For the Longitudinal Restraint Test, the fasteners shall not be disassembled from the rail after the Repeated Load Test with One Anchor Bolt, nor shall the rail hold down assemblies be re-torqued.
  - 3. Fastener B shall be subjected to Dynamic to Static Stiffness Ratio Test, then undergo Heat Aging Process, and then retested through each of the Static Tests without replacement of any component followed by another Dynamic to Static Stiffness Ratio Test.
  - 4. Fasteners C shall be undergo Heat Aging Process and then tested for Uplift Repeated Load Test followed by Corrosion Process. Fasteners C shall then be retested through each of the Static Tests without replacement of any component.
  - 5. Fasteners D shall be tested as specified below for the Push-Pull Test. Fasteners D shall then be retested through each of the tests for Static Tests, without replacement of any component. For the Longitudinal Restraint Test, the fasteners shall not be disassembled from the rail after the Push-Pull Test, nor shall the rail hold down assemblies be re-torqued.
- B.. The sequence shall be performed without replacement of any fastener component. ~~Components may be reset and/or tightened after the Repeated Load Test, Push-Pull Test and Longitudinal Restraint Test.~~
- C. Static Tests:
  - 1. Vertical Load Test - A vertical load increasing in increments of 2,000 pounds to a maximum load of 32,000 pounds shall be applied downward at the center of the rail head midway between the two fasteners and normal to the rail.

The load shall be applied at the rate of not less than 200 pounds per minute nor more than 2000 pounds per minute. For each increment of load the vertical deflection of the rail head shall be measured to the nearest 0.001 inch and recorded. The load shall be removed and the final position of the rail head measured and recorded. The recorded values for vertical load vs. deflection shall be plotted on a graph as shown on Exhibit F.

Acceptance Criteria -

- a. Calculate the fastener stiffness as the slope of a straight line determined by a linear least-squares regression of the load per fastener versus each deflection for load per fastener between 4,000 pounds and 12,000 pounds. The fastener stiffness shall be within 15 percent of 140,000 pounds per inch. The load versus displacement curve shall be within the limits identified in Exhibit F.
- b. The tangent to load-versus-deflection curve at each load between and including 4,000 pounds and 12,000 pounds per fastener shall be within 10 percent of the fastener stiffness determined above. For the purpose of calculation, the tangent to the load versus deflection curve at each deflection,  $X_n$ , and each load,  $P_n$ , are approximated as:

$$(P_{n+1} - P_{n-1}) / (X_{n+1} - X_{n-1})$$

where P is the load at deflection  $X_n$ .

- c. Total deflection of the elastomer at the 15,000 pound load per fastener shall not exceed 25 percent of the uncompressed thickness. After removal of the maximum load, the fastener shall return to within 0.005 inch of its original position within one minute.  
At no time during the tests shall a fastener component exhibit any sign of failure by slippage, yielding, fracture, or bond failure.
- d. Values obtained when this test is repeated, after performance of other tests, shall be within 20 percent of the initial test values.

2. Vertical Uplift Test - A vertical load shall be applied to the center of the rail head midway between the two fasteners and normal to the rail, alternating from a vertical downward load to a vertical upward load. The peak load per cycle shall be increased in increments of 200 pounds each cycle to 4,800 pounds. The loads and deflections shall be continually measured to the nearest 0.001 inch and simultaneously recorded on a load versus time graph and a deflection versus time graph respectively. The load shall be removed and the final position of the rail head measured and recorded. The reaction force to the uplift load shall be applied to the test block on which the fastener is mounted.

Acceptance Criteria - The ratio of the deflection for the total uplift test load to the deflection for the total vertical downward test load shall be between plus 5 percent and plus 135 percent of the deflection for a 4,000 pound downward vertical load as determined from the Vertical Load Test. When the vertical load is continuously varied from vertical downward loads to uplift loads, there shall be no indication of backlash or free play at times when the load or the deflection changes direction. After removal of the maximum load, the rail shall immediately return to within 0.005 inch of its original position. At no time during the test shall any fastener component, including the anchorage to the test block, exhibit any sign of failure by slippage, yielding or fracture.

3. Lateral Load Test - While applying a vertical load of 27,000 pounds downward at the center of the rail head midway between the two fasteners and normal to the rail, a lateral load, increasing in increments of 1,000 pounds to a maximum load of 18,000 pounds, at a rate of 1,000 pounds per minute, shall be applied horizontally to the rail head at a point 0.625 inch below the top of rail at the location of vertical load.

For each load increment, the lateral deflection of the rail head at a point 0.625 inch below the top of rail shall be measured to the nearest 0.001 inch and recorded. The lateral load shall be removed and the final position of the rail head measured and recorded. The recorded values for lateral load vs. deflection shall be plotted on a graph similar to **Figure E**.

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**Acceptance Criteria** - The lateral load versus deflection curve for each fastener shall lie within the envelope shown on **Exhibit G**. The lateral deflection of the rail head for a lateral load of 4,000 pounds per fastener shall not exceed 0.150 inch. The average lateral deflection at maximum load shall not exceed 0.360 inch. After removal of the load, the difference between the original and final positions of the gauge line shall not exceed 0.062 inch. At no time during the test shall any fastener component exhibit any sign of failure by slippage, yielding or fracture.

4. **Lateral Restraint Test** - A lateral load increasing in increments of 1,000 pounds from zero pounds to 10,000 pounds shall be applied normal to the rail at the base of rail midway between the two fasteners.

The lateral deflection of the rail shall be measured at the intersection of the centerline of the fastener and the gauge line of the rail to the nearest 0.001 inch and recorded after each increment of loading.

**Acceptance Criteria** - At no time during the test shall any component of the fastener show signs of slippage, yielding, or fracture. The difference between the original and final positions of the gauge line shall not exceed 0.062 inch. The lateral deflection of the rail when fully loaded shall not exceed 0.125 inches from original gauge line of the rail.

5. **Longitudinal Restraint Test** - During the longitudinal restraint test, the rail ends shall be supported on a roller or other low friction supports, properly elevated to prevent the longitudinal load from binding the rail in the fastener.

A load shall be applied longitudinally at the centerline of rail at the base of the rail increasing in increments of 500 pounds up to a total of 7,000 pounds or until the rail deflects 0.6 inch from the initial condition, whichever occur first. The rate at which load is applied shall be approximately 1,000 pounds per minute. Each load increment shall be maintained constant at a minimum of 30 seconds or until the longitudinal deflection of the rail ceases before increasing the load to the next increment. For each load the longitudinal deflection of the rail relative to the fastener shall be measured to the nearest 0.001 inch and recorded. The longitudinal load shall be removed at slippage of rail and the final position of the rail measured and recorded. The recorded values for longitudinal load vs. deflection shall be plotted on a graph as shown on **Exhibit H**.

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**Acceptance Criteria** - The longitudinal load vs. deflection curve, when plotted on **Exhibit H**, shall lie entirely within the shaded area. The difference between the original and final positions of the rail shall not exceed 0.125 inch plus the slippage distance of the rail. At no time during the test shall any fastener component exhibit any sign of failure by slippage, yielding, bond failures or fracture except that slippage which may occur between the rail clip and the rail.

6. **Voltage Withstand Test** - Prepare a fully assembled fastener and apply a DC potential of 15KV between the rail head and the metal base plate of the fastener body for one minute.

Acceptance Criteria - The elastomer shall withstand this test with no visible damage such as splits, cracks, pinholes or fractures, and no evidence of arcing, arc tracking, or other voltage breakdown.

7. Electrical Resistance & Impedance Tests -

a. Electrical Resistance Test - Mount a completely assembled fastener on 1/4 inch thick metallic ground plate sized to extend ½ inch beyond all edges of the fastener.

1) Dry Resistance - 24 hours prior to testing, store the assembled fastener in a clean, dry environment with ambient temperature of 60F to 80F and 50 to 70 percent humidity. Apply 100 volts DC between the rail head and the ground plate for three minutes. Measure the applied voltage and the resulting current flow, or directly measure the resistance with an accuracy of plus or minus two percent.

2) Wet Resistance - Perform this test on the same fastener that passed the Dry Resistance Test. Place the assembled fastener in a nonmetallic trough or suitable container. Size the container such that there is a minimum of two inches between the sides and bottom of the fastener/ground plate assembly and sides and bottom of the container. Pour water into the container to a level midway up to the rail web covering all surfaces of the fastener. Maintain this level of immersion for 10 minutes. The water resistivity shall be 1,000 to 1,500 ohm-cm (use potable water and adjust resistivity by addition of sodium chloride). Drain water from container to a level ½ inch below the ground plate, and without drying or otherwise disturbing the fastener, apply 100 volts DC to the rail head and ground plate and calculate the resistance within 15 seconds. Repeat measurement and calculation every five minutes for the first hour and every ten minutes for the second hour.

3) Electrical Impedance Test - On a fully assembled fastener, apply a potential of 50 volts AC to the rail head for three minutes for each increment of measurement for frequencies from 20Hz to 10kHz, in increments of 20Hz up to 100 Hz, 200 Hz to 1,000 Hz, and 2,000 Hz up to 10kHz. Measure the impedance after three minutes with an accuracy of plus or minus two percent and record for each frequency.

Acceptance Criteria (for Electrical Resistance & Impedance Tests) -

a. Dry DC Resistance - not less than 20 megohms.

b. Wet DC Resistance - not less than one megohms for the average of three consecutive readings within two hours after draining. The difference between each of the three readings and the average reading shall not exceed 10 percent of the average reading.

c. The minimum impedance for any frequency between 100 hz through 10 khz shall not be less than 9,500 ohms.

8. Vertical and Lateral Repeated Load Test - Loads shall be applied to the rail head in such a manner as to produce a vertical downward load of 28,000 pounds, and lateral loads midway between the two fasteners, 0.625 inch below top of rail, of 8,000 pounds to the gauge side of the rail head and 5,000 pounds to the field side of the rail head. The application of the lateral loads shall be alternated, each combined with alternate application and release of the vertical load, a total of three million complete cycles. Application of the field side load and then the gauge side load with two applications of the vertical load constitutes one cycle.

The frequency shall be regulated to prevent the temperature of the components from exceeding 70 degree C. Re-torquing of threaded elements subsequent to the completion of 500,000 cycles of loading will not be permitted without the written approval of the WMATA Engineer.

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Acceptance Criteria - The fastener shall withstand the three million cycles of load application with no evidence of failure by slippage, yielding, wear, grooving or fracture at any time during the test.

9. Repeated Load Test with One Anchor Bolt - After completion of the Vertical and Lateral Repeated Load Test, the fastener shall be reassembled as specified using only the original components previously subjected to testing. The Vertical and Lateral Repeated Load Test shall then be repeated with a minimum of 15,000 cycles with the gauge side anchor bolt loosened to a minimum of 1/4 inch gap.

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Acceptance Criteria - The fastener and concrete block shall withstand the 15,000 cycles of loading with the gauge side anchor bolt loosened with no evidence of failure by slippage, yielding or fracture.

10. Heat-Aging Process - Fully assemble a fastener as specified above except the anchor bolts need not be installed and age the fastener in an air oven for a period of 166 hours at a temperature of 70 degree C using the aging methods specified in ASTM Designation D573, "Accelerated Aging of Vulcanized Rubber by the Oven Method". This is a conditioning process for the fasteners that will be further tested as indicated in **Exhibit E**.

11. Corrosion Process - Expose the fastener body, without loose components, to a five percent solution in accordance with ASTM B117, "Standard Test Method for Salt Spray (Fog) Testing", for 500 hours. This is a conditioning process for the fasteners that will be further tested as indicated in **Exhibit E**.

12. Uplift Repeated Load Test - The rail fasteners, fully assembled as specified above, shall have loads applied to the rail head in such a manner as to produce alternating vertical downward load of 20,800 pounds and a vertical upward load of 4,800 pounds at the centerline of the rail and midway between the two fastener normal to the rail. The application of the two vertical loads shall constitute one complete cycle and shall be applied for a minimum of 1.5 million cycles. The frequency shall be regulated to prevent the components' temperature from exceeding 70 degree C. Retorquing threaded elements subsequent to completion of 500,000 cycles of loading will not be permitted.

Acceptance Criteria - The fastener shall withstand 1.5 million complete cycles of load application with no evidence of failure. Upon visual inspection, no component of the fastener, shall exhibit any evidence of failure by yielding, slippage or fracture.

The rail shall exhibit no evidence of wear or grooving that would contribute to a failure of the rail under operating conditions.

13. Push-Pull Test - During the Push-Pull Test, the rail ends shall be supported on rollers or other low friction supports, properly elevated to prevent the longitudinal load from binding the rail in the fasteners. A cycling longitudinal load shall be applied to the centroid of the rail at one end to deflect the rail plus and minus 3/4 inch about the initial position for a total of 50 cycles.

Immediately afterward, a cycling load equal to 80% of the ultimate slippage loads as recorded in the longitudinal restraint test shall be applied for a total of 25,000 pushing and pulling cycles. Repositioning of the rail clips at anytime will not be permitted.

Acceptance Criteria - The fastener shall withstand 25,000 cycles of loading with no evidence of failure. Upon visual examination, no component of the fastener, shall exhibit any evidence of failure by yielding slippage or fracture, except that slippage may occur between rail clips and rail but not between rail clips and the fastener body.. The rail shall exhibit no evidence of wear or grooving that would contribute to rail failure under operating conditions.

14. Dynamic to Static Stiffness Ratio Test - Using the same assemblage as noted in the Vertical Load Test, Apply an oscillating downward load at the centerline of the rail head and the centerline of the fastener so as to produce a sinusoidal load alternating between 8,000 and 18,000 pounds at a rate of between 10 and 20 hertz.

Continuously record the load and deflection versus time on a high speed oscillograph or high speed digital recorder. After a minimum of 1,000 cycles, determine the dynamic stiffness from the ratio of peak-to-trough force to peak-to-trough deflection from the recorded data.

Between five to ten minutes after completion of the dynamic stiffness measurement and removal of all load , apply a vertical load beginning at zero pounds and increasing in 2,000 pound increments to a maximum of 20,000 pounds, at a rate not less than 200 pounds per minute nor more than 2,000 pounds per minute, at the centerline of the fastener assembly. For each increment of load between 2,000 and 20,000 pounds, record the vertical deflection of the rail head to the nearest 0.001 inch. The static stiffness of the fastener shall be the difference in load divided by the difference in deflection between 8,000 and 18,000 pounds.

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Acceptance Criteria - The dynamic stiffness shall not exceed 1.5 times the static stiffness.

## 1.11 DELIVERY, HANDLING AND STORAGE

- A. Fasteners shall be packed and shipped in a manner that shall prevent a load on any fastener from exceeding 1,000 pounds.
- B. Fasteners shall not be stored by the Contractor in a wet location or where the ambient temperature will exceed 120 degree F.
- C. Fasteners shall be packaged on wood pallets and wrapped in minimum 6 MIL plastic to permit outdoor storage in a secured area. Rail hold-down assemblies, shoulders, bolts, nuts and other loose items shall be packaged by component type in secure shipping kegs or boxes and clearly identified. The method and materials of packaging shall be submitted for approval by the **WMATA** Engineer.
- D. The Contractor shall replace all fasteners damaged during packaging, pre-delivery storage and shipping without additional cost to the Authority.
- E. Fasteners shall be delivered FOB to Authority furnished storage sites **as directed by the WMATA Engineer to the Washington Metropolitan area**. Unloading and final storage will be by others. Provide the **WMATA** Engineer two weeks notice prior to any fastener delivery.

- F. Fasteners used in the production quality control testing shall be packed and labeled separately from the rest of their lot.

**PART 2 - PRODUCTS**

**2.01 MATERIAL REQUIREMENTS**

~~A. Fastener components shall comply with the following material requirements:~~

- ~~1. Metal Plate
 
  - ~~a. The top, bottom and cover plates shall be metal castings of grade 65-45-12 ductile iron per ASTM A-536.~~
  - ~~b. The chemical composition shall meet the acceptable level per SAE J434.~~
  - ~~c. The Brinell hardness in accordance with ASTM E-10 shall be within 156-217 BHN range per SAE J434. The microstructure shall be within limits set by SAE J434. The fracture energy at 21.1C in accordance with ASTM E-23 shall be greater than 3 foot-pounds.~~
  - ~~d. The test report shall include all information listed in paragraph 12 of ASTM E E23.~~~~
- ~~2. Elastomer: Elastomer shall be a blend of 85% natural rubber and 15% chloroprene and shall comply with the following requirements:-~~

**A. Fastener Body:**

- 1. Metal Components:**
  - a. Both the metal top plates and bottom plates shall be one-piece ductile iron. The minimum thickness of the top plate shall be ½ inch and 3/8 inch for the bottom plate.**
  - b. The ductile iron castings shall be minimum Grade 65-45-12 in accordance with ASTM A536, "Standard Specifications for Ductile Iron Castings". The chemical composition shall meet the acceptable level per SAE J434, "Automotive Ductile Iron Castings". The Brinell hardness when tested in accordance with ASTM E10, "Standard Test Method for Brinell Hardness of Metallic Materials", shall be within 156-217 BH range per SAE J434.**
- 2. Elastomer:**
  - a. The minimum thickness of the elastomer between the top plate and the bottom plate parallel to the rail seat shall be ½ inch .**
  - b.. The elastomer shall be neoprene or natural rubber or a blend of neoprene and natural rubber.**
- 3. Manufacturing Tolerances:**
  - a. Manufacturing tolerances for the fastener shall be as shown in Table 1.**

<b>Table 1 - Direct Fixation Fastener Manufacturing Tolerances</b>	
<b>DIMENSION</b>	<b>TOLERANCE</b>
Length and width	Plus or minus 1/8 inch
Height	Plus or minus 1/32 inch
Squareness	All angles within plus or minus 1/32 inch
Centering of holes	Plus or minus 1/32 inch
Diameter of holes	Plus or minus 1/32 inch
Durometer Shore A	Plus or minus 5

Serration depth	Plus or minus 1/64 inch
Serration spacing	Plus or minus 1/64 inch
Width between shoulders at rail base	Plus 1/16 inch or minus zero inch

B. Rail Hold Down Assembly: Rail clip shall be a resilient spring clip type such as the Pandrol e-2056 (left handed) and as specified herein. Spring-wedge type rail clips will not be permitted. Rail clip shoulder shall be cast as integral part of the metal top plate. Welding of the rail clip shoulder to the top plate will not be permitted.

1. Materials - Rail clips shall be forged from alloy steel bars and heat treated to achieve the minimum spring action holding power as specified herein.
2. Minimum Design Criteria:
  - a. Clips must be one piece, threadless and detachable.
  - b. There shall be two clips to each complete rail fastener assembly.
  - c. Holding force shall be generated by spring action.
  - d. Surface hardness of clips shall be between 44 and 48 HRC.
  - e. The range of vertical hold down force (toe load) per clip shall be between 2,100 and 3,000 lbs. with a total force range of 4,200 to 6,000 lbs. per rail seat.
  - f. The minimum static longitudinal slip per complete rail fastener assembly, with two clips shall be 3,000 lbs.
  - g. Field installation and removal of clips shall be accomplished by one man using standard track tools or by commercially available equipment.
  - h. Clip shall be proven design and produced by an ISO 9000 certified manufacturer with a minimum of ten years documented in-track experience in the United States.

C. Rail Anchorage Assembly - Anchor bolts shall be 7/8 inch diameter, carbon steel, electroplated with zinc in accordance with ASTM B633, Type II, SC 4.

~~D. Clip bolts shall be heavy hex structural, Type 3, ASTM A325.~~

- ~~1. The one sixteenth inch shims shown on **Exhibit D** shall be made of steel and shall provide full bearing support to the bottom of the fastener.~~
- ~~2. Rail clip shall be in accordance with AISI 5160 and shall have a Rockwell hardness between 44 degree C and 48 degree C in accordance with ASTM E18.~~

## ~~2.02 STIFF DIRECT FIXATION FASTENER SYSTEM~~

~~A. The Stiff Direct Fixation Fastener System shall consist of the following components:~~

- ~~1. Fastener body (elastomeric tie plate), part number J-16281-1 as manufactured and previously supplied to WMATA by Lord Corporation, Erie, PA.~~
- ~~2. Pandrol Slip in Shoulder as manufactured and previously supplied to WMATA by Pandrol, Inc. and shown on their Drawing No. 5705, "Cast Shoulder to Suit Lord Plate" for 115 RE Rail, two per fastener body.~~
- ~~3. Pandrol Spring Clip, Type PR602A, two per fastener body.~~
- ~~4. Anchor bolt, heavy hex structural, Type 3, ASTM A325 7/8" - 9 x 3 - 1/4", two per fastener body.~~
- ~~5. Washer, hardened weathering steel, ASTM F436, 2" O.D., 0.94" I.D. and 1/8" thick, two per fastener body.~~
- ~~6. Anchor insert as specified in Section 05653, Direct Fixation Track Construction, 2.01.C.1, two per fastener body.~~

## 2.02 VIBRATION ATTENUATING DIRECT FIXATION FASTENER (EGG TYPE)

- A. The Vibration Attenuating Direct Fixation Fastener or egg-type fastener shall be manufactured by Advanced Track Products, Inc. (ATP), and previously supplied to the Authority or an approved equal.
- B. In addition to being highly resilient, the fastener must provide:
  - 1. Vertical and lateral stability to the rail
  - 2. Longitudinal restraint to the rail
  - 3. Electrically isolate the rail from the trackbed
  - 4. Satisfactory service life comparable to that expected of standard direct fixation fasteners.

~~2.03 ELECTRICALLY INSULATED BALLASTED TRACK FASTENERS (EIBTF)~~

- ~~A. Electrically Insulated Ballasted Track Fasteners (EIBTF) shall be as manufactured by L. B. Foster, Co., and previously supplied to the Authority, or an approved.~~
- ~~B. Fasteners include fastener bodies, rail clips and screw spikes.~~

~~2.04 F-17 DIRECT FIXATION FASTENER~~

- ~~A. As applicable, and if specified, the Standard Fastener F-17 design shall be as shown on the Contract Drawings.~~

**PART 3 - EXECUTION**

**3.01 FASTENER TESTING - SOURCE QUALITY CONTROL**

- A. Test Plan:
  - 1. Tests specified herein shall be performed in accordance with the approved test plan.
  - 2. The Contractor shall notify the **WMATA** Engineer fourteen days in advance of the commencement of testing including preparation of the test equipment for testing.
  - 3. Testing shall be performed in the presence of the **WMATA** Engineer unless otherwise approved in writing by the **WMATA** Engineer.
- B. Starting Tests and Procedures:
  - 1. After a test sequence is begun, it shall be completed.
  - 2. In the event of failure of a test rig component, the **WMATA** Engineer shall determine if the failure was attributable to the fastener.
  - 3. If the fastener did contribute to the failure, or if there is doubt, then, with the approval of the **WMATA** Engineer, the testing shall cease and the test report shall be submitted with all findings.  
If the fastener did not contribute to the failure, the component shall be replaced and the testing continued.
- C. Configuration for Testing:
  - 1. Testing Setup and Preparation:
    - a. Except for specific tests noted herein, ~~four~~ **eight** fasteners complete with the modified rail section, as shown in ~~Exhibit C~~ **Exhibit A** and of length as determined ~~from Exhibit D~~, shall be used.
    - b. Before assembly, the fasteners shall be clean and dry.

- c. The fasteners shall be spaced one inch apart.
  - d. The fasteners shall be mounted and anchored on a test block and the spring clips shall be positioned to hold the modified rail section.
  - e. The anchor bolts shall be torqued to 300 foot-pounds.
  - f. All reactions to load shall be through the fasteners to the test block.
  - g. The test block shall be of reinforced concrete with female threaded inserts cast or set on it to receive the 7/8-inch fastener anchor bolts. The top surface of the test block shall be a flat plane with a wood float finish and with the face of the inserts set parallel to the surface with a tolerance of plus zero above and minus 1/32-inch below the surface.
    - 1) Concrete: The strength of the concrete shall be 4,000 psi as determined from standard test specimens taken in accordance with ASTM C31 and ASTM C172 and cured and tested in accordance with ASTM C39. Rebar shall be placed as shown in Exhibit D.
    - 2) Inserts:
      - a) Inserts shall be of corrosion resistant steel threaded to 1-1/2 inch depth to receive ASTM A325 7/8-inch bolts and shall meet 40,000-pound bolt load.
      - b) Washer face bearing of the insert against the fastener shall be equal to the bearing area of an A563 heavy nut for 7/8-inch bolt.
      - c) Length and anchorage configuration shall withstand 12,000 pounds unrestrained pullout and resist 250 foot-pounds torque without yielding.
      - d) Inserts shall be coated with an epoxy resin insulating coating, 100-percent dry powder epoxy resins, Scotch Kote Brand Protective Resins No. 203, Minnesota Mining and Manufacturing Company; Corvel Epoxy ECB-1363A, Polymer Corporation; or equal.
  - 2. Instrumentation:
    - a. Instrumentation for all required deflection and rotation measurements shall be designed so as to measure each rail motion parameter relative to the test block.
    - b. Each instrument shall be designed to measure the motion intended with minimum effects on the data from other motions.
- D. Temperature: Before commencing, and during all tests, the fastener shall be stabilized at an ambient temperature of 22 degrees C, plus or minus 5 degrees C unless otherwise specified.

~~E. Spring Rate and Deflection Test:~~

~~1. The set of fasteners shall be tested as follows:~~

- ~~a. The four fasteners shall be loaded and have the deflections measured as shown in Exhibit D. The modified rail section shall be instrumented for rotation about its longitudinal axis. The total vertical and lateral response loads will be the sum of the load values measured on the two vertical and lateral load cells between the loading rams and the load points. Exhibit E shows the vertical and lateral response loading as a function of time. The vertical load points shall be loaded equally with a vertical load that varies as shown by Curve V. The occurrence of one wave as shown by Curve V shall be considered as one cycle. The lateral load points shall be loaded equally with a lateral load that varies as one cycle. The lateral load points shall be loaded equally with a lateral load that varies as shown by Curve L. The~~

vertical and lateral loads shall occur simultaneously as shown in **Exhibit E**. The direction of the lateral load shall reverse, as shown by Curve L and Reverse Curve L in **Exhibit E**, with every cycle. There may be a no-load pause between cycles of no longer than one half of the cycle length.

b. The fasteners shall be pre-loaded with 1,000 cycles of Case 1 loading. After the pre-load cycles, the instruments used to monitor deflection and rotation shall be zeroed in a no-load condition. Then the Case 1 loading shall be cycled 10 times during which data of vertical and lateral loads, deflections and rotation as functions of time shall be analog graphs shall be recorded directly from the instrumentation's output signal. At the completion of the 10 cycles the load shall be removed and data shall be continuously collected for one minute after the loads are removed.

c. The test data shall be presented in both analog and digitized form. The analog graphs shall be drawn at a rate of not less than 100 mm per second during the 10 cycles and not less than one mm per second during the one minute period after the loads are removed. The vertical scale shall be set to make full use of a strip chart which is at least 40 mm wide per channel. Analog graphs of loads (for each load cell), deflections (for each deflection) and rotations at each end shall include calibration (scales) and annotation which fully describe the graphs. Digitized data shall show vertical and lateral fastener loads, average vertical deflection, average lateral deflection at base of rail, and average rotation values at every 0.01 seconds for each cycle and at one minute of rest after release of the loads. The fastener load shall be computed as one fourth of the total response load. The digitized data may be a computer printout formatted similar to **Exhibit F**. The lateral deflection to be reported in **Exhibit F** is the average value at the base of the rail.

d. All deflection and rotation instrumentation shall measure, relative to the test block, to the nearest 0.001 inch and 0.02 degrees, respectively. The instrumentation for measuring the response loads (the total load applied to all four fasteners) shall have an accuracy of plus and minus two percent or plus and minus 50 pounds whichever is larger. The test operator shall perform the tests so that the instrumentation indicates that the response load is within plus and minus 100 pounds of the specified loads.

e. The fastener shall also be tested as in the preceding steps a. through d. with the loads shown for Case 2 on **Exhibit E**.

2. Fastener Test Set to Satisfy Acceptance Criteria: Each fasteners in a four fastener test set shall satisfy the following acceptance criteria:

a. The fastener shall demonstrate response repeatability for each loading case. Repeatability shall be demonstrated if the deflections for a fastener at each load level indicated by the lettered points on Curves V and L do not vary by more than plus or minus 0.002 inch or plus or minus seven percent whichever is larger, from the average for the 10 cycles. Once repeatability has been demonstrated, the fifth cycle of the 10 recorded shall be chosen from each of the loading cases for further analysis as follows:

b. For each case, the spring rate for the fastener shall be determined from the maximum downward vertical fastener load (first occurrence of Point B; **Exhibit E**, Curve V) and the downward vertical fastener deflection which occurs at that time. The average spring rate for the four fasteners shall be between 90,000 and 100,000 pounds per inch.

c. The digital data shall be grouped into increments in the following manner:

1) Vertical:

a) Three equal time increments from zero deflection near 0.20 seconds to peak deflection near Point B (**Exhibit E**, Curve V) at 0.36 seconds.

b) One increment from peak deflection near Point B (**Exhibit E**, Curve V) at 0.36 seconds to peak deflection near Point

- ~~c) One increment from peak deflection near Point C (**Exhibit E**, Curve V) at 0.43 seconds to peak deflection near Point B (**Exhibit E**, Curve V) at 0.50 seconds.~~
- ~~d) Three equal time increments from peak deflection near Point B (**Exhibit E**, Curve V) at 0.50 seconds to zero deflection near 0.66 seconds.~~
- ~~2) Lateral:~~
  - ~~a) Three equal time increments from zero deflection near 0.20 seconds to peak deflection near Point E (**Exhibit E**, Curve L) at 0.36 seconds.~~
  - ~~b) Two equal time increments from peak deflection near Point E (**Exhibit E**, Curve L) at 0.36 seconds to Point F (**Exhibit E**, Curve L) near 0.50 seconds.~~
  - ~~c) Three equal time increments from Point F (**Exhibit E**, Curve L) at 0.50 seconds to zero deflection near 0.66 seconds.~~
- ~~3) Incremental Spring Rates:~~
  - ~~a) Linear regression shall be used to determine the incremental fastener spring rate for each increment fastener spring rate for each increment as previously defined. The incremental spring rates shall be shown **Exhibit F**. The minimum incremental spring rate shall not be less than 80 percent for vertical and 70 percent for lateral of the maximum incremental spring rate for the first three increments beginning near 0.20 seconds. The criteria shall be applied individually to both the vertical and lateral data for Cases 1 and 2.~~
- ~~d. The vertical deflection at Point A on Curve V for Cases 1 and 2 shall not be less than 0.000 inches and shall indicate a deflection in the up direction.~~
- ~~e. Maximum elastomer compressive and shear strains shall not exceed 25 percent and 50 percent respectively for Case 1 shown on **Exhibit E**.~~
- ~~f. The peak average lateral deflections measured six inches above the rail base for Case 2 shall be between 0.322 and 0.344 inches and for Case 1 shall be between 0.186 and 0.228 inches. The maximum angle of rotation of the modified rail section about the longitudinal axis shall not exceed 0.5 degree for Case 1.~~
- ~~g. After completion of the loading cycles and with one minute of rest with no load, the vertical deflections shall not exceed 0.005 inch and the average lateral deflections at both the rail base and six inches above the base shall not exceed 0.01 inch.~~
- ~~h. The rail base shall remain in full contact with the rail seat of the fastener during the cycling.~~
- ~~i. The analog data shall show uniform deflection and load indicating no free play.~~
- ~~j. At no time during the test shall any fastener component, including the anchorage to the test block, exhibit any sign of failure by slippage, yielding or fracture. Analog data shall be reviewed for indications of slippage, yielding or fracture.~~
- ~~k. When this test is repeated in the test sequence the deflections shall not have increased by more than 10 percent and the spring rate shall not have decreased by more than 10 percent from the initial performance.~~

F. Longitudinal Restraint Test:

- ~~1. On a set of fasteners for the "first loading" a load shall be applied longitudinally to the rail, at the intersection of the rail centerline and the bottom of the base of the rail, with increasing increments of 1,000 pounds until the rail deflects 1.0 inch from the initial~~

condition relative to the test block. For each load, the longitudinal deflection relative to the test block for the rail and each fastener shall be measured to the nearest 0.001 inch and shall be recorded. The longitudinal load shall be removed and the final position (after one minute) of the rail and of each fastener shall be measured and recorded. After resetting the deflection gauges to zero the test shall be repeated in the opposite direction for the "second loading". For each direction the recorded values for longitudinal load versus rail deflection and average fastener deflection shall be plotted on a graph as shown in **Exhibit G**. Deflection gauges shall be zeroed with no load applied to the rail (the original position). Each load increment shall be maintained constant within plus or minus two percent of nominal or plus or minus 50 pounds, whichever is greater, until the longitudinal deflection of the rail ceases before the data is read and recorded. The longitudinal deflection shall be determined as having ceased when the deflection rate is less than 0.001 inch per 30 seconds:

2. ~~Test Acceptance Criteria:~~

- a. ~~For the "first loading", the longitudinal load versus rail deflection curve, when plotted in **Exhibit G**, shall lie entirely within the limits defined by the "Upper Limit" and the "Lower Limit, First Loading".~~
- b. ~~For the "Second Loading" the "Upper Limit" and the "Lower Limit", Second Loading" limits shall be used~~
- c. ~~The slippage between the rail and fastener shall not occur prior to 0.15 inches of rail deflection relative to the test block.~~
- d. ~~The difference between the original and final average fastener deflections shall not exceed 0.125 inch.~~
- e. ~~At no time during the test shall any fastener component exhibit any sign of failure by slippage, yielding, or fracture, except that slippage which may occur between the fastener and the rail.~~

G. ~~Electrical Resistance Test:~~

1. ~~Fasteners and All Components:~~

- a. ~~Each of the four fasteners with all components shall be immersed for 70 hours in boiling distilled de-ionized water. The fasteners shall be fully enveloped in the boiling action.~~
- b. ~~After removal from the water, with surface air drying and with the fastener at a temperature in the range of 29 deg. C plus or minus 6 deg. C, each fastener shall be installed separately on test block, with a 0.25 inch thick steel ground plate dimensioned large enough and situated to extend a minimum of 0.25 inches beyond the periphery of the fastener and located between the fastener and the test block, and tested for electrical resistance.~~
- c. ~~With both anchor bolts of a fastener grounded to the ground plate, 100 volts dc shall be applied between the rail head and the ground plate for three minutes. The actual current flow shall be measured to the nearest 0.1 microampere and recorded.~~
- d. ~~Then 1,000 volts dc shall be applied between the rail head and ground plate for two hours, after which 100 volts dc shall be applied again for three minutes and the actual current flow shall be measured, as above, and recorded.~~
- e. ~~A potential of 50 volts RMS ac shall be applied between the rail head and ground plate for three minutes for each increment of measurement for frequencies from 20 Hertz to 10 kilohertz in increments of measurement of 20 Hz up to 100 Hz; 200 Hz up to 1 kHz; and 2kHz up to 10 kHz. The impedance after three minutes after three minutes shall be determined with an accuracy of plus or minus two percent and recorded for each frequency.~~

2. ~~Acceptance Criteria:~~

- a. ~~The maximum current for 100 volts dc shall be 1.0 microampere.~~
- b. ~~The minimum impedance for any frequency with 50 volts RMS ac shall be 10,000 ohms.~~

~~II. Repeated Load Test:~~

- ~~1. The test fasteners shall be loaded and instrumented as described for the Spring Rate and Deflection Test except that in **Exhibit E** (2 of 2), Cases 4 and 5 shall be used and the direction of the lateral load, Curve L, shall not be reversed at any time. The direction of the lateral load relative to the fasteners shall be the same for both cases.~~
- ~~2. No adjustments (re-torquing, re-application or resetting) of any component during this test shall be made without approval from the Engineer. All adjustments shall be reported.~~
- ~~3. For every two cycles of testing each case shall be cycled one time. Each case shall be cycled a total of 90,000 cycles. The analog and digital instrumentation and recording devices for the lateral and vertical response loads and deflections shall be operative and used to monitor the test. At 10,000 and 179,000 total cycles, 100 continuous cycles of vertical and lateral response loads and deflections shall be recorded as analog load data and shall be reported in the test report. Of the 100 cycles, one sample of each of the two cases shall be digitized in increments of 0.01 seconds and reported in the test report as shown in **Exhibit F**. The digitized data may be formatted similar to **Exhibit F** with a computer printout.~~
- ~~4. Acceptance Criteria:
  - ~~a. At no time during the test shall any fastener component, including the anchorage to the test block, exhibit any sign of failure by slippage, yielding or fracture.~~
  - ~~b. More than a 10 percent increase in deflection or decrease in spring rate during the test is a sign of failure.~~
  - ~~c. The final anchor bolt~~
  - ~~d. torque shall not be less than 290 foot-pounds for any bolt.~~
  - ~~e. On the end of the fastener from which the maximum lateral load is directed, the elastomer shall be free of blemishes and blisters.~~
  - ~~f. On the other end, a surface blister or blemish no longer than 3/4 inch in length is acceptable and in the cut out region parallel to the rail, for the shimmed fasteners only, tears may occur with a maximum depth of 5/16 inch.~~
  - ~~g. Bottom holes shall be free of all tears.~~~~

~~I. Push-Pull Test II~~

- ~~1. Application of Cyclical Longitudinal Load
  - ~~a. A cyclical longitudinal load shall be applied at the rate of one cycle per second to the base of the rail at the rail centerline to slip the rail relative to the top metal element plus and minus 1/2 inch about the initial position for a total of 2,000 cycles. A different cycle rate may be submitted for approval.~~
  - ~~b. No adjustment (retorquing, re-application or resetting) of any component during the cycling shall be made without approval of the Engineer. All adjustment shall be reported.~~~~
- ~~2. Acceptance Criteria:
  - ~~a. At no time during the test shall any component of the fastener shown signs of failure by yielding, fracture or slippage except for slippage of the rail relative to the fastener.~~
  - ~~b. The rail shall exhibit no evidence of wear, polishing, or grooving that would contribute to rail failure under operating conditions.~~
  - ~~c. Minor polishing or grooving due to removal of mill scale and surface irregularities that occurs due to the slippage of the rail through the fastener will not be cause for rejection subject to approval by the Engineer.~~~~

**E. Production Quality Control:**

1. General - Following successful completion of the qualification tests, acceptance of the qualification test reports by the WMATA Engineer, and start of the fastener assembly manufacturing, Production type quality control sampling and testing shall be conducted and performed by an independent testing facility approved by the WMATA Engineer and shall be a member of the American Council of Independent Laboratories. Elastomer samples and fastener assemblies shall be selected from regular production and subjected to testing to ensure that high quality standards are maintained and that design requirements set forth in these specifications are met through the completion of the production process.
2. Production Elastomer Tests -
  - a. Samples of elastomer from every mixed batch of material used in the manufacture of production fastener shall be tested to verify compliance of the elastomer batch mix with the following testing requirements:
    - 1) Hardness Test
    - 2) Tensile Strength and Ultimate Elongation Test
    - 3) Specific gravity : and
    - 4) Cure Characteristic in accordance with ASTM D2084 or an equivalent industry accepted standard.
  - b. Certificate of Compliance from the supplier of the elastomer shall be submitted to the Engineer guaranteeing compliance of the elastomer with requirements of these specifications.
3. Fastener Assembly Tests
  - a. Production quality control testing of fasteners shall be performed on two (2) fasteners from the first 50 fasteners and on two (2) fasteners from each production lot. A production lot is defined as a quantity of manufactured and completed fasteners produced in a continuous run, but not to exceed 5,000 units. As requested, fasteners may be selected for testing by the WMATA Engineer. Permanently mark the fasteners used for production testing and meeting all test requirements as production test fasteners and deliver fasteners to the Authority. These fasteners shall be subjected to the following tests:
    - 1) Vertical Load Test
    - 2) Vertical Uplift Test
    - 3) Lateral Load Test
    - 4) Lateral Restraint Test
    - 5) Longitudinal Restraint Test
    - 6) Voltage Withstand Test
    - 7) Electrical Resistance Test
    - 8) Vertical and Lateral Repeated Load Test (500,000 cycles)
  - b. The configuration for testing and the acceptance criteria shall be as specified above, and the value obtained for the slope of the load-deflection curve in the Vertical load Test shall be within 20 percent of that obtained in the original compliance testing.
  - c. The quality control tests shall commence no later than fourteen days after fabrication of the fastener. Should any fastener fail to meet the test requirements, two additional fasteners from that same production lot shall be tested. In the event any of the two additional fasteners fail, 100 percent of the remainder of the lot shall be rejected or tested and only those successfully passing all tests shall be incorporated in the final delivered quantity.
  - d. In addition to the quality control tests and at the discretion of the WMATA Engineer, all components of the rail fasteners shall be subjected to full or partial testing for compliance with these specifications.

The cost of all such additional testing required by the WMATA Engineer

for any component that is proved to comply with these specifications will be at the expense of the Authority. The cost of all such additional testing of any component that is proven not to comply with these specifications shall be at no expense to the Authority.

- e. Production quality control testing may be performed at any test facility, including such facilities at the contractor's plant, provided they meet the approval of the WMATA Engineer and satisfies the requirements of the American Council of Independent Laboratories "Manual of Practice, Quality Control System" - Requirements for Testing and Inspection Laboratory, and ASTM E320. Testing equipment shall be in good repair, of adequate capacity and shall be accurately calibrated. Copies of calibration certificates shall be submitted to the WMATA Engineer. The WMATA Engineer shall be notified not less than 14 days in advance of dates scheduled for quality control tests.
  - f. Two copies of the results of all tests shall be submitted to the WMATA Engineer within seven days after performance of the tests.
4. Acceptance - Final acceptance of production lots of direct fixation rail fasteners will be based upon the fastener and all its components complying with these specifications as determined by the WMATA Engineer, based on the results of the quality control tests and the certified statements submitted to the WMATA Engineer by the Contractor.

### **3.02 APPROVAL**

- A. General - Prior to approval of the rail fastener, the Contractor shall submit to the WMATA Engineer the following:
  - a. Six copies of both the approved shop drawings of the fastener. This information shall give special attention to torquing of bolts, use of gauges (if required), setting of lateral adjustment devices, and other details of assembly that may not be readily apparent from the shop drawings of the fastener.
  - b. Three rail fasteners complete with elastomer and all hardware as specified herein.
  - c. Six copies of certified statements describing the chemical composition of all elastomer components of the rail fastener.
  - d. Six copies of a certified laboratory report of the results of all Qualification tests specified herein.
- B. Alteration of Rail Fasteners - After approval of the rail fasteners by the Authority, no change in the design or manufacturing process shall be made without the written approval of the WMATA Engineer. The WMATA Engineer, at his discretion, may require the testing, certification, and approval of any altered rail fastener at no additional cost to the Authority. All production of rail fasteners which have not been approved by the Authority shall be at the Contractor's risk.

## **PART 4 - MEASUREMENT AND PAYMENT**

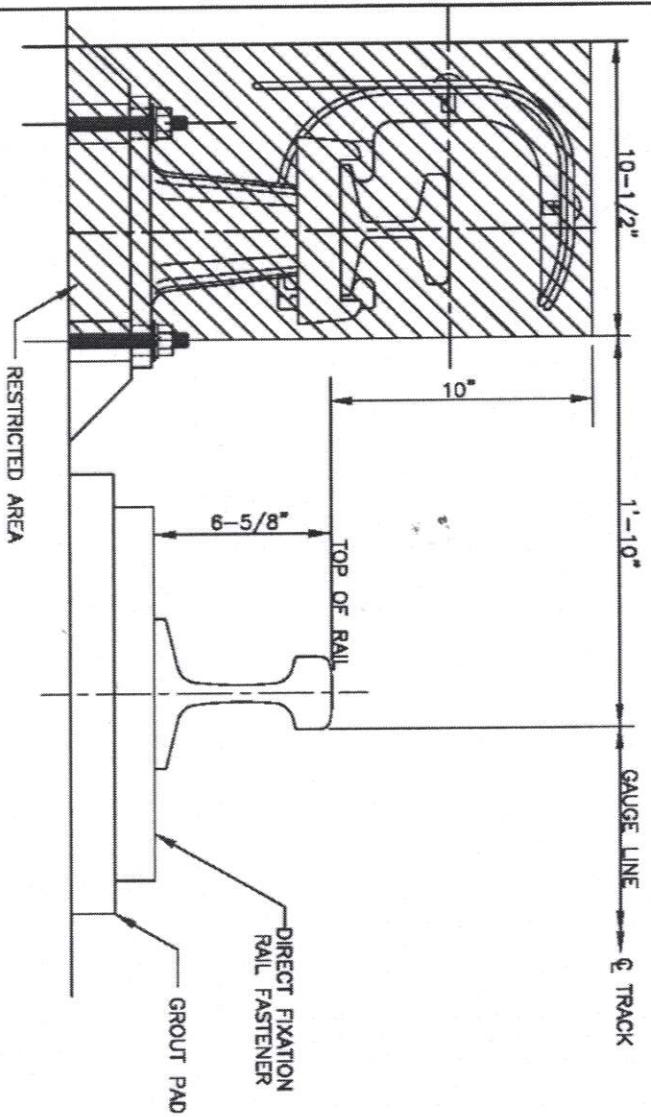
### **4.01 MEASUREMENT**

- A. Measurement of work specified in this section will be made in the following manner:
  - 1. No separate measurement.

**4.02****PAYMENT**

- A. Compensation for work specified in this Section will be made in the following manner:
  - 1. Included in the price of the work of which it is a part.

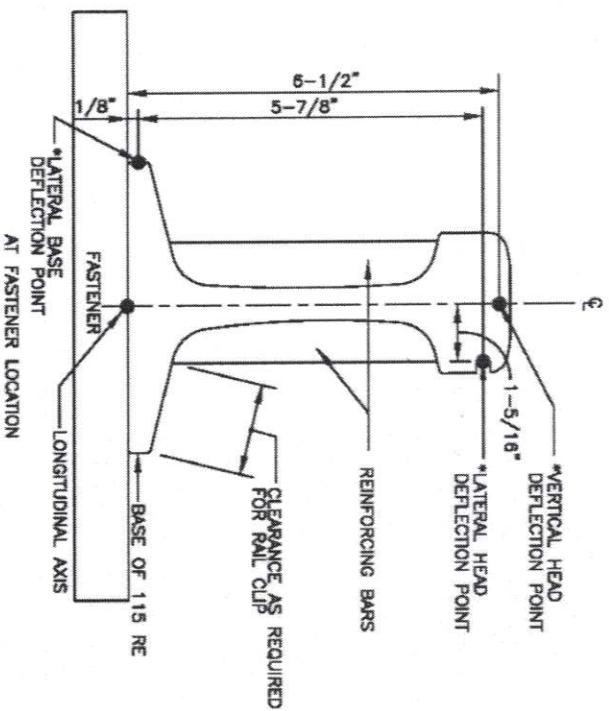
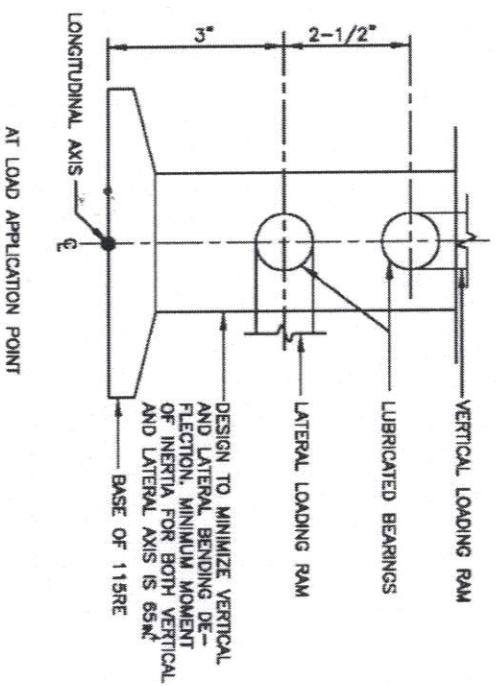




WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

EXHIBIT 05657-B  
 RESTRICTED AREA DURING  
 INSTALLATION AND MAINTENANCE

SCALE	NONE	DATE	DECEMBER 2007
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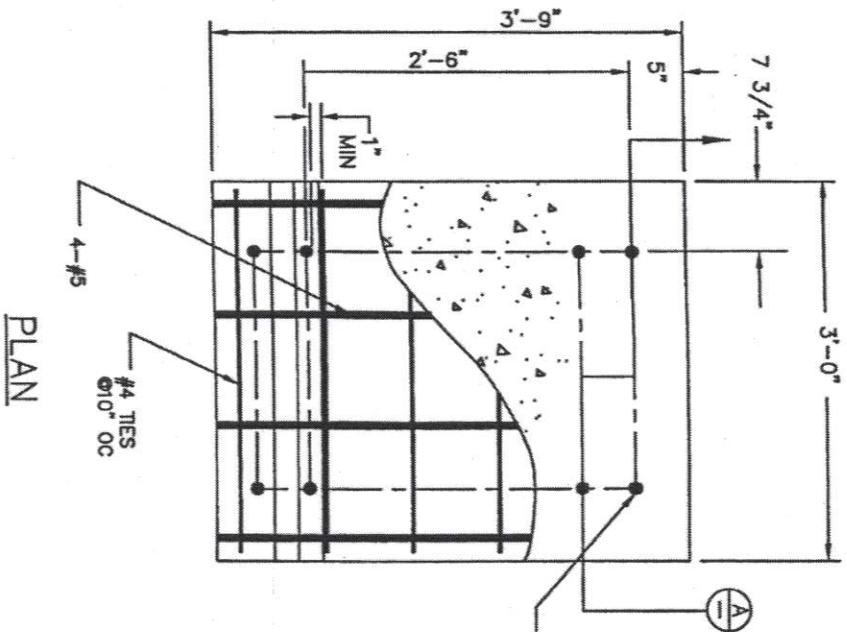


WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

EXHIBIT 05657-C  
MODIFIED RAIL SECTION

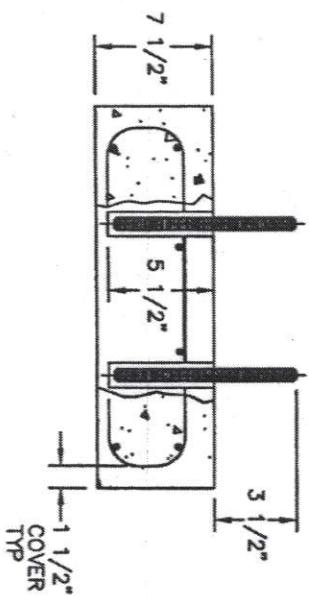
SCALE NONE

DATE DECEMBER 2007



PLAN

Holes to be located using existing holes in base plate, Fig A



SECTION

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

SCALE		NONE		DATE		DECEMBER 2007		TITLE		EXHIBIT 05657-D CONCRETE TEST BLOCK FOR TESTING ANCHOR ASSEMBLIES FOR D.F. RAIL FASTENER	
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FURNISHED BY CONTRACTOR  
16 FASTENERS

RETAINED BY AUTHORITY  
8 FASTENERS

FORWARD FOR TESTING  
8 FASTENERS

FASTENERS "A", "B", "C" & "D"

(CONDUCT STATIC TESTS 1-7 ON ALL FOUR SETS OF FASTENERS)

1. VERTICAL LOAD TEST
2. LATERAL UPLIFT TEST
3. LATERAL LOAD TEST
4. LATERAL RESTRAINT TEST
5. LONGITUDINAL RESTRAINT TEST
6. VOLTAGE WITHSTAND TEST
7. ELECTRICAL RESISTANCE AND IMPEDANCE TEST

FASTENER "A"

FASTENER "B"

FASTENER "C"

FASTENER "D"

VERTICAL & LATERAL  
REPEATED LOAD  
TEST

DYNAMIC TO STATIC  
STIFFNESS RATIO  
TEST

HEAT AGING

PUSH PULL  
TEST

REPEATED LOAD  
TEST WITH ONE  
ANCHOR BOLT  
LOOSEMED

HEAT AGING

UPLIFT REPEATED  
LOAD TEST

REPEAT TESTS 1-7

REPEAT TESTS 1-7

REPEAT TESTS 1-7

CORROSION

DYNAMIC TO STATIC  
STIFFNESS RATIO  
TEST

REPEAT TESTS 1-7

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

THIS

EXHIBIT 05657-E

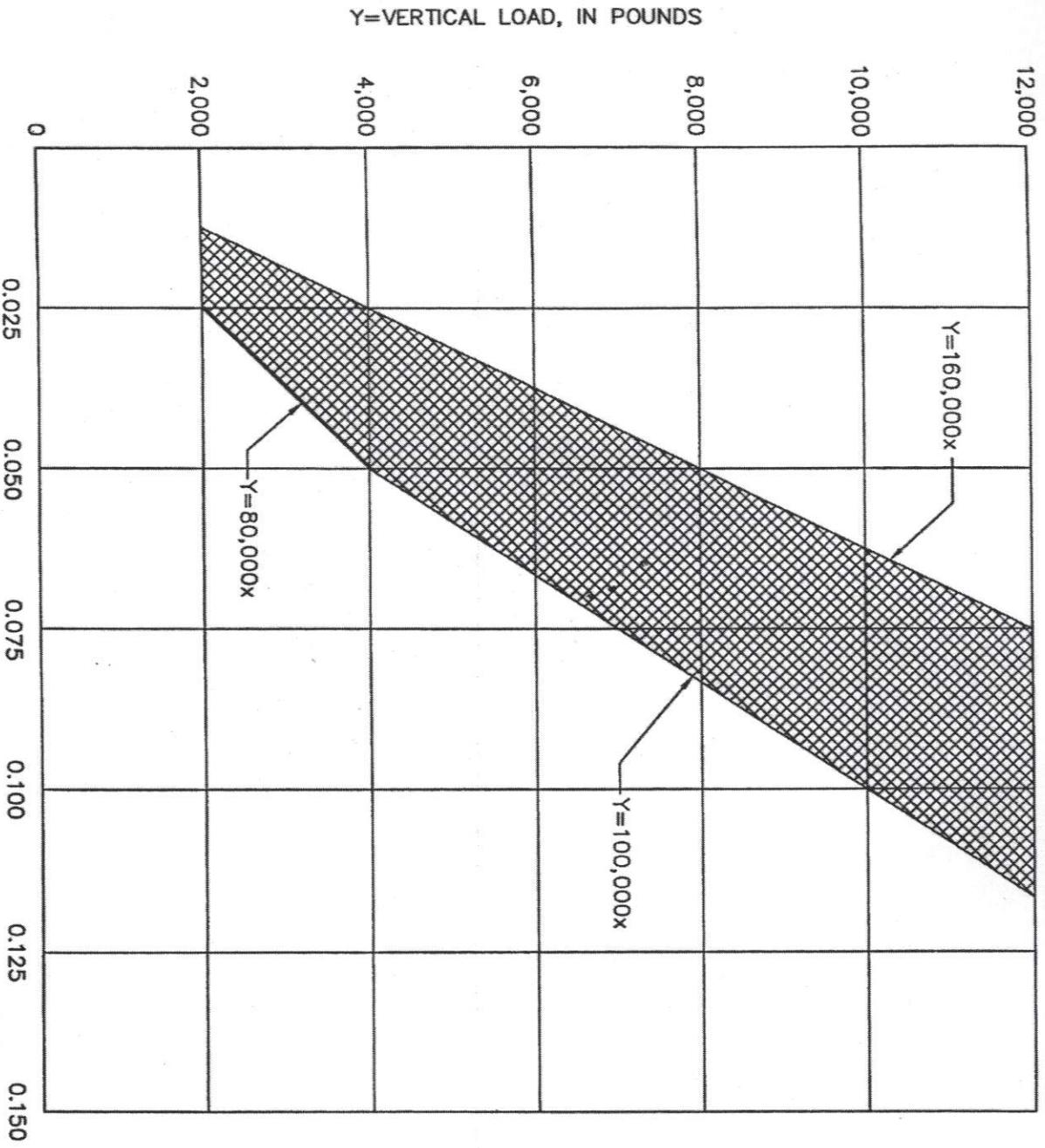
FASTENER ASSEMBLIES  
QUALIFICATION TESTING SEQUENCE  
FOR D.F. RAIL FASTENER

SCALE

NONE

DATE

DECEMBER 2007

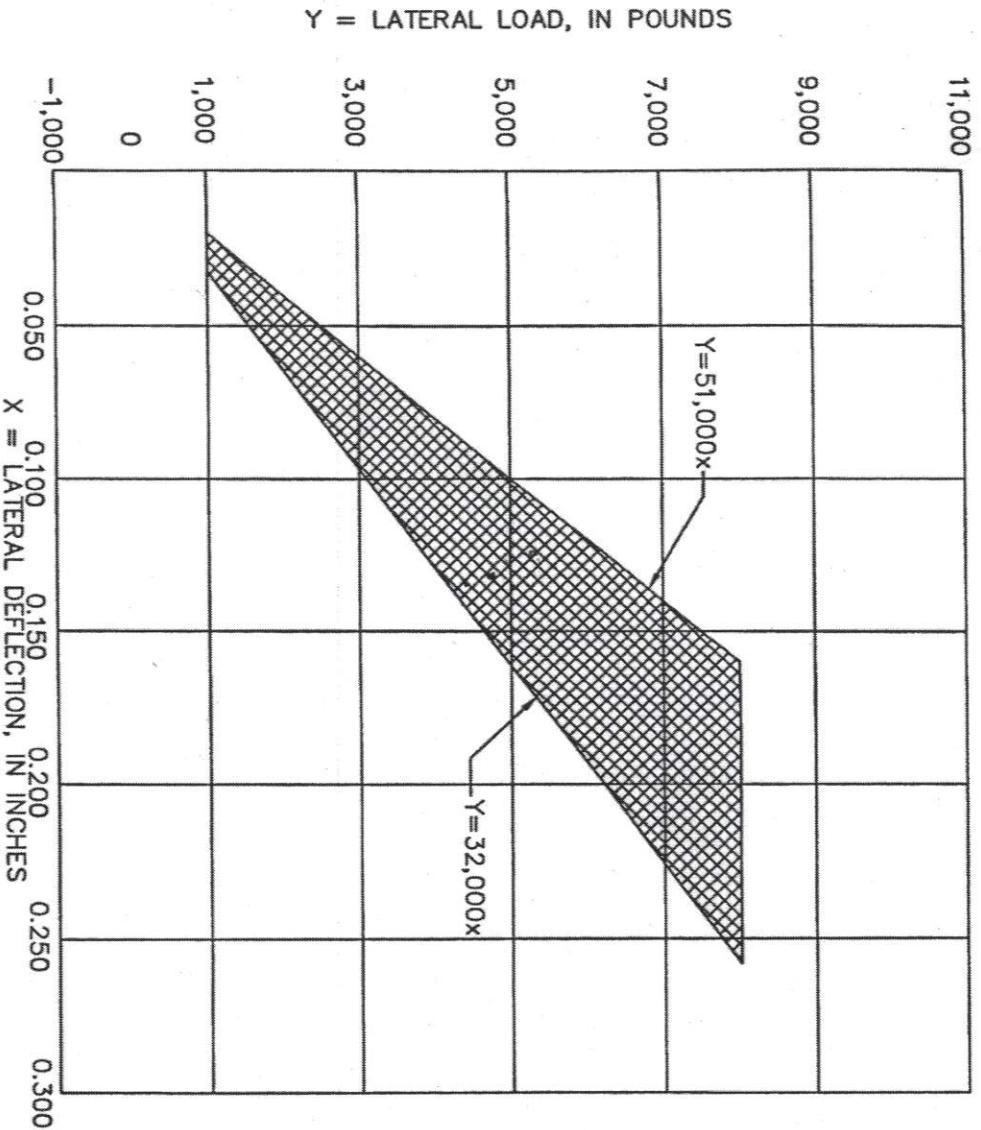


ACCEPTANCE LOAD VS. DEFLECTION ENVELOPE INDICATED SPRING RATES ARE ONLY FOR DEFINING ENVELOPE OUTLINE

X=VERTICAL DEFLECTION, IN INCHES

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

SCALE:	DATE:	TITLE:
NONE	DECEMBER 2007	EXHIBIT 05657-F VERTICAL LOAD TEST ACCEPTANCE CRITERIA FOR FOR D.F. RAIL FASTENER



NOTES:

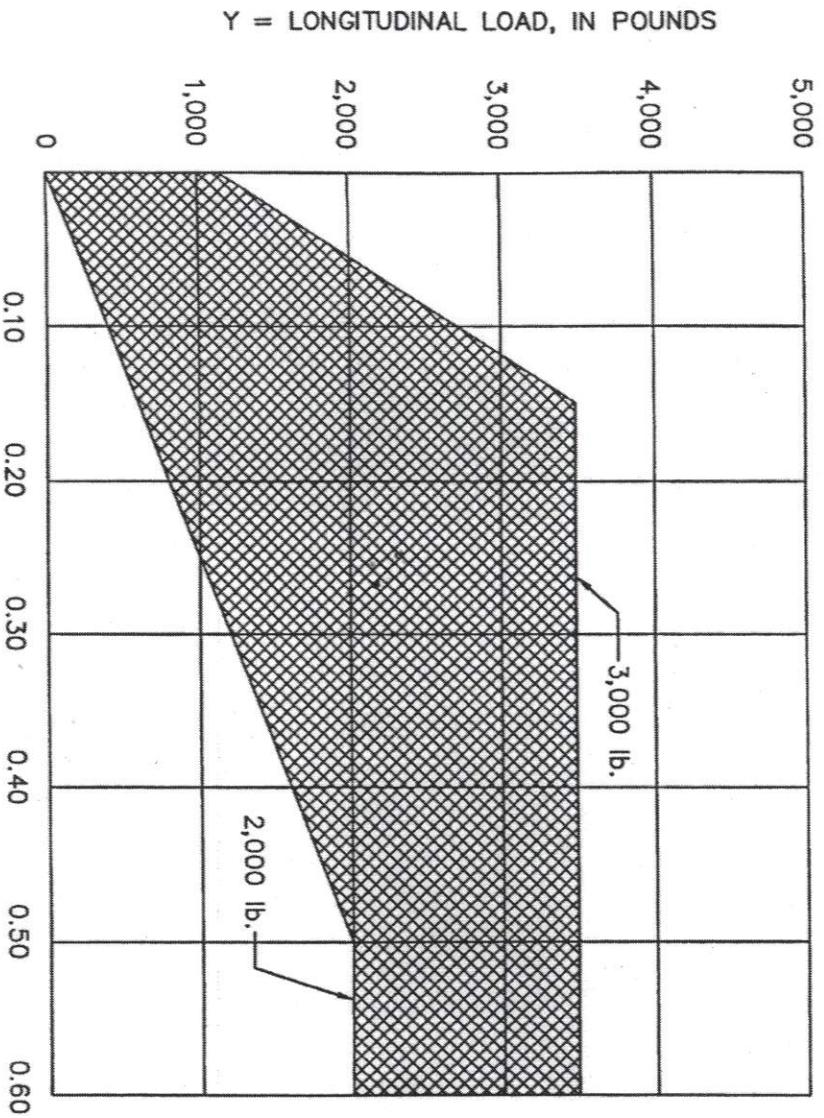


ACCEPTANCE LOAD VS. DEFLECTION ENVELOPE INDICATED SPRING RATES ARE ONLY FOR DEFINING ENVELOPE OUTLINE

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

SCALE	NONE	DATE	DECEMBER 2007
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TITLE	EXHIBIT 05657-G LATERAL LOAD TEST ACCEPTANCE CRITERIA FOR D.F. RAIL FASTENERS
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X = LONGITUDINAL DEFLECTION, IN INCHES

NOTES:

 ACCEPTANCE LOAD VS. DEFLECTION ENVELOPE INDICATED SPRING RATES ARE ONLY FOR DEFINING ENVELOPE OUTLINE

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

TITLE	
EXHIBIT 05657-H LONGITUDINAL RESTRAINT TEST ACCEPTANCE CRITERIA FOR D.F. RAIL FASTENERS	
SCALE: NONE	DATE: DECEMBER 2007

END OF SECTION

## SECTION 05658

### TRACK APPURTENANCES AND OTHER TRACK MATERIAL

#### PART 1 - GENERAL

##### 1.01 SUMMARY

- A. This Section specifies **designing, fabricating, testing and furnishing** of track appurtenances. The Work specified herein consists of furnishing and installing bonded standard joints, bonded insulated joints, bumping posts, tie plates with resilient rail clips, spikes, tie plugs, emergency guard rail, derail, switch stand, and other track materials required for track construction.
- B. All track appurtenances and other track material (OTM) shall be new and conform to the requirements **as specified**. All materials shall conform to the dimensional requirements for 115 RE rail, as recommended by current AREMA Specifications or as specified.

##### 1.02 RELATED SECTIONS

- A. Section 05651 - General Track Construction
- B. Section 05652 - Ballasted Track Construction
- C. Section 05653 - Direct Fixation Track Construction

##### 1.03 REFERENCES

- A. Association of American Railroads (AAR) - Signal Manual
- B. American Railway Engineering and Maintenance-of-Way Association (AREMA)
  - 1. AREMA Manual for Railway Engineering, **latest edition**.
  - 2. AREMA Portfolio of Trackwork Plans
- C. American Society of Testing and Materials (ASTM)
  - 1. ASTM A36
  - 2. ASTM A66
  - 3. ASTM A325
  - 4. ASTM D257
  - 5. ASTM D395
  - 6. ASTM D412
  - 7. ASTM D471
  - 8. ASTM D518
  - 9. ASTM D570
  - 10. ASTM D573
  - 11. ASTM D695
  - 12. ASTM D1149
  - 13. ASTM D1229
  - 14. ASTM D2240**
- D. National Electrical Manufacturers Association (NEMA)
  - 1. NEMA LI 1 Industrial Laminated Thermosetting Products
- E. American Institute of Steel Construction
  - 1. Manual of Steel Construction.

## 1.04 QUALITY ASSURANCE

- A. Quality Assurance Program - Refer to Section 05651, General Track Construction, and conform to the requirements of the Quality Assurance Program.
- B. Testing Laboratory Services - Refer to Section 01410, Testing Laboratory Services
- C. Before permanently installing either bonded standard joints or bonded insulated joints, pre-qualify each crew and its foreman by testing two samples of each type of bonded joint in accordance with the Longitudinal Compression Test specified herein. Prepare test samples in track. The bonded insulated joints tests shall be performed with one sample using high strength rail and the other sample using standard rail. Both bonded standard joint samples shall use high strength rail.
  - 1. The two sample joints shall have a 1/4-inch gap between the rail ends.
  - 2. The joints shall be tested in compression. A load shall be applied longitudinally in increments of 25,000 pounds. Each load increment shall be maintained constant until the longitudinal deflection of the rail ceases before increasing the load to the next increment.
  - 3. The load shall be increased in these increments until a total load of 650,000 pounds is attained or failure occurs. At each increment of loading, the load and differential movement of the rail and joint bars shall be measured to 0.0001 inch and recorded.
  - 4. The assembled joints may be sawn in half where the rails are butted together. The sawing shall be done in such a manner as to prevent overheating or damage to the bond and the cut shall be perpendicular to the centerline of the top of the rail with a tolerance of plus or minus one degree. A device shall be fabricated so that the reaction at the sawn ends occur only on the face of the joint bars.
  - 5. At no time shall any of the bonded standard rail joints show any indication of slippage before a compressive load of 650,000 pounds is applied to the joint, nor shall the magnitude of the differential movement be more than 1/8-inch in any direction. At the completion of the test, after the load in the rail has been released, the relative position of rail and joint bar shall be within 1/32-inch of its original value.
  - 6. The test shall be performed by an approved independent laboratory. Should any sample joint fail to meet the specified requirements of the test, another joint may be tested or a different manufacturer's product may be tested as directed by the engineer. For qualification testing, materials required shall be furnished by the contractor at no additional cost to the Authority.
  - 7. Failure of any test sample disqualifies the responsible foreman for permanent installation work. Assign a new foreman and repeat procedure and test.
  - 8. Bonded insulated joint bar and bonded standard joint bar to conform to:
    - a. Fishing height: plus or minus 1/64 inch
    - b. Length: plus or minus 1/8 inch
    - c. Straightness, as determined by a 36-inch straightedge: plus or minus 1/32 inch
    - d. End post thickness: plus or minus 1/64 inch
    - e. Projection below base of rail - 1/16 inch
    - f. Bolt hole location - as specified in AREMA Manual for Railway Engineering, Chapter 4, for 36-inch joint bar modified to receive 1-1/8 inch bolt.
- D. Equipment: Use equipment that is specifically designed to fasten proprietary bolts in bonded joint installation. Use the same equipment for field installation of bonded joints and for assembling test samples.
- E. Tolerances
  - 1. Other track material (OTM) to conform to tolerances as per AREMA.

F. Testing of Elastomer Material

1. The following test shall be performed on each of two pads or on specimens taken from two pads that are identical in all respects to the elastomer proposed for use in special trackwork. All testing shall be at no expense to the Authority.
2. In the event specimens cannot be taken from finished pads, samples certified by the supplier to have been taken from a batch of compound used for making the elastomeric component and having a cure equivalent to the cure of the elastomer component shall be used for the tests.
  - a. The elastomer shall be tested in accordance with ASTM D412, to determine the tensile strength and the ultimate elongation. The tensile strength shall be not less than 1500 psi and the ultimate elongation shall be not less than 350 percent.
  - b. The elastomer shall be tested for 22 hours at 100C in accordance with ASTM D395, Method B, to determine the percent of compression set. The compression set shall not exceed 30 percent.
  - c. The elastomer shall be aged for 336 hours at 70C in accordance with ASTM D573. The change of hardness and the percentage of change from the original tensile strength and original ultimate elongation shall not exceed 40 percent. The change in hardness, measured on the Durometer A scale shall not exceed 10 points.
  - d. Test specimens shall be prepared in accordance with Procedure A of ASTM D518. The test specimens shall be tested in accordance with ASTM D1149, at a temperature of 40C, and at an ozone concentration of 50 pphm. The elastomer shall not exhibit any cracking when examined in accordance with ASTM D1149 at the end of a 100 hour exposure.
  - e. The elastomer shall be tested at minus 10C for 94 hours in accordance with ASTM D1229, to determine the percent compression set at 30 minutes after release (t30 reading). The compression set shall not exceed 50 percent.
  - f. One test for oil absorption shall be conducted with ASTM No. 3 oil at 100C for 70 hours and another test using a different sample shall be conducted with ASTM No. 1 oil at 100C for 70 hours in accordance with ASTM D471, to determine the volume change of the elastomer. The volume change for the No. 1 oil shall not exceed minus 10 or plus 20 percent. The volume change for the No. 3 oil shall not exceed 100 percent all not exceed 100 percent.
  - g. Prior to commencing production of elastomer pad sheets, a prototype pad, using the chemical composition intended for production pads, shall be prepared and tested using a one inch by eight inch by one foot nine inch steel plate with two special plate anchorage assemblies two inches from the edges of diagonally opposite corners. The plate and the prototype pad shall be assembled, mounted on a reinforced concrete slab simulating actual field conditions, and subjected to the following tests.
    - 1) A vertical load increasing in increments of 1000 pounds to a maximum load of 15,000 pounds shall be applied downward at the center of plate normal to the plate. For each load the vertical deflection of the center of the plate shall be measured to the nearest 0.001 inch and recorded. The load shall be removed and the final position of the plate measured and recorded. The recorded values for vertical load and deflection shall be plotted on a graph as shown on **Exhibit 05658-C**.
    - 2) The load vs. deflection curve shall lie within the envelope shown on **Exhibit 05658-C** for loads in the range from 4,500 pounds to the load corresponding to a 120,000 pound vehicle.

Throughout that loading range, the spring rate of the fastener, slope of the load-deflection curve, shall not be less than 80,000 pounds per inch or more than 130,000 pounds per inch and shall be of a constant slope within 10 percent. In the event the curve fails to meet the requirements specified above, the chemical formulation of the pad, the coring size, or both shall be modified and the new elastomer pad design retested.

- 3) An electrical resistance test with one anchor bolt grounded, 100 volts dc shall be applied to the rail head for three minutes. The actual current flow shall be measured to the nearest 0.1 microampere and recorded. Then 1000 volts dc shall be applied to the rail head for two hours, after which 100 volts dc shall be applied again for three minutes and the actual current flow shall be measured, as above, and recorded. A potential of 50 volts rms ac shall be applied to the rail head for three minutes for each increment of measurement for frequencies from 20 Hertz to 10 kilohertz in increments of measurement of 20 Hz up to 100 Hz; 200 Hz up to 1000 Hz; and 2000 Hz up to 10 kHz. The impedance after three minutes shall be determined with an accuracy of plus or minus two percent and recorded for each frequency. The maximum current for 100 volts dc shall be 1.0 microampere. The minimum impedance for any frequency with 50 volts rms ac shall be 10,000 ohms.

#### 1.05 SUBMITTALS:

- A. Refer to Section 01300, Submittals.
- B. Certificates of Compliance for materials specified in Part 2: Products
- C. **The Contractor shall submit for approval shop drawings for fabrication of the components and assemblies for all appurtenances listed in this section. No fabrication or manufacturing shall be performed prior to drawing approval. Provide** shop drawings on:
1. Bonded insulated and bonded standard joints
  2. Standard joints
  3. Proprietary bolts and fasteners
  4. Hydraulic bumping posts
  5. Tie plates
  6. Rail clips
  7. Screw spike insulators
  8. Shims for DF Fasteners
  9. Fabrication of the elastomer pads together with a detailed description of the chemical composition and manufacturing processes used in making the elastomer pads.
- D. The Contractor, shall in accordance with Specification Section 01300, Submittals, submit shop drawings or detailed catalog cuts of track appurtenances and OTM not fully shown or not in conformance with AREMA Portfolio of Trackwork Plans and Specifications. **No fabrication or manufacturing shall be performed prior to drawing approval.**
- E. Product data on:
1. Bonded insulated joints and adhesives
  2. Bonded standard joints and adhesives
  3. Proprietary bolts and fasteners
  4. Hydraulic bumping posts
  5. Tie plates, rail clips, elastomer pads and screw spike insulators

6. Corrosion preventing oil or grease
  7. Elastomer pads
- F. Four samples of Fox Industries FX-120 Grade Track Crossing (or approved equal): Six inch by six inch sample.
- G. Two elastomer pads, or samples taken from pads, for each type of pad specified herein.
- H. Certificates and procedure reports:
1. Certificates of product conformance
  2. Qualification tests for bonded insulated joints and bonded standard joints
  3. Crew qualification tests for bonded joint installation
  4. Negative return bonding installation procedure
  5. Certified statements showing the results of all elastomer pad tests specified herein.
  6. Elastomer pad formulations tested and approved for use on an Authority project within five years prior to opening of bids will be accepted without further testing provided the Contractor submits copies of such certified test reports and verifies the materials furnished are the same as those tested.
  7. Certified statements from the supplier of the elastomer shall be submitted stating compliance of the elastomer with the requirements of these specifications.
- I. Record of field connections:
1. A record of each bonded standard joint shall be submitted
  2. Prior to fabrication, emergency guard rail schedule of string lengths and expansion gap locations

## **PART 2 - PRODUCTS**

### **2.01 BOLTED JOINTS (INSULATED AND STANDARD)**

- A. General Requirements: Johnson "Blue" Vulca Bond, or approved equal, with the following requirements:
1. Insulated joints shall be highly resistant to abrading, cracking, cutting, spalling and fatigue failure under impact loads, and shall exhibit deflection characteristics comparable to standard bolted joints.
  2. Joint bars shall be quenched and tempered carbon steel in accordance with the AREMA Manual.
  3. Joint bars shall be 36 inches in length.
  4. Joint bars shall have six, 1 - 1/8 inch diameter bolt holes.
  5. Joint bars shall provide full web contact. Inside face of insulated joint bars shall have the insulating material pre-bonded and shall be smooth with no stamping or branding.
  6. End posts shall project 1/4 inch, plus or minus 1/16 inch, below the base of rail.
  7. All insulated joints shall be furnished complete with bars, end posts, bushings, washer plates, bolts, nuts and washers.
  8. Bolts and nuts shall conform to the material requirements of current AREMA Specifications for Heat-Treated Carbon-Steel Track bolts and Carbon-Steel Nuts.
  9. Track bolts shall be oval necked and have a nominal diameter of 5 - 1/2 inches in length in conformance with current AREMA Design for Track Bolts and Nuts.
  10. Spring washers shall be single coil, helical spring washers for 1 inch bolts and shall conform to current AREMA Specifications for Spring Washers.
  11. Flat washers shall be 2 - 1/4 inches OD, 1 - 3/16 inch ID and 1/8 inch minimum thickness and shall conform to current AREMA Specifications.

## **2.02 BUMPING POSTS**

- A. Revenue Vehicle Bumping Post
  - 1. Requirements: Furnish Hydro-Bumper, Holley Engineering Company, or approved equal, with the following minimum requirements:
  - 2. Design:
    - a. Suitable for installation on ballasted track and direct fixation track.
    - b. Permit bolting to web of running rail without anchorage to cross ties or concrete.
    - c. Symmetrical about centerline of track.
    - d. No part extending more than two inches below base of rail.
    - e. Fabricated to dimensions shown.
    - f. Equipped with head capable of absorbing 1,000,000 foot-pounds of energy in 30 inches travel.
  - 3. Provided with one coat of manufacturer's standard shop coat applied to exterior surfaces after complete removal of all foreign matter.
  - 4. Furnish the product of an established manufacturer regularly engaged in the production of bumping posts.
- B. Maintenance Vehicle Bumping Post
  - 1. Steel bumping post, Type WA, Western-Cullen-Hayes, Inc., or approved equal.
    - a. Shock-absorbent head of multiple-spring-and-shockpad design.
    - b. Permit installation by bolting to running rails without anchorage to cross-ties or concrete invert.
    - c. No part extending more than two inches below base of rail.
  - 2. Install at the end of M/W tracks in accordance with the manufacturers requirements.
  - 3. Provided with one coat of manufacturer's standard shop coat applied to exterior surfaces after complete removal of all foreign matter.
  - 4. Furnish the product of an established manufacturer regularly engaged in the production of bumping posts.

## **2.03 TIE PLATES**

- A. Fastener tie plates for Pandrol Spring Clip e2056, 5 - 1/2" rail base, 7" wide and punched for 7/8" screw pikes as manufactured by Pandrol, Inc. Bethlehem Steel, or approved equal.
- B. All tie plates shall be canted 40 to 1 inward.

## **2.04 SPIKES**

- A. Screw spikes, as manufactured by Pandrol, Inc., Bridgeport, NJ, or approved equal, shall be 7" in length, 7/8" diameter, hot forged, made from medium carbon steel to meet ASTM A66. The head shall be configured for use with a 7/8" socket.
- B. Cut track spikes shall be 6 inches by 5/8 inch with reinforced throat, and shall conform to current AREMA "Specifications for Soft-Steel Track Spikes" and "Design for Cut Track Spikes".

## **2.05 TIE PLUGS**

- A. Tie plugs shall be treated, five inches in length and conform to current AREMA Specifications for Tie Plugs for 5/8-inch spikes.

## **2.06 EMERGENCY GUARD RAIL**

- A. Structural angle, cover plates, and base plates shall be as shown and shall comply with ASTM A36.
- B. Structural angle shall be fabricated as specified in the current AISC, Manual of Steel Construction.
- C. Holes shall be punched or drilled through the member perpendicular to its face and shall be clean cut, without torn or ragged edges.
- D. Structural angles shall be furnished in lengths of not less than 25 feet.
- E. Structural angles and plates shall be given a shop coating of rust inhibiting primer, Title Clad II Hi-Bild Primer by Sherwin Williams; 9100 High Performance Epoxy by Rust - Oleum, or approved equal, at the point of fabrication, except that contact areas within three inches of surfaces to be field welded shall not be shop coated. No finish coats of paint are required for emergency guard rail.
- F. Washer head drive spike 3/4 inch x 7 inch as manufactured by A&K Railroad Materials, Inc. Lewis Bolt & Nut Company, L. B. Foster Company, or approved equal.

## **2.07 DERAIL**

- A. Sliding type, Model HBP, Hayes Track Appliance Company, or approved equal.
- B. No part of derail shall extend more than 1 - ½ inches above top of rail when derail is in non-derailing position. Designed for height of 7 - ½ inches from top of rail to bottom of guide box flanges. Stroke: 6- 1/4 inches or less to move from off-rail position to derailing position. Equipped with designated derail blocks.

## **2.08 SWITCH STAND**

- A. Switch stand for installation on hand throw switch shall be Foster Parallel-Throw, Low-Type, Design 51A as manufactured by L. B. Foster Company, or approved equal.

## **2.09 SPRING CLIPS**

- A. Pandrol type e2056
- B. Two per tie plate

## **2.10 SHIMS FOR DF FASTENERS**

- A. Shims for DF fasteners shall be galvanized steel in 1/8-inch and 1/16-inch thicknesses and shall provide full bearing of the fastener on the grout pad.
- B. Slotted shims will not be permitted.
- C. The Contractor shall submit for the Engineer's approval shop drawings of the shims proposed for use.

## 2.11 ELASTOMER PADS

- A. Elastomer pads shall be furnished for use under special plates in special trackwork and shall be fabricated from polychloroprene (neoprene) as specified below
- B. Physical Characteristics
  - 1. Elastomer pads shall be 3/4 inch thick and extend 1 inch beyond the plate edges on all sides.
  - 2. All pads shall have a Durometer A hardness of 50 in accordance with ASTM D2240.
  - 3. Elastomer pads furnished for use under all special plates shall be cut from a uniformly cored sheet conforming to the following requirements:
    - a. Coring shall consist of cylindrical holes 11/16 inch in depth. A continuous membrane 1/16 inch thick shall close one end of all holes.
    - b. Cored holes shall be 1-5/8 inches on center measured between adjacent holes in all directions.
    - c. Anchor bolt holes, 1-5/8 inch in diameter, shall be cut at the required locations on the pad.
    - d. Tolerances for finished pads shall be as follows:
      - 1) Length and width: Plus or minus 1/4 inch.
      - 2) Thickness: Plus or minus 0.03 inch.
      - 3) Squareness: Plus or minus 1 degree.
      - 4) Centering of holes: Plus or minus 1/32 inch.
      - 5) Diameter of holes: Plus or minus 1/32 inch.
      - 6) Durometer: Plus or minus 5 points.
    - e. The diameter of the core holes shall be as follows:
      - 1) Pads for use under all special plates having a longitudinal dimension greater than 12 inches measured along the rail shall have a diameter of 1 - 1/8 inch.
      - 2) Pads for use under plates having a longitudinal dimension measured along the rail equal to or less than 12 inches shall have a diameter of 3/4 inch.

## 2.12 RAIL TROUGH BACKFILL (BUILDING)

- A. Fill trenches for tracks within shop buildings with Fox Industries FX-120 Grade Track Crossing, or approved equal.

## 2.13 ANCHOR ASSEMBLY

- A. Threaded Studs
  - 1. Partially - threaded studs shall be as shown, shall be 7/8 - inch diameter for plates in special trackwork and shall conform to ASTM A449 except that chemical requirements shall conform to ASTM A325 for Type 3 bolts, with the chromium, nickel, and copper elements in such combination to achieve maximum corrosion resistance consonant with strength and hardness requirement.
  - 2. They shall be furnished with ASTM A325 nuts, DH Grade and Finish.
  - 3. In addition, nuts shall be a type which provides a positive means of preventing loosening due to in-service vibrations, conforming to Industrial Fastener Institute Standards IFI - 100 and IFI - 101.
  - 4. Studs shall have the embedded portion deformed to resist a nut removal torque of 250 foot - pounds minimum.
  - 5. The studs, nuts and washers shall be galvanized or cadmium plated of such type and thickness as to achieve maximum corrosion protection without causing excessive embrittlement or galling.

- B. Insulating Materials
  - 1. The insulating fiber washer and one piece fiber washer/sleeve shall conform to the requirements shown on the Contract Drawings and as specified herein.
  - 2. All insulating washers and sleeves shall conform to the requirements specified in the NEMA Standard Publication, LI-1 Grade G-10.
- C. Double - Coil Spring Washers
  - 1. Double - coil spring washers for use in special trackwork shall be galvanized or cadmium - plated parallel coil spring washers as shown and specified.
  - 2. Using six randomly selected production double - coil spring washers, measure load vs. deflection from 1,000 pounds to 3,000 pounds in 200 - pound increments to determine the deflection or spring compression required to obtain 2,000 - pound bolt tension.

### **PART 3 - EXECUTION**

#### **3.01 PREPARATION**

- A. Bolted Joints (Bonded joint and standard joint installation):
  - 1. End-harden rail ends of standard rail as specified in Section 05651, General Track Construction.
  - 2. Remove rail brands which are located in joint bar rail contact areas. All rail brands shall be removed from the rail by grinding for the entire length of the joint bar.
  - 3. Rail welds shall be at least eight feet from the center of the joint.
  - 4. Drill rail holes in conformance with the Contract Drawings and AREMA Specifications or manufacturer's printed instructions using a template as the drilling guide. Debur field drilled holes.
  - 5. Calibrate bolt-tightening equipment by testing three typical bolts in a device capable of indicating actual bolt tension.
- B. Fox Industries FX-120 Grade Track Crossing: Comply with manufacturer's requirements.

#### **3.02 INSTALLATION:**

- A. Joints:
  - 1. Bonded insulated joints shall be installed at all insulated joint locations shown. The exact location will be furnished by the Engineer. No insulated joint, except within the limits of special trackwork, shall be installed without the Engineer's approval. All other joints shall be bonded standard joints. Bonded standard joints used to connect CWR strings shall be installed with negative return bonds.
  - 2. The bonded joint shall be supported by the appropriate direct fixation fastener or plate as shown.
  - 3. Additional preparation and the installation shall be in accordance with the manufacturer's recommendations. The manufacturer's recommendations will include procedures for sandblasting of rail and heat curing of assembled joints.
  - 4. All bonded joints shall be installed under the direct supervision of a qualified foreman.
  - 5. Bolted Standard Joints
    - a. Standard joints shall be assembled with a full complement of bolts, nuts and spring washers. Before installing joint bars, rail surfaces to be covered by the bars shall be cleansed and coated with an oil or grease approved by the Engineer to prevent corrosion.
    - b. Bolts shall be installed and the nuts threaded finger tight.

- c. Bolt tension shall then be increased to 20,000 to 30,000 lbs. by use of a track wrench or power torque wrench. Bolts shall be tightened starting from the center bolts and working to the end bolts.
  - d. Bolts shall be tightened twice; first, after the track has been brought to approximately true alignment; second, immediately before the completion and final acceptance of the trackwork. Re-tightened track bolts shall be brought to a tension of 15,000 to 25,000 lbs.
  - e. Bolted standard joints used to connect CWR strings shall be installed with negative return bonds.
    - 1) Negative return bonds shall be as specified in this Section's article for Negative Return Bonding.
6. Bolted Insulated Joints:
- a. Installation shall be in accordance with the manufacturer's recommendations and as directed by the Engineer.
  - b. Rail surfaces within the insulated joint bars shall be clean and free of oil, dirt, rust and metal filings.
  - c. Joint Resistance Testing will be as specified in this Section's article for Insulated Joint Resistance Test.
7. Insulated Joint Resistance Test: All testing shall be **witnessed** by the **WMATA** Engineer.
- a. Equipment: The insulated joint resistance test shall be conducted using the following Authority test equipment (See **Exhibit 05658-A**):
  - b. General Railway Signal (GRS) Track Quality Meter (TQM) 20182-36 GR.1.
  - c. Standard Resistance Test Fixture.
  - d. Acceptance Criteria: The insulated joint shall have a minimum resistance of 5,000 ohms.
8. Negative Return Bonding:
- a. The Contractor shall furnish and install negative return bonds as specified and shown at all bonded standard joints used to join CWR strings.
  - b. Negative Return Bonds: Shall include two web type at each location.
  - c. Web Bond: Manufactured Bond, 500 KCMIL, stranded copper, single conductor, 2000 volt, UL Type RHW, 48 inches long insulated, as manufactured by Erico Products, Inc., fastened to rail with 5/8" compression fastener, Huck Manufacturing Co. C50LR-BR20-16 and terminal lug, Bundy Type, YA34-L, each end.
  - d. The Contractor shall install all negative return bonds in accordance with the manufacturer's instructions.
  - e. The Contractor shall submit installation procedures for approval.
  - f. The contact surfaces of the running rail web shall be cleaned on each side of mill scale, oil, grease or other foreign matter to near white finish.
  - g. Any raised lettering from the steel mill shall be ground flat with the adjacent surface.
  - h. Each negative return bond shall be installed with sufficient amount of slack to accommodate expansion or contraction.
9. Electrical Testing of Negative Return Bonding
- a. The bond resistance of each negative bonded joint shall be tested by the Contractor to verify that it does not exceed 0.000050 ohms.
  - b. The Null Balance method of testing shall be employed utilizing the four terminal arrangement, two potential and two current terminals. The P1 and P2 leads shall be attached to the rail 46 inches apart and equal distance from the ends of the 500 KCMIL cable. The C1 and C2 current leads shall be attached to the rail approximately six inches outside of the P1 and P2 leads. The meter dials shall then be manipulated to achieve a balanced condition of the meter. This procedure is to be followed for each negative return bonded rail joint.

The resistance of each bonded rail joint shall be recorded and submitted to the **WMATA Engineer**. Bonds which exceed 0.000050 ohms shall be removed, replaced and retested. **Reference Exhibit 05658-A.**

10. Record of Field Connections
  - a. A record of each bonded standard joint shall be submitted **for review and approval by the WMATA Engineer.**
  - b. This record shall be in the format shown in Exhibit 05658-B.
  
- B. Bumping Posts:
  1. Prior to final acceptance, bumping posts shall be cleaned, sand blasted, primed, painted and lubricated as directed by the Engineer. Gauge transitions to provide the required track gauge for bumping posts installations shall be as specified for Section 05651, General Track Construction.
  2. Bumping post shall be installed where shown and specified on the Contract Drawings.
  3. Insulated joints shall be installed as shown and specified **in the field installation drawings.**
  4. All holes in the running rails for bumping post installation shall be centered 2 - 7/8 inches above the base of the rail and shall be drilled in conformance with AREMA requirements.
  5. Flame cutting of holes will not be permitted.
  6. Prior to final acceptance, the Contractor shall make all adjustments directed by the **WMATA Engineer** to ensure that all bumping posts are in proper operating condition and ready for service.
  
- C. Fox Industries FX-120 Grade Track Crossing: Comply with manufacturer's requirements.

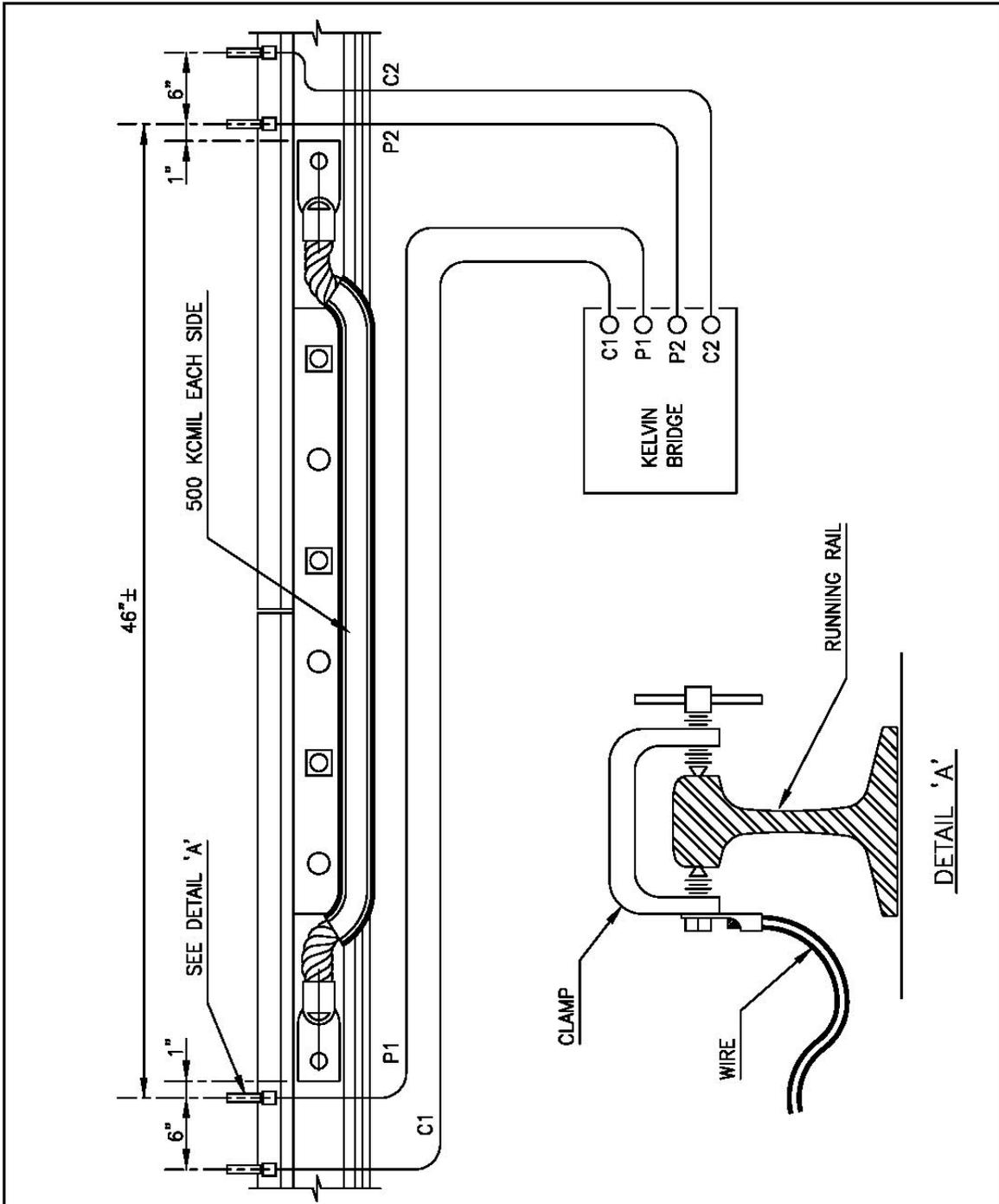
#### **PART 4 - MEASUREMENT AND PAYMENT**

##### **4.01 MEASUREMENT:**

- A. Measurement of work specified in this Section will be made in the following manner:
  1. No separate measurement.

##### **4.02 PAYMENT:**

- A. Compensation for work specified in this Section will be made in the following manner:
  1. Included in the price of the work of which it is a part.



WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

DEPARTMENT OF  
TRANSIT SYSTEM DEVELOPMENT  
OFFICE OF  
ENGINEERING & ARCHITECTURE

NEGATIVE RETURN BOND  
RESISTANCE TEST  
EXHIBIT 05658-A

RECORD OF FIELD CONNECTIONS

DATE: \_\_\_\_\_

TIME: \_\_\_\_\_

TYPE OF CONNECTION:      BONDED JOINT   

TRACK DESIGNATION: \_\_\_\_\_

LOCATION:      STATION \_\_\_\_\_

RAIL STRING DESIGNATION: \_\_\_\_\_ AHEAD \_\_\_\_\_ BACK

MECHANICAL TEST: \_\_\_\_\_ PASSED \_\_\_\_\_ FAILED

BOND RESISTANCE: \_\_\_\_\_ OHMS

TYPE OF RAIL:                  HIGH STRENGTH                  STANDARD                  ( CIRCLE ONE )

MANUFACTURER OF BONDED JOINT \_\_\_\_\_

AIR TEMPERATURE: \_\_\_\_\_

RAIL TEMPERATURE: \_\_\_\_\_

WEATHER CONDITIONS: \_\_\_\_\_

TRACK ALIGNMENT AND CONSTRUCTION: \_\_\_\_\_

( CURVE, TANGENT, GRADE, ETC. )

NAME OF ENGINEER OR REPRESENTATIVE PRESENT: \_\_\_\_\_

NAME OF CONTRACTOR'S FOREMAN PRESENT: \_\_\_\_\_

NAME OF MANUFACTURER'S REPRESENTATIVE PRESENT: \_\_\_\_\_

CONTRACTOR'S REPRESENTATIVE: \_\_\_\_\_

( SIGNATURE )

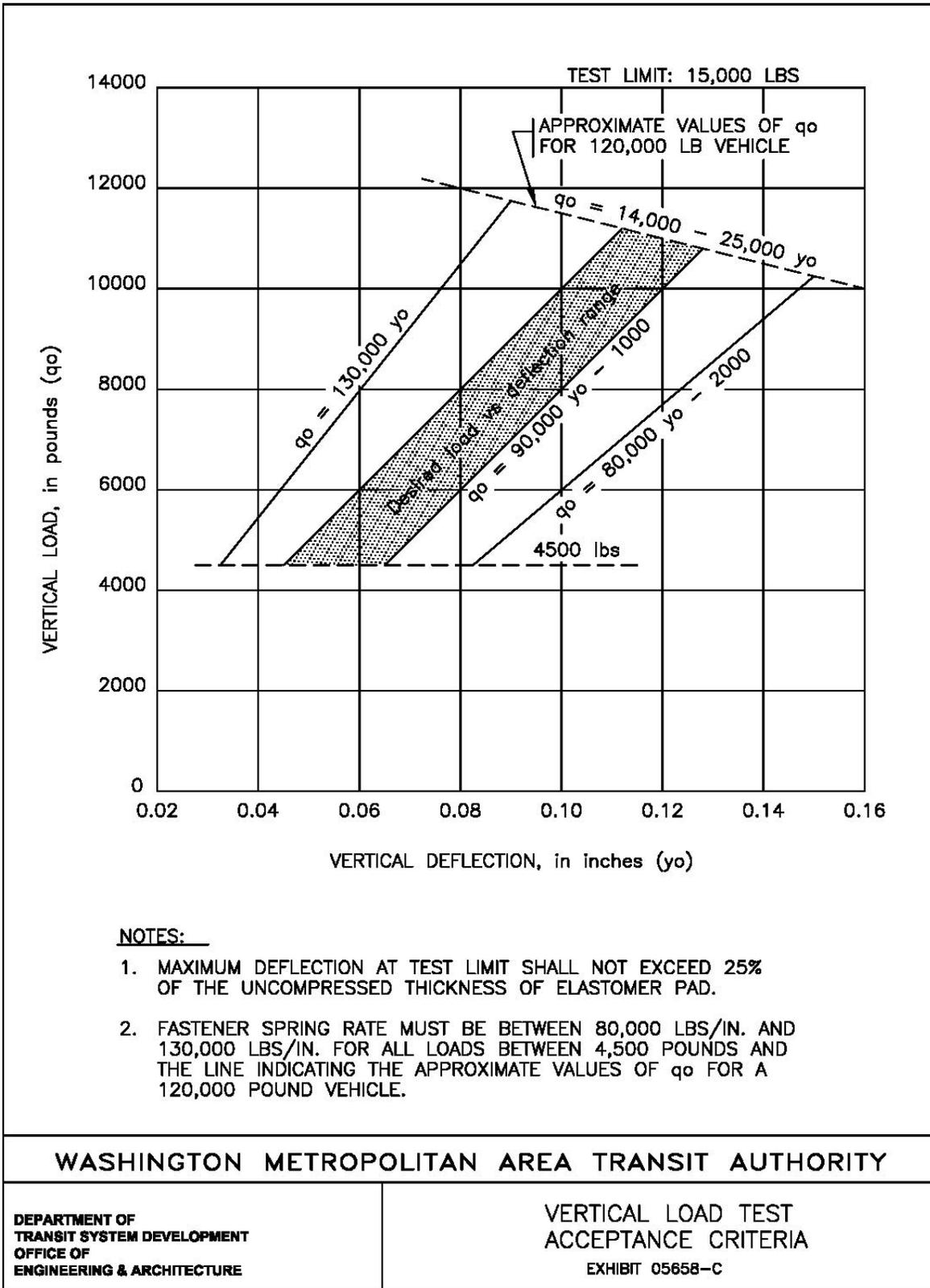
AUTHORITY REPRESENTATIVE: \_\_\_\_\_

( SIGNATURE )

WASHINGTON METROPLITAN AREA TRANSIT AUTHORITY

DEPARTMENT OF  
TRANSIT SYSTEM DEVELOPMENT  
OFFICE OF  
ENGINEERING & ARCHITECTURE

RECORD OF FIELD CONNECTIONS  
EXHIBIT 05658-B



END OF SECTION

## SECTION 05659

### SPECIAL TRACKWORK

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies manufacture, fabrication, shop assembly, inspection, testing, packaging and shipping special trackwork materials.
- B. Special trackwork shall include components for installations in both ballasted and direct fixation track.
- C. This Section also specifies fabricating and furnishing guarded turnouts as shown and specified.

##### 1.02 RELATED SECTIONS

- A. Section 05651 - General Track Construction
- B. Section 05652 - Ballasted Track Construction (BTC)
- C. Section 05653 - Direct Fixation Trackwork Construction (DFTC)
- D. Section 05654 - Special Trackwork Construction - Ballasted
- E. Section 05655 - Special Trackwork Construction - Direct Fixation
- F. Section 05656 - Running Rail
- G. Section 05657 - Direct Fixation Rail Fasteners
- H. Section 05658 - Track Appurtenances and Other Track Material
- I. Section 06130 - Timber Ties
- J. Section 06131 - Composite (Plastic) Ties

##### 1.03 REFERENCES

Pertinent provisions of the following listed standards and publications shall apply to the Work, except as they may be modified herein, and are hereby made part of these Specifications to the extent required.

- A. American Railway Engineering and Maintenance-of-Way Association, Manual for Railway Engineering, herein referred to as the AREMA Manual.
- B. American Railway Engineering and Maintenance-of-Way Association, Portfolio of Trackwork Plans, herein referred to as the AREMA Portfolio.
- C. American Society of Testing and Materials (ASTM)
- D. Association of American Railroads (AAR) Signal Manual

- E. American Council of Independent Laboratories' Manual of Practice
- F. American Welding Society (AWS)
- G. Industrial Fastener Institute (IFI)

#### **1.04 QUALITY ASSURANCE/CONTROL**

- A. Quality Assurance Program - Refer to Section 05651, General Track Construction, and conform to the requirements of the Quality Assurance Program.
- B. Tolerances: Conform to the AREMA Portfolio - Plan No. 1010-89, Permissible Variations in Completed Frogs; Plan No. 1011-84, Permissible Variations in Completed Switches; the AREMA Manual, Section 7, and the AREMA Manual, Section 5, in all aspects unless modified by the contract documents.
- C. Codes, Regulations, Reference Standards and Specifications:
  - 1. Except as modified in the contract documents, design, manufacture, test, assemble, inspect, ship, unload and stack special trackwork in accordance with the AREMA Portfolio and the AREMA Manual.
  - 2. Except as modified in the contract drawings, use rail in the special trackwork conforming to the requirements of the AREMA Manual, Chapter 4, and Section 05656, Running Rail.

#### **1.05 TESTING**

- A. Notify the Authority in writing not less than 14 days in advance of dates scheduled for any test. The Authority retains the right to witness testing. Do not conduct test until authorized by the Authority.
- B. Testing Laboratory:
  - 1. Perform qualification and production quality control tests using either an independent testing laboratory or a qualified manufacturer's laboratory reviewed by the Authority. If an independent testing laboratory is selected, it shall be a member of the American Council of Independent Laboratories. If a manufacturer's laboratory is selected, it shall satisfy the requirements of the American Council of Independent Laboratories' Manual of Practice - Quality Control System - Requirements for A Testing and Inspection Laboratory, and ASTM E329.
  - 2. The selected laboratory shall use the proper equipment and qualified personnel for testing such as described in this Section.
- C. Testing Equipment: Provide equipment in good operating condition, of adequate capacity and range, and accurately calibrated. Use testing equipment that is in calibration with standards which are certified and traceable to the National Bureau of Standards within one year immediately preceding the test date. Submit copies of calibration certificates with test reports.
- D. Documentation: In conjunction with the specified tests, submit the following documents for review:
  - 1. Test program plan: In this plan, identify Contractors' approach for accomplishing each of the specified qualification and production quality control tests. Include the projected schedule for test procedure submittals, test executions, and test results report submittals.
  - 2. Test procedures for each test, describing the objective, equipment, and instrumentation that will be used, procedure to be implemented, and the anticipated

results. Include working drawings detailing test equipment and set-up of direct fixation rail fastener that will be tested.

3. Test report:
  - a. A separate report of test results for each test which includes original data calculations, test procedure references, test equipment identification, test personnel, date of test, specified requirements, actual test results, nonconformance if any, and interpretation of the results. Highlight conformance or deviation in a report summary.
  - b. Accompany the written test reports with a photographic record of the tests. Include photographs of sufficient clarity to distinguish relevant details as described or referenced in the respective written report.

## **1.06 PRODUCTION QUALITY CONTROL TESTS OF INSULATION PIECES**

- A. Test insulated gauge plates and switch rods in accordance with AAR Signal Manual, Part 14.5.3.

## **1.07 SUBMITTALS**

- A. Refer to Section 01300, Submittals.
- B. Shop drawings for special trackwork components, including the following
  1. Insulated curved split switches, including stock rails.
  2. Insulated switch rods, including clip assemblies.
  3. All insulation materials, parts and assemblies.
  4. Closure rails.
  5. Frog guard rails.
  6. All special plates, including details of components.
  7. Switch panel details.
  8. Rail braces.
  9. Direct fixation rail fasteners, including details of components.
  10. Complete layouts and details for all types of turnouts, single crossovers, double crossovers, and crossing diamonds.
  11. Installation drawings for each type of assembly used during construction.
- C. Product data:
  1. Certification of the procedure used in the depth hardening of frog castings
  2. Test data for the rail used in all fabrication for compliance with AREMA and these specifications.
- D. Refer to Section 01322, Certificates and Reports, and submit the following:
  1. Certificates of material compliance required by AREMA and this Specification.
  2. Test reports of chemical analyses, Brinell hardness, electrical insulation, and other tests required by AREMA and this Specification.
  3. Frog depth hardening results
- E. Testing laboratory, testing equipment, test program plan, test procedures and test reports for the direct fixation rail fasteners, including the following testing laboratory information for review by the Authority prior to testing:
  1. Name and address of the laboratory
  2. A description of the facilities and testing equipment that will be assigned for this testing.
  3. Names, experience, and qualifications of the personnel that will be laboratory's experience in performing this testing.

4. For the testing of the direct fixation rail fasteners, a list of the laboratory's experience in testing this type of rail fasteners or fastener - like assemblies
- F. A certified copy of reports on the analyses and tests required by referenced ASTM specifications.
- G. Contractor's method for locating all special plates, not in the switch panel, which span two or more ties, drilling the ties and holding the plates in place during shop assembly and inspection.
- H. Configuration and method of fabrication for switches.
- I. Check list or measurement report for all switches and frogs approved by the Engineer. This shall show the design size and allowable tolerance required by AREMA, or as shown and specified in these contract documents, as well as the actual size.
- J. Detailed description of the procedure for bonded insert and bonded joint installation approved by the Engineer.
- K. Method of packaging and loading each unit approved by the Engineer.

#### **1.08 PREASSEMBLY**

- A. Completely assemble, prior to shipment, the turnouts, crossing diamonds, and crossovers in Contractor's fabrication shop for inspection by the Contractor's Quality Control (QC) Staff, For mainline turnouts and crossovers, assemble on the specified switch ties and/or the direct fixation fasteners which will be incorporated into the Work.
- B. Fully bolt and assemble rail joints for all turnouts. For inspection, use temporary joint bars with "C" clamps for shop assembly. Install 3/16 inch end post shim where insulated joint bars are indicated. Do not apply adhesive during this process.
- C. No bracing, wedging, or support blocking will be permitted to hold components to proper gauge and alignment.
- D. Variations from the Authority reviewed shop drawings or other contract documents will constitute noncompliance and will not be accepted for shipment unless or until proper modification are made and reviewed by the Authority.
- E. Make available to the Authority, without charge, the facilities and assistance to examine the work during its progress, and when the product is finished, to satisfy the Authority that the finished product will comply with the contract documents. Provide templates and one yard straight edge or longer, as necessary, to check flangeways, rail end drilling, switch rail planing, and other features of the Work usually checked by templates.
- F. Present material for inspection in a safe area away from excessive noise and manufacturing activities. Provide labor to facilitate inspection of the top, side and bottom of frogs and switches.
- G. With minimal bar pressure acting on the switch rail at rod number 1, 25% or more of the switch point contact length, starting from the tip of the point, shall make positive, firm contact with the ball of the stock rail.
- H. With no pressure acting on the switch rail, the maximum allowable spring back between the switch point and the ball of the stock rail shall be 3/16 inch, measure six inches back from the tip of the point.

- I. For inspection and review, match mark rails in appropriate colors, and sequentially number fasteners or switch ties, in accordance with the Authority reviewed System. Submit the match marking and numbering system on the Contracting Drawings for the Contractor's QC Staff before match marking and numbering commences.

## **PART 2 - PRODUCTS**

### **2.01 GENERAL REQUIREMENTS**

- A. Special trackwork materials, including oval-neck track bolts of one-inch nominal diameter, nuts and spring washers, and special trackwork assemblies shall be in accordance with AREMA except as modified on the contract drawings and specifications.
- B. Rail, switches, frogs and other track material shall be in accordance with AREMA dimensional requirements for 115 RE rail section except as modified on the contract drawings and specifications.
- C. Heel ends of switch rails, and ends of stock, closure and connecting rails shall be beveled in accordance with AREMA requirements.
- D. Cut all rail ends in accordance with AREMA requirements except that tolerance to be taken up in the rail base.
- E. Drill rail ends to receive 36-inch, six-hole joint bars in accordance with AREMA and as shown. Standard joints shall be drilled to allow butting of rail ends. Insulated joints shall be drilled to allow for a 3/8-inch end post. Drill holes in accordance with joint manufacturers instructions, plus or minus 1/32-inch.
- F. All rail shall be in accordance with Section 05656, Running Rail.
  1. Guard rails: 132 RE section.
  2. All other rail: 115 RE section.
- G. Drill and ream holes with edges beveled.
- H. All joints required for installation shall be new material.
- I. Supply all ties in accordance with Section 06130, Timber Ties or Section 06131, Composite (Plastic) Ties.

### **2.02 STOCK RAILS, CLOSURE RAILS AND CONNECTING RAILS**

- A. Length: As shown plus or minus 1/8-inch.
- B. All ends drilled except ends to be connected to CWR which shall be drilled in the field.

### **2.03 FROGS**

- A. Railbound manganese steel construction as shown
- B. Frog casting
  1. Depress heel of manganese frog casting in accordance with AREMA Plan 617-89.
  2. Depth-harden impact areas of manganese frog castings.
- C. Frog inserts

1. Cast inserts of carbon steel in accordance with AREMA Specification M3.
  2. Provide inserts of one-piece construction.
  3. Provide inserts having full-face contact conforming to configuration of 115 RE rail.
  4. Provide available bonding area per inch of length equivalent to that available for bonded standard joints where applicable. Adjust dimensions of bonded inserts to allow for glue and fabric.
  5. Ensure the inserts are smooth and straight and do not exceed the following permissible variations:
    - a. Width between rail webs: Plus or minus 1/32-inch of that shown.
    - b. Depth of flangeway groove: Plus or minus 1/16-inch of that shown.
    - c. Length of insert: Plus or minus 1/8-inch of that shown.
    - d. Straightness of all portions of inserts adjacent to rail using 36-inch straightedge: Plus or minus 1/32-inch.
    - e. Finishing height variance of inserts from that required for bonding area: Plus or minus 1/64-inch.
- D. Assembly: Prior to delivery, assemble frogs as shown.
1. Bonding adhesive: As manufactured for bonded joint bars by Allegheny Drop Forge Company, Portec, Inc. or equal, applied as directed by the manufacturer to all contact surfaces between inserts and rail.
  2. Secure frog, except for insert, with 1-3/8 inch diameter high strength bolts in accordance with AREMA requirements.
  3. Assemble inserts with 1-1/8 inch diameter high-strength bolts, ASTM A490, and lock nuts. Position bolt holes in accordance with AREMA Plans 621-89 and 1010-89 and as shown. Bolt holes 1-3/8 inches in diameter plus or minus 1/32- inch.
  4. Flat washers: ASTM F436.
  5. Equip bolts as shown with one beveled or flat headlock washer and one flat or beveled washer to provide square bearing and to permit tightening of nuts by wrench.
  6. Lock nuts: IFI-100 and IFI-101, ASTM A563, Grade C.
  7. Tension bolts to between 75 percent and 85 percent of proof load. Exact value as directed by the Engineer. Ascertain bolt tension by means of torque wrench. Determine desired torque by test similar to that described in IFI-101.

## 2.04 FROG GUARD RAILS

- A. Length: 12'-6"
- B. Complete with blocks and bolts as shown.

## 2.05 SWITCHES

- A. Switch Rails: As shown.
  1. Switch rails and stock rails: In accordance with Section 05656, Running Rail, and AREMA Plan 221-62, Detail 5100.
    - a. Stock rails may be thick web or constructed with reinforcing bars.
    - b. Stock rail lengths: as shown or as required for switch panel..
  2. Bolts, rivets, fittings and spring washers in accordance with Appendix A of the AREMA, Portfolio.
    - a. Fabricate five bolt heel joint assembly in accordance with AREMA Plan 221-62 and AREMA Manual.
    - b. Fabricate forged steel rail stops in accordance with AREMA requirements.
    - c. Switch inserts with bolts: As specified for frog inserts.

- B. Drill stock rails for ballasted special trackwork as shown. Switch heaters will be furnished and installed by other trades.

## **2.06 SWITCH RODS**

- A. Switch rods and clips of vertical design, Type MJS, modified as shown.
  - 1. Insulated construction.
  - 2. Assembled.
  - 3. Test in accordance with AAR requirements.
  - 4. Length: As shown.
- B. Switch rods must be capable of at least one (1) inch plus/minus adjustment after the initial specified 5 inch throw has been set.
- C. Contractor's shop drawings shall provide the required spread measurement for each switch rod which are needed to support the specified throw.

## **2.07 RAIL BRACES**

- A. Boltless adjustable brace equal to those formerly manufactured by Bethlehem Steel, modified to permit installation of one inch diameter electric switch heaters on rail web of ballasted turnouts.
- B. Shop weld rail brace backing blocks to switch plates.
- C. Rail brace backing blocks to permit mounting on 3/4-inch thick flat plates. Allow for modification to fit 1/4-inch recessed gauge plates. Ensure that distance from rail base to horizontal bearing surface of backing block is the same in each case to permit use of standardized wedge.
- D. Clearance between backing block and rail base: Determined by design of selected brace.
- E. Brace shall use left-hand Pandrol spring clips e2056.

## **2.08 PLATES**

- A. Furnish special trackwork units with special plates as shown, fabricated of 3/4-inch thick steel, ASTM A36 in accordance with designs shown or AREMA requirements.
- B. Plates complete with specified rail base backing blocks, riser plates, rail stops and rail clamp blocks welded thereon.
- C. Riser plates and rail stops fabricated of ASTM A36 steel as shown and as specified.
- D. Punch holes in each plate perpendicular to face. Cut clean without torn or ragged edges.
- E. Straighten plates cold in press or roller until surface and line requirements are met. The following tolerances are not cumulative.
  - 1. Plate thickness: Plus or minus 1/32-inch.
  - 2. Middle ordinate: Place plate on horizontal support. Place straightedge or wire string from one end of plate to the other on the concave side. Measure distance between plate surface and straightedge or stringline. Distance not to exceed 0.001 inch per inch of length with surface upsweep or downsweep uniform.
  - 3. Plate thickness of dual rail stops, single rail stops and riser plates: Plus or minus 1/32-inch.

4. Straightness of edge of dual rail stops, single rail stops and riser plates parallel and adjacent to base of running rail: Plus or minus 1/32-inch.
  5. Transverse dimension of dual rail stops: Plus or minus 1/32-inch.
  6. Tolerances other than those specified: Plus or minus 1/8-inch.
  7. Spike hole locations for ballasted special trackwork: Plus or minus 1/8-inch.
- F. Identification of plates:
1. Stamp with suitably sized characters not less than 1/2-inch in height, located on top surface and plainly visible when assembled.
  2. Include Contract Number and identification designation as shown.
- G. Fillet weld rail braces, rail stops, riser plates and rail clamps to their respective plates as shown in accordance with AWS D1.1.
- H. In special trackwork fabricated for ballasted trackwork, seven inch wide elastic fastener tie plates suitable for e2056 Pandrol spring clips shall be used at all support locations not having special frog, switch, gauge or guard plates.

## **2.09 GAUGE PLATES**

- A. Switch gauge plates as shown and as specified for plates.
- B. Insulation shall be a four hole 7-1/2" x 8" x 3/4" epoxy fiberglass splice block fastened to the plate with Huck type compression fasteners. The insulating material shall have a tensile strength of 70 ksi, compressive strength of 100 ksi and a tensile modulus of  $3.4 \times 10^6$ .

## **2.10 TURNOUT GUARD RAIL**

- A. Length: As shown.
- B. Complete with blocks and bolts as shown.
- C. Type: 132 RE rail.
- D. Planned in accordance with AREMA Plan No. 504-89.

## **2.11 RAIL JOINTS**

- A. Furnish all standard and insulated joints within the turnout

## **2.12 GUARDED TURNOUTS**

- A. Guard Rail Stop:
  1. Ductile Iron: ASTM A536, Grade 65-45-12 to fit 115 RE rail and as supplied for NYCTA guarded turnouts.
    - a. Direct Fixation Turnouts:
      - 1) Ductile iron rail stops shall be attached to the steel plate with 7/8" square neck carriage bolts, ASTM A325, inserted through a square punched hole from the underside of the plate. A heavy hex nut, Grade 3 ASTM 563 and flat washer, weathering steel ASTM F436 shall complete the assembly; three bolts, nuts and washer per rail stop.
    2. Ballasted Turnouts:
      - a. Ductile iron rail stops shall be attached to the tie and plate; three studs with nuts and washers per rail stop. Cast rail stops and house chairs shall be

fastened through the ties with 7/8 " diameter double end threaded studs, flat washers and heavy hex nuts. The nuts and washers shall be fastened to the stud on the underside of the tie and on top of the casting similar to NYCTA guarded turnouts.

3. The rail stop shall be backed with a 6" x 2" x 1/2" steel block welded to the rail plate.
- B. Manganese Housing Assembly:
1. Cast manganese steel: AREMA Manual.
  2. Housing: Similar to that manufactured for the NYCTA.
    - a. Direct fixation - 6' - 2 1/2" long.
    - b. Ballasted track - 5' - 5" long.
  3. Housing Chairs: Ductile Iron ASTM A536 Grade 65-45-12, as manufactured for NYCTA.
    - a. Direct fixation housing chairs shall be fastened to steel plates and gauge plates similar to ductile iron rail stops, except that one hole, as shown, in each chair shall be sized for an anchor assembly instead of the square neck carriage bolt.
    - b. Ballasted housing chairs shall be fastened to ties, steel plates and gauge plates similar to ductile iron rail stops.
    - c. The first housing chair number shall be configured for bolting to a 132 RE guard rail which continues ahead of the point of switch as shown.
  4. No part of the housing shall extend more than 1-1/2 inches above the top of rail.

## **PART 3 -EXECUTION**

### **3.01 INSTALLATION**

- A. Direct Fixation Special Trackwork Fabrication
1. Fabrication of special trackwork for direct fixation track shall be as specified and shall comply with the applicable related Sections:
    - a. General Track Construction (GTC), Section 05651.
    - b. Direct Fixation Trackwork Construction (DFTC), Section 05653.
    - c. Special Trackwork Construction - Direct Fixation, Section 05655.
    - d. Direct Fixation Rail Fasteners, Section 05657.
  2. Tolerances
    - a. The final gauge, cross level, superelevation, horizontal alignment and vertical alignment of direct fixation special trackwork shall be as shown and specified. Tolerances shall be as specified for direct fixation track construction for GTC. Switch points in normal position shall be square within 5/8 inch.
- B. Ballasted Special Trackwork Fabrication
1. Fabrication of special trackwork for ballasted track shall be as specified and shall comply with the applicable related Sections:
    - a. General Track Construction (GTC), Section 05651.
    - b. Ballasted Track Construction (BTC), Section 05652.
    - c. Special Trackwork Construction - Ballasted, Section 05654.
    - d. Track Appurtenances and Other Track Material, Section 05658
    - e. Timber Ties, Section 06130
    - f. Composite (Plastic) Ties, Section 06131.
  2. Tolerances
    - a. The gauge, cross level, superelevation, and horizontal and vertical alignment of ballasted special trackwork shall be as shown and specified. Tolerances shall be as specified for ballasted track construction for BTC. Switch points in normal position shall be square within 5/8 inch

- b. Screw spike holes drilled in ties shall be 11/16 inch diameter and not less than five inches nor more than six inches deep.
    - c. Tolerance of plus or minus 1/16 inch shall be maintained for the distance between screw spike holes.
    - d. Tolerance of plus or minus 1/8 inch shall be maintained in the centering of screw spike holes across the width of the tie.
  - 3. Ties shall be bored for screw spikes, and only screw spikes will be permitted in special trackwork.
  - 4. The number and locations of holes shall conform to the location and number of screw spikes shown for each special plate.
  - 5. Elastic fastener tie plates shall have four screw spikes, one at each corner.
  - 6. Boring of holes in excess of those required will not be permitted.
  - 7. Boring in timber ties shall be performed with the heartwood face down. Holes bored in timber ties shall be treated with pentachlorophenol oil immediately after boring.
  - 8. Holes shall be located so that each tie plate will be centered on the tie at a right angle to the rail.
  - 9. Prior to installing tie plates, the surface of the tie shall be swept clean to allow full bearing of the plate on the tie.
  - 10. Boring and spiking will ensure that the outside shoulder of the plates will have full bearing against the rail base when the rails are at proper line and gauge.
  - 11. Spikes shall be started vertically and square, and shall be installed straight. Straightening of spikes will not be permitted. Spikes bent during installation shall be withdrawn and the holes plugged (with treated tie plugs if wood, as per manufacturers instruction if composite). Screw spikes shall be installed firmly to the top surface of the plates.
  - 12. All special plates, not in the switch panel, which span two or more ties shall not be spiked during shop assembly to preclude un-spiking for disassembly and packaging. The Contractor's method for locating these plates, drilling the ties and holding the plates in place during shop assembly and inspection shall be approved by the Engineer.
- C. Identification Numbers:
- 1. As shown on the drawing, each turnout has an identification number. This number shall be stamped on a metal tag and the tag affixed to each panel and separate component bundle.
  - 2. Tags shall be made of corrosive-resistant metal such as anodized aluminum or brass. Fastening nails shall be of the same material as the tags. Numbers shall be stamped in characters 1/2 inch minimum in height. Tags shall be a minimum of .050 inches thick, 1-1/4 inches wide and two inches long.
- D. Package and label parts and replacement materials in moisture-proof containers suitable for shipment and storage.
- E. Take special care to package anchor inserts for direct fixation rail fasteners, so as to prevent damage to the epoxy coating.
- F. Submit method of packaging to the Contractor's QC Staff for acceptance before shipping the anchor inserts.
- G. Attach copies of shipping list in the package and so that the list is readable from the exterior of the package.

#### **PART 4 - MEASUREMENT AND PAYMENT**

**4.01 MEASUREMENT:**

- A. Measurement of work specified in this Section will be made in the following manner:
  - 1. No separate measurement.

**4.02 PAYMENT:**

- A. Compensation for work specified in this Section will be made in the following manner:
  - 1. Included in the price of the work of which it is a part.

**END OF SECTION**

## SECTION 05659

### SPECIAL TRACKWORK

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies manufacture, fabrication, shop assembly, inspection, testing, packaging and shipping special trackwork materials.
- B. Special trackwork shall include components for installations in both ballasted and direct fixation track.
- C. This Section also specifies fabricating and furnishing guarded turnouts as shown and specified.

##### 1.02 RELATED SECTIONS

- A. Section 05651 - General Track Construction
- B. Section 05652 - Ballasted Track Construction (BTC)
- C. Section 05653 - Direct Fixation Trackwork Construction (DFTC)
- D. Section 05654 - Special Trackwork Construction - Ballasted
- E. Section 05655 - Special Trackwork Construction - Direct Fixation
- F. Section 05656 - Running Rail
- G. Section 05657 - Direct Fixation Rail Fasteners
- H. Section 05658 - Track Appurtenances and Other Track Material
- I. Section 06130 - Timber Ties
- J. Section 06131 - Composite (Plastic) Ties

##### 1.02 REFERENCES

- A. Pertinent provisions of the following listed standards and publications shall apply to the Work, except as they may be modified herein, and are hereby made part of these Specifications to the extent required.
  - 1. American Railway Engineering and Maintenance-of-Way Association, Manual for Railway Engineering, herein referred to as the AREMA Manual, **latest edition**.
  - 2. American Railway Engineering and Maintenance-of-Way Association, Portfolio of Trackwork Plans, herein referred to as the AREMA Portfolio, **latest edition**.
  - 3. American Society of Testing and Materials (ASTM)
  - 4. Association of American Railroads (AAR) Signal Manual
  - 5. American Council of Independent Laboratories' Manual of Practice
  - 6. American Welding Society (AWS)
  - 7. Industrial Fastener Institute (IFI)

#### 1.04 QUALITY ASSURANCE/CONTROL

- A. Quality Assurance Program - Refer to Section 05651, General Track Construction, and conform to the requirements of the Quality Assurance Program.
- B. **Quality Assurance Program must be submitted to the Authority and must be consistent with ISO 9001.**
- C. Tolerances: Conform to the AREMA Portfolio - Plan No. 1010-89, Permissible Variations in Completed Frogs; Plan No. 1011-84, Permissible Variations in Completed Switches; the AREMA Manual, Section 7, and the AREMA Manual, Section 5, in all aspects unless modified by the contract documents.
- D. Codes, Regulations, Reference Standards and Specifications:
  - 1. Except as modified in the contract documents, design, manufacture, test, assemble, inspect, ship, unload and stack special trackwork in accordance with the AREMA Portfolio and the AREMA Manual. **After approval by the Engineer, match mark all components and package as specified.**
  - 2. **Contractor's checklist/measurement report shall be provided. The checklist shall be completed and submitted to the Engineer for approval prior to shipping any special trackwork.**
  - 3. Except as modified in the contract drawings, use rail in the special trackwork conforming to the requirements of the AREMA Manual, Chapter 4, and Section 05656, Running Rail.\
- E. **WMATA, or its representatives, reserve the right to visit the producers facility during usual business hours unscheduled to a) observe sampling and testing procedures, b) obtain samples of the prepare material being produced and shipped, and c) review plant inspection methods, quality control procedures, equipment and examine test results of current and previous tests.**

#### 1.05 TESTING

- A. Notify the Authority in writing not less than 14 days in advance of dates scheduled for any test. The Authority retains the right to witness testing. Do not conduct test until authorized by the Authority.
- B. Testing Laboratory:
  - 1. Perform qualification and production quality control tests using either an independent testing laboratory or a qualified manufacturer's laboratory reviewed by the Authority. If an independent testing laboratory is selected, it shall be a member of the American Council of Independent Laboratories. If a manufacturer's laboratory is selected, it shall satisfy the requirements of the American Council of Independent Laboratories' Manual of Practice - Quality Control System - Requirements for A Testing and Inspection Laboratory, and ASTM E329.
  - 2. The selected laboratory shall use the proper equipment and qualified personnel for testing such as described in this Section.
- C. Testing Equipment: Provide equipment in good operating condition, of adequate capacity and range, and accurately calibrated. Use testing equipment that is in calibration with standards which are certified and traceable to the National Bureau of Standards within one year immediately preceding the test date. Submit copies of calibration certificates with test reports.

- D. Documentation: In conjunction with the specified tests, submit the following documents for review:
1. Test program plan: In this plan, identify Contractors' approach for accomplishing each of the specified qualification and production quality control tests. Include the projected schedule for test procedure submittals, test executions, and test results report submittals.
  2. Test procedures for each test, describing the objective, equipment, and instrumentation that will be used, procedure to be implemented, and the anticipated results. Include working drawings detailing test equipment and set-up of direct fixation rail fastener that will be tested.
  3. Test report:
    - a. A separate report of test results for each test which includes original data calculations, test procedure references, test equipment identification, test personnel, date of test, specified requirements, actual test results, nonconformance if any, and interpretation of the results. Highlight conformance or deviation in a report summary.
    - b. Accompany the written test reports with a photographic record of the tests. Include photographs of sufficient clarity to distinguish relevant details as described or referenced in the respective written report.

#### **1.06 PRODUCTION QUALITY CONTROL TESTS OF INSULATION PIECES**

- A. Test insulated gauge plates and switch rods in accordance with AAR Signal Manual, Part 14.5.3.

#### **1.07 SUBMITTALS**

- A. Refer to Section 01300, Submittals.
- B. Shop drawings for special trackwork components, including the following
1. Insulated curved split switches, including stock rails.
  2. Insulated switch rods, including clip assemblies.
  3. All insulation materials, parts and assemblies.
  4. Closure rails, turnout rails and connecting rails as provided in the contract documents.
  5. Frog and frog guard rails.
  6. All special plates, including details of components.
  7. Switch panel details.
  8. Rail braces and housing chairs.
  9. Direct fixation rail fasteners, including details of components.
  10. Complete layouts and details for all types of turnouts, single crossovers, double crossovers, and crossing diamonds.
  11. Installation drawings for each type of assembly used during construction.
- C. Product data:
1. Certification of the procedure used in the depth hardening of frog castings.
  2. Test data for the rail used in all fabrication for compliance with AREMA and these specifications.
- D. Refer to Section 01322, Certificates and Reports, and submit the following:
1. Certificates of material compliance required by AREMA and this Specification.
  2. Test reports of chemical analyses, Brinell hardness, electrical insulation, and other tests required by AREMA and this Specification.
  3. Frog depth hardening results

- E. Testing laboratory, testing equipment, test program plan, test procedures and test reports for the direct fixation rail fasteners, including the following resting laboratory information for review by the Authority prior to testing:
  - 1. Name and address of the laboratory
  - 2. A description of the facilities and testing equipment that will be assigned for this testing.
  - 3. Names, experience, and qualifications of the personnel that will be laboratory's experience in performing this testing.
  - 4. For the testing of the direct fixation rail fasteners, a list of the laboratory's experience in testing this type of rail fasteners or fastener - like assemblies
- F. A certified copy of reports on the analyses and tests required by referenced ASTM specifications.
- G. Contractor's method for locating all special plates, not in the switch panel, which span two or more ties, drilling the ties and holding the plates in place during shop assembly and inspection.
- H. Configuration and method of fabrication for switches.
- I. Check list or measurement report for all switches and frogs approved by the Engineer. This shall show the design size and allowable tolerance required by AREMA, or as shown and specified in these contract documents, as well as the actual size.
- J. Detailed description of the procedure for bonded insert and bonded joint installation approved by the Engineer.
- K. Method of packaging and loading each unit approved by the Engineer.

**1.08 PREASSEMBLY**

- A. Completely assemble, prior to shipment, the turnouts, crossing diamonds, and crossovers in Contractor's fabrication shop for inspection by the Contractor's Quality Control (QC) Staff, For mainline turnouts and crossovers, assemble on the specified switch ties and/or the direct fixation fasteners which will be incorporated into the Work.
- B. Fully bolt and assemble rail joints for all turnouts. For inspection, use temporary joint bars with "C" clamps for shop assembly. Install 3/16 inch end post shim where insulated joint bars are indicated. Do not apply adhesive during this process.
- C. No bracing, wedging, or support blocking will be permitted to hold components to proper gauge and alignment.
- D. Variations from the Authority reviewed shop drawings or other contract documents will constitute noncompliance and will not be accepted for shipment unless or until proper modification are made and reviewed by the Authority.
- E. Make available to the Authority, without charge, the facilities and assistance to examine the work during its progress, and when the product is finished, to satisfy the Authority that the finished product will comply with the contract documents. Provide templates and one yard straight edge or longer, as necessary, to check flangeways, rail end drilling, switch rail planing, and other features of the Work usually checked by templates.
- F. Present material for inspection in a safe area away from excessive noise and manufacturing activities. Provide labor to facilitate inspection of the top, side and bottom of frogs and switches.

- G. With minimal bar pressure acting on the switch rail at rod number 1, 25% or more of the switch point contact length, starting from the tip of the point, shall make positive, firm contact with the ball of the stock rail.
- H. With no pressure acting on the switch rail, the maximum allowable spring back between the switch point and the ball of the stock rail shall be 3/16 inch, measure six inches back from the tip of the point.
- I. For inspection and review, match mark rails in appropriate colors, and sequentially number fasteners or switch ties, in accordance with the Authority reviewed System. Submit the match marking and numbering system on the Contracting Drawings for the Contractor's QC Staff before match marking and numbering commences.
- J. Provide the record of the Contractor's completed turnout inspection checklist to WMATA.

## **PART 2 - PRODUCTS**

### **2.01 GENERAL REQUIREMENTS**

- A. Special trackwork materials, including oval-neck track bolts of one-inch nominal diameter, nuts and spring washers, and special trackwork assemblies shall be in accordance with AREMA except as modified on the contract drawings and specifications.
- B. Rail, switches, frogs and other track material shall be in accordance with AREMA dimensional requirements for 115 RE rail section except as modified on the contract drawings and specifications.
- C. Heel ends of switch rails, and ends of stock, closure and connecting rails shall be beveled in accordance with AREMA requirements.
- D. Cut all rail ends in accordance with AREMA requirements except that tolerance to be taken up in the rail base.
- E. Drill rail ends to receive 36-inch, six-hole joint bars in accordance with AREMA and as shown. Standard joints shall be drilled to allow butting of rail ends. Insulated joints shall be drilled to allow for a 3/8-inch end post. Drill holes in accordance with joint manufacturers instructions, plus or minus 1/32-inch.
- F. All rail shall be in accordance with Section 05656, Running Rail.
  - 1. Guard rails: 132 RE section.
  - 2. All other rail: 115 RE section.
- G. Drill and ream holes with edges beveled.
- H. All joints required for installation shall be new material.
- I. Supply all ties in accordance with Section 06130, Timber Ties or Section 06131, Composite (Plastic) Ties.

### **2.02 STOCK RAILS, CLOSURE RAILS AND CONNECTING RAILS**

- A. Length: As shown plus or minus 1/8-inch.
- B. All ends drilled except ends to be connected to CWR which shall be drilled in the field.

- C. Standard Rail and weight shall be new 115 RE rail section, and shall be in conformance with AREMA recommended rail sections, 115 RE rail section and specifications for steel rails, (latest edition).
- D. Rail lengths as identified in the contract documents. The standard rail length of rails shall be either 39, 78 or 80 feet.
- E. Refer to Section 5656.2.01 for physical characteristics of running rails.

## 2.03 FROGS

- A. Railbound manganese steel construction as shown
- B. Frog casting
  - 1. Depress heel of manganese frog casting in accordance with AREMA Plan 617-89.
  - 2. Depth-harden impact areas of manganese frog castings.
- C. Frog inserts
  - 1. Cast inserts of carbon steel in accordance with AREMA Specification M3.
  - 2. Provide inserts of one-piece construction.
  - 3. Provide inserts having full-face contact conforming to configuration of 115 RE rail.
  - 4. Provide available bonding area per inch of length equivalent to that available for bonded standard joints where applicable. Adjust dimensions of bonded inserts to allow for glue and fabric.
  - 5. Ensure the inserts are smooth and straight and do not exceed the following permissible variations:
    - a. Width between rail webs: Plus or minus 1/32-inch of that shown.
    - b. Depth of flangeway groove: Plus or minus 1/16-inch of that shown.
    - c. Length of insert: Plus or minus 1/8-inch of that shown.
    - d. Straightness of all portions of inserts adjacent to rail using 36-inch straightedge: Plus or minus 1/32-inch.
    - e. Finishing height variance of inserts from that required for bonding area: Plus or minus 1/64-inch.
- D. Assembly: Prior to delivery, assemble frogs as shown.
  - 1. Bonding adhesive: As manufactured for bonded joint bars by Allegheny Drop Forge Company, Portec, Inc. or equal, applied as directed by the manufacturer to all contact surfaces between inserts and rail.
  - 2. Secure frog, except for insert, with 1-3/8 inch diameter high -strength bolts in accordance with AREMA requirements.
  - 3. Assemble inserts with 1-1/8 inch diameter high-strength bolts, ASTM A490, and lock nuts. Position bolt holes in accordance with AREMA Plans 621-89 and 1010-89 and as shown. Bolt holes 1-3/8 inches in diameter plus or minus 1/32- inch.
  - 4. Flat washers: ASTM F436.
  - 5. Equip bolts as shown with one beveled or flat headlock washer and one flat or beveled washer to provide square bearing and to permit tightening of nuts by wrench.
  - 6. Lock nuts: IFI-100 and IFI-101, ASTM A563, Grade C.
  - 7. Tension bolts to between 75 percent and 85 percent of proof load. Exact value as directed by the Engineer. Ascertain bolt tension by means of torque wrench. Determine desired torque by test similar to that described in IFI-101.

## 2.04 FROG GUARD RAILS

- A. Length: 12'-6"
- B. Complete with blocks and bolts as shown.

## 2.05 SWITCHES

- A. Minimum yield strength: 95,000 psi.
- B. Switch Rails: As shown.
  - 1. Switch rails and stock rails: In accordance with Section 05656, Running Rail, and AREMA Plan 221-62, Detail 5100.
    - a. Stock rails may be thick web or constructed with reinforcing bars.
    - b. Stock rail lengths: as shown or as required for switch panel..
  - 2. Bolts, rivets, fittings and spring washers in accordance with Appendix A of the AREMA, Portfolio.
    - a. Fabricate five bolt heel joint assembly in accordance with AREMA Plan 221-62 and AREMA Manual.
    - b. Fabricate forged steel rail stops in accordance with AREMA requirements.
    - c. Switch inserts with bolts: As specified for frog inserts.
- C. Drill stock rails for ballasted special trackwork as shown. Switch heaters will be furnished and installed by other trades.
- D. Floating heel blocks for No. 10 and No. 15 switch as shown.
- E. Floating heel block for No. 8 guarded switch as manufactured by Rail Products and Fabricators or equal.
- F. The guarded turnouts shall have a modified five bolt hell joint assembly to accommodate the stock rail, switch rail and guard rail in accordance with AREMA Plan 221-62 and AREMA Specifications.

## 2.06 SWITCH RODS

- A. Switch rods and clips of vertical design, Type MJS, modified as shown.
  - 1. Insulated construction.
  - 2. Assembled.
  - 3. Test in accordance with AAR requirements.
  - 4. Length: As shown.
- B. Switch rods must be capable of at least one (1) inch plus/minus adjustment after the initial specified 5 inch throw has been set.
- C. Contractor's shop drawings shall provide the required spread measurement for each switch rod which are needed to support the specified throw.

## 2.07 RAIL BRACES

- A. Boltless adjustable brace equal to those formerly manufactured by Bethlehem Steel, modified to permit installation of one inch diameter electric switch heaters on rail web of ballasted turnouts.
- B. Shop weld rail brace backing blocks to switch plates.

- C. Rail brace backing blocks to permit mounting on 3/4-inch thick flat plates. Allow for modification to fit 1/4-inch recessed gauge plates. Ensure that distance from rail base to horizontal bearing surface of backing block is the same in each case to permit use of standardized wedge.
- D. Clearance between backing block and rail base: Determined by design of selected brace.
- E. Brace shall use left-hand Pandrol spring clips e2056.

## **2.08 PLATES**

- A. Furnish special trackwork units with special plates as shown, fabricated of 3/4-inch thick steel, ASTM A36 in accordance with designs shown or AREMA requirements.
- B. Plates complete with specified rail base backing blocks, riser plates, rail stops and rail clamp blocks welded thereon.
- C. Riser plates and rail stops fabricated of ASTM A36 steel as shown and as specified.
- D. Punch holes in each plate perpendicular to face. Cut clean without torn or ragged edges.
- E. Straighten plates cold in press or roller until surface and line requirements are met. The following tolerances are not cumulative.
  - 1. Plate thickness: Plus or minus 1/32-inch.
  - 2. Middle ordinate: Place plate on horizontal support. Place straightedge or wire string from one end of plate to the other on the concave side. Measure distance between plate surface and straightedge or string line. Distance not to exceed 0.001 inch per inch of length with surface upsweep or downsweep uniform.
  - 3. Plate thickness of dual rail stops, single rail stops and riser plates: Plus or minus 1/32-inch.
  - 4. Straightness of edge of dual rail stops, single rail stops and riser plates parallel and adjacent to base of running rail: Plus or minus 1/32-inch.
  - 5. Transverse dimension of dual rail stops: Plus or minus 1/32-inch.
  - 6. Tolerances other than those specified: Plus or minus 1/8-inch.
  - 7. Spike hole locations for ballasted special trackwork: Plus or minus 1/8-inch.
- F. Identification of plates:
  - 1. Stamp with suitably sized characters not less than 1/2-inch in height, located on top surface and plainly visible when assembled.
  - 2. Include Contract Number and identification designation as shown.
- G. Fillet weld rail braces, rail stops, riser plates and rail clamps to their respective plates as shown in accordance with AWS D1.1.
- H. In special trackwork fabricated for ballasted trackwork, seven inch wide elastic fastener tie plates suitable for e2056 Pandrol spring clips shall be used at all support locations not having special frog, switch, gauge or guard plates.

## **2.09 GAUGE PLATES**

- A. Switch gauge plates as shown and as specified for plates.

- B. Insulation shall be a four hole 7-1/2" x 8" x 3/4" epoxy fiberglass splice block fastened to the plate with Huck type compression fasteners. The insulating material shall have a tensile strength of 70 ksi, compressive strength of 100 ksi and a tensile modulus of  $3.4 \times 10^6$ .

## 2.10 TURNOUT GUARD RAIL

- A. Length: As shown.
- B. Complete with blocks and bolts as shown.
- C. Type: 132 RE rail.
- D. Planned in accordance with AREMA Plan No. 504-89.

## 2.11 RAIL JOINTS

- A. Furnish all standard and insulated joints within the turnout.
- B. End post shall be reinforced epoxy fiberglass or approved equal.

## 2.12 GUARDED TURNOUTS

- A. Guard Rail Stop:
  - 1. Ductile Iron: ASTM A536, Grade 65-45-12 to fit 115 RE rail and as supplied for NYCTA guarded turnouts.
    - a. Direct Fixation Turnouts:
      - 1) Ductile iron rail stops shall be attached to the steel plate with 7/8" square neck carriage bolts, ASTM A325, inserted through a square punched hole from the underside of the plate. A heavy hex nut, Grade 3 ASTM 563 and flat washer, weathering steel ASTM F436 shall complete the assembly; three bolts, nuts and washer per rail stop.
  - 2. Ballasted Turnouts:
    - a. Ductile iron rail stops shall be attached to the tie and plate; three studs with nuts and washers per rail stop. Cast rail stops and house chairs shall be fastened through the ties with 7/8" diameter double end threaded studs, flat washers and heavy hex nuts. The nuts and washers shall be fastened to the stud on the underside of the tie and on top of the casting similar to NYCTA guarded turnouts.
  - 3. The rail stop shall be backed with a 6" x 2" x 1/2" steel block welded to the rail plate.
- B. Manganese Housing Assembly:
  - 1. Cast manganese steel: AREMA Manual.
  - 2. Housing: Similar to that manufactured for the NYCTA.
    - a. Direct fixation - 6' - 2 1/2" long.
    - b. Ballasted track - 5' - 5" long.
  - 3. Housing Chairs: Ductile Iron ASTM A536 Grade 65-45-12, as manufactured for NYCTA.
    - a. Direct fixation housing chairs shall be fastened to steel plates and gauge plates similar to ductile iron rail stops, except that one hole, as shown, in each chair shall be sized for an anchor assembly instead of the square neck carriage bolt.
    - b. Ballasted housing chairs shall be fastened to ties, steel plates and gauge plates similar to ductile iron rail stops.

- c. The first housing chair number shall be configured for bolting to a 132 RE guard rail which continues ahead of the point of switch as shown.
4. No part of the housing shall extend more than 1-1/2 inches above the top of rail.

## 2.13 ELASTOMER PADS

- A. Elastomer pads shall be furnished for use under special plates in special trackwork shall be fabricated from polychloroprene (neoprene) as shown and as specified below.
- B. Physical Characteristics
  1. Elastomer pads shall be 3/4 inch thick and extend 1 inch beyond the plate edges on all sides.
  2. All pads shall have a Durometer A hardness of 50 in accordance with ASTM D2240.
  3. Elastomer pads furnished for use under all special plates shall be cut from a uniformly cored sheet conforming to the following requirements:
    - a. Coring shall consist of cylindrical holes 11/16 inch in depth. A continuous membrane 1/16 inch thick shall close one end of all holes.
    - b. Cored holes shall be 1-5/8 inches on center measured between adjacent holes in all directions.
    - c. Anchor bolt holes, 1-5/8 inch in diameter, shall be cut at the required locations on the pad.
    - d. Tolerances for finished pads shall be as follows:
      - 1) Length and width: Plus or minus 1/4 inch.
      - 2) Thickness: Plus or minus 0.03 inch.
      - 3) Squareness: Plus or minus 1 degree.
      - 4) Centering of holes: Plus or minus 1/32 inch.
      - 5) Diameter of holes: Plus or minus 1/32 inch.
      - 6) Durometer: Plus or minus 5 points.
    - e. The diameter of the core holes shall be as follows:
      - 1) Pads for use under all special plates having a longitudinal dimension greater than 12 inches measured along the rail shall have a diameter of 1 - 1/8 inch.
      - 2) Pads for use under plates having a longitudinal dimension measured along the rail equal to or less than 12 inches shall have a diameter of 3/4 inch.
- C. Testing of Elastomer Material
  1. The following test shall be performed on each of two pads or on specimens taken from two pads that are identical in all respects to the elastomer proposed for use in special trackwork. All testing shall be at no expense to the Authority.
  2. In the event specimens cannot be taken from finished pads, samples certified by the supplier to have been taken from a batch of compound used for making the elastomeric component and having a cure equivalent to the cure of the elastomer component shall be used for the tests.
    - a. The elastomer shall be tested in accordance with ASTM D412, to determine the tensile strength and the ultimate elongation. The tensile strength shall be not less than 1500 psi and the ultimate elongation shall be not less than 350 percent.
    - b. The elastomer shall be tested for 22 hours at 100C in accordance with ASTM D395, Method B, to determine the percent of compression set. The compression set shall not exceed 30 percent.
    - c. The elastomer shall be aged for 336 hours at 70C in accordance with ASTM D573. The change of hardness and the percentage of change from the original tensile strength and original ultimate elongation shall not exceed 40 percent. The change in hardness, measured on the Durometer A scale shall not exceed 10 points.

- d. Test specimens shall be prepared in accordance with Procedure A of ASTM D518. The test specimens shall be tested in accordance with ASTM D1149, at a temperature of 40C, and at an ozone concentration of 50 pphm. The elastomer shall not exhibit any cracking when examined in accordance with ASTM D1149 at the end of a 100 hour exposure.
- e. The elastomer shall be tested at minus 10C for 94 hours in accordance with ASTM D1229, to determine the percent compression set at 30 minutes after release (t30 reading). The compression set shall not exceed 50 percent.
- f. One test for oil absorption shall be conducted with ASTM No. 3 oil at 100C for 70 hours and another test using a different sample shall be conducted with ASTM No. 1 oil at 100C for 70 hours in accordance with ASTM D471, to determine the volume change of the elastomer. The volume change for the No. 1 oil shall not exceed minus 10 or plus 20 percent. The volume change for the No. 3 oil shall not exceed 100 percent all not exceed 100 percent.
- g. Prior to commencing production of elastomer pad sheets, a prototype pad, using the chemical composition intended for production pads, shall be prepared and tested using a one inch by eight inch by one foot nine inch steel plate with two special plate anchorage assemblies two inches from the edges of diagonally opposite corners. The plate and the prototype pad shall be assembled, mounted on a reinforced concrete slab simulating actual field conditions, and subjected to the following tests.
  - 1. A vertical load increasing in increments of 1000 pounds to a maximum load of 15,000 pounds shall be applied downward at the center of plate normal to the plate. For each load the vertical deflection of the center of the plate shall be measured to the nearest 0.001 inch and recorded. The load shall be removed and the final position of the plate measured and recorded. The recorded values for vertical load and deflection shall be plotted on a graph as illustrated in Specification Section 05658, **Exhibit 05658-C**.
  - 2. The load vs. deflection curve shall lie within the envelope illustrated in Specification Section 05658, **Exhibit 05658-C** for loads in the range from 4,500 pounds to the load corresponding to a 120,000 pound vehicle. Throughout that loading range, the spring rate of the fastener, slope of the load-deflection curve, shall not be less than 80,000 pounds per inch or more than 130,000 pounds per inch and shall be of a constant slope within 10 percent. In the event the curve fails to meet the requirements specified above, the chemical formulation of the pad, the coring size, or both shall be modified and the new elastomer pad design retested.
  - 3. An electrical resistance test with one anchor bolt grounded, 100 volts dc shall be applied to the rail head for three minutes. The actual current flow shall be measured to the nearest 0.1 microampere and recorded. Then 1000 volts dc shall be applied to the rail head for two hours, after which 100 volts dc shall be applied again for three minutes and the actual current flow shall be measured, as above, and recorded. A potential of 50 volts rms ac shall be applied to the rail head for three minutes for each increment of measurement for frequencies from 20 Hertz to 10 kilohertz in increments of measurement of 20 Hz up to 100 Hz; 200 Hz up to 1000 Hz; and 2000 Hz up to 10 kHz. The impedance after three minutes shall be determined with an accuracy of plus or minus two percent and recorded for each frequency.

The maximum current for 100 volts dc shall be 1.0 microampere.  
The minimum impedance for any frequency with 50 volts rms ac shall be 10,000 ohms.

## **2.14 SEPARATOR BLOCKS**

- A. Separator blocks shall be five inches long made of steel or cast iron configured for a 1-7/8 inch flangeway between 115 RE running rail and 132 RE guard rail.
- B. Connect separator blocks with a 1-3/8 inch high strength, square head bolt, spring washer and heavy hex nut with one beveled or flat headlock washer and one flat or beveled washer to provide square bearing and to permit tightening of nuts by wrench.

## **2.15 GUARD RAIL JOINTS**

Except for the insulated joint shown in the rail layout diagram, joints in the guard rail shall not be nearer than four (4) feet to a joint in the 115 RE running rail.

## **2.16 TIMBER TIES**

See Specification Section 06130.

# **PART 3 - EXECUTION**

## **3.01 INSTALLATION**

- A. Direct Fixation Special Trackwork Fabrication
  - 1. Fabrication of special trackwork for direct fixation track shall be as specified and shall comply with the applicable related Sections:
    - a. General Track Construction (GTC), Section 05651.
    - b. Direct Fixation Trackwork Construction (DFTC), Section 05653.
    - c. Special Trackwork Construction - Direct Fixation, Section 05655.
    - d. Direct Fixation Rail Fasteners, Section 05657.
  - 2. Tolerances
    - a. The final gauge, cross level, superelevation, horizontal alignment and vertical alignment of direct fixation special trackwork shall be as shown and specified. Tolerances shall be as specified for direct fixation track construction for GTC. Switch points in normal position shall be square within 5/8 inch.
- B. Ballasted Special Trackwork Fabrication
  - 1. Fabrication of special trackwork for ballasted track shall be as specified and shall comply with the applicable related Sections:
    - a. General Track Construction (GTC), Section 05651.
    - b. Ballasted Track Construction (BTC), Section 05652.
    - c. Special Trackwork Construction - Ballasted, Section 05654.
    - d. Track Appurtenances and Other Track Material, Section 05658
    - e. Timber Ties, Section 06130
    - f. Composite (Plastic) Ties, Section 06131.
  - 2. Tolerances
    - a. The gauge, cross level, superelevation, and horizontal and vertical alignment of ballasted special trackwork shall be as shown and specified. Tolerances shall be as specified for ballasted track construction for BTC. Switch points in normal position shall be square within 5/8 inch

- b. Screw spike holes drilled in ties shall be 11/16 inch diameter and not less than five inches nor more than six inches deep.
    - c. Tolerance of plus or minus 1/16 inch shall be maintained for the distance between screw spike holes.
    - d. Tolerance of plus or minus 1/8 inch shall be maintained in the centering of screw spike holes across the width of the tie.
  3. Ties shall be bored for screw spikes, and only screw spikes will be permitted in special trackwork.
  4. The number and locations of holes shall conform to the location and number of screw spikes shown for each special plate.
  5. Elastic fastener tie plates shall have four screw spikes, one at each corner.
  6. Boring of holes in excess of those required will not be permitted.
  7. Boring in timber ties shall be performed with the heartwood face down. Holes bored in timber ties shall be treated with pentachlorophenol oil immediately after boring.
  8. Holes shall be located so that each tie plate will be centered on the tie at a right angle to the rail.
  9. Prior to installing tie plates, the surface of the tie shall be swept clean to allow full bearing of the plate on the tie.
  10. Boring and spiking will ensure that the outside shoulder of the plates will have full bearing against the rail base when the rails are at proper line and gauge.
  11. Spikes shall be started vertically and square, and shall be installed straight. Straightening of spikes will not be permitted. Spikes bent during installation shall be withdrawn and the holes plugged (with treated tie plugs if wood, as per manufacturers instruction if composite). Screw spikes shall be installed firmly to the top surface of the plates.
  12. All special plates, not in the switch panel, which span two or more ties shall not be spiked during shop assembly to preclude un-spiking for disassembly and packaging. The Contractor's method for locating these plates, drilling the ties and holding the plates in place during shop assembly and inspection shall be approved by the Engineer.
- C. Identification Numbers:
  1. As shown on the drawing, each turnout has an identification number. This number shall be stamped on a metal tag and the tag affixed to each panel and separate component bundle.
  2. Tags shall be made of corrosive-resistant metal such as anodized aluminum or brass. Fastening nails shall be of the same material as the tags. Numbers shall be stamped in characters ½ inch minimum in height. Tags shall be a minimum of .050 inches thick, 1-1/4 inches wide and two inches long.
- D. Package and label parts and replacement materials in moisture-proof containers suitable for shipment and storage.
- E. Take special care to package anchor inserts for direct fixation rail fasteners, so as to prevent damage to the epoxy coating.
- F. Submit method of packaging to the Contractor's QC Staff for acceptance before shipping the anchor inserts.
- G. Attach copies of shipping list in the package and so that the list is readable from the exterior of the package.

**PART 4 - MEASUREMENT AND PAYMENT**

**4.01 MEASUREMENT:**

- A. Measurement of work specified in this Section will be made in the following manner:
  - 1. No separate measurement.

**4.02 PAYMENT:**

- A. Compensation for work specified in this Section will be made in the following manner:
  - 1. Included in the price of the work of which it is a part.

**END OF SECTION**

## SECTION 05660

### RESTRAINING RAIL AND LUBRICATORS

#### PART 1 GENERAL

##### 1.01 SECTION INCLUDES

- A. Furnish, fabrication and installation a restraining rail system.
- B. Furnish and install the lubricators to include concrete pads, lubrication distribution system, track connections and testing.
- C. Furnish and install all required electrical work for the lubrication system.

##### 1.02 RELATED SECTIONS

- A. Section 05651- General Track Construction
- B. Section 05652 - Ballasted Track Construction
- C. Section 05653 - Direct Fixation Track Construction
- D. Section 05656 - Running Rail
- E. Section 05658 - Track Appurtenances and Other Track Material (OTM)
- F. Division 16 - Contact Rail Sections

##### 1.03 REFERENCES

- A. Pertinent provisions of the following listed standards and publications shall apply to the Work, except as they may be modified herein, and are hereby made part of these Specifications to the extent required.
  - 1. American Railway Engineering and Maintenance-of-Way Association (AREMA), Manual for Railway Engineering, herein referred to as the AREMA Manual, **latest edition**.
  - 2. American Railway Engineering and Maintenance-of-Way Association (AREMA), Portfolio of Trackwork Plans, herein referred to as the AREMA Portfolio.
  - 3. American Society for Testing and Materials (ASTM):
  - 4. National Electric Code (NEC) and regulations of the jurisdictional authorities.
  - 5. Insulated Cable Engineers Association (ICEA)
  - 6. National Electrical Manufacturers Association (NEMA)
  - 7. Institute of Electrical and Electronics Engineers (IEEE)
  - 8. Underwriters Laboratories (UL)
  - 9. Military Specifications (MIL or MILSPEC)

##### 1.04 SUBMITTALS

- A. Submittals shall be as specified in Section 01300, Submittals.
- B. Submit a list of proposed suppliers, of all components within 90 days of notice to proceed. Subsequent changes in proposed suppliers shall be submitted as they occur.

- C. Submit the following to the **WMATA** Engineer for approval at least 120 days before the anticipated rolling dates.
- D. Date schedule of 132 RE rail production, inspection, shipment and final delivery.
  - 1. Detailed description of the steel metallurgy
  - 2. Lengths in which the restraining rail section will be provided.
  - 3. Description of the method and verification testing to achieve the required rail hardness.
  - 4. Detailed description of the metallurgy and method of fabrication of the mounting brackets.
  - 5. Detailed description of other components used in the restraining rail and guard rail assemblies including but not limited to shims, bolts, washers, nuts, etc.
- E. Provide two sample bracket assemblies (unpainted), each consisting of one bracket with one foot of restraining rail and all necessary hardware.
- F. Submit the method of handling and shipping for review and approval at least four (4) weeks before shipping of 132 RE rail and accompanying brackets and hardware.
- G. Submit the marking scheme for restraining rail and guard rail identification for installation not less than 30 days before fabrication.
- H. Provide processing reports and a list showing the heat and ingot for every piece for informal review during the in-plant inspection and formally submit the same information to the **WMATA** Engineer.
- I. Provide test records, including mechanical properties tests, hardness measurements, ultrasonic test records and all other required test documentation, for informal review during the in-plant inspection and formally submit the same information to the **WMATA** Engineer.
- J. Lubricator Electrical Work:
  - 1. Submit shop drawings and manufacturer's literature.
  - 2. Submit descriptions and **all** wiring diagrams of equipment.
  - 3. Submit field test procedures for cable.
  - 4. Submit flame retardance and smoke density test reports and data for tests performed not more than 12 months prior to submittal, for cables which are identical to the cable furnished.
  - 5. Provide certified test reports demonstrating that the cable complies in all respects with the requirements of the referenced Standards and Tests, and as modified herein.
  - 6. Provide certificate of conformance to specified wire requirements. Include certificate with submittal of shop drawings and with each cable shipment.
- K. **Deliverables: Provide the WMATA Engineer one (1) Operation & Maintenance Manual and complete Parts Manual for each rail lubricator.**

#### **1.05 QUALITY CONTROL**

- A. Develop and maintain a quality control program regulating methods, procedures, and process to ensure compliance with standards of quality required by the Contract Documents.
- B. Records of all inspection work by the Contractor shall be kept complete and made available to the **WMATA** Engineer during the performance of the Contract.

- B. Inspection and Testing:
1. The products and material incorporated into the work will be subject to inspection by the Engineer at the Contractor's and Subcontractor's facilities, place of manufacture, the shipping point, and at the shipping destination. Inspection and tests by the **WMATA** Engineer will be performed in such a manner as not to unduly delay the work.
  2. **WMATA, or its representatives, reserve the right to visit the producers facility during usual business hours unscheduled to a) observe sampling and testing procedures, b) obtain samples of the prepare material being produced and shipped, and c) review plant inspection methods, quality control procedures, equipment and examine test results of current and previous tests.** Whether or not the **WMATA** Engineer inspects or tests any materials, the Contractor will not be relieved from any responsibility regarding defects or other failures to meet the Contract requirements, nor will such inspection or testing be considered as a guarantee of acceptance of any material which may be delivered later.
  3. Perform all tests and analyses specified in the AREMA Manual (**latest edition**) and submit the results to the **WMATA** Engineer for approval.
  4. Make all rail tests and inspections at the mill prior to shipment. Assume full responsibility for all testing indicated. Give the **WMATA** Engineer sufficient notice when testing in any form is proposed so he may witness the tests.
  5. Provide the **WMATA** Engineer free entry at all times to the manufacturer's mill to inspect processing and testing of rail while work on this Contract is being performed.
  6. Performed all tests specified herein at no additional cost to the Authority.
  7. Testing must be witnessed and certified by a qualified independent testing firm or individual.

#### **1.06 DELIVERY, HANDLING AND STORAGE**

- A. Restraining rail shall be stacked and banded for shipment according to normal practice. Brackets shall be palletized.
- B. Package small loose parts, i.e. bolts, washers and nuts in secure shipping boxes and kegs.
- C. Lift restraining rail at two points, with the rail weight evenly distributed to each lift point. Handle carefully to avoid damage.
- D. Load restraining rail with adequate wood strips between the tiers of rail to prevent damage in transit.

### **PART 2 - PRODUCTS**

#### **2.01 RESTRAINING RAIL SYSTEM**

- A. Rail: 132 RE head hardened or high strength in accordance with AREMA Requirements
  1. Hardness: 341 to 388 Brinell
  2. Length: 39 feet minimum
- B. Separator Block: Cast Ductile Iron.
- C. Shims: ASTM A36.
- D. Bolts: 1-3/8" diameter, square head, Type 3, ASTM A325.
- E. Nut: Hexagonal, Grade C3, ASTM A563.

- F. Steel Base Plate and Stop Block: ASTM A36.
- G. Spring Washer: AREMA Manual, Section 4.
- H. Flat Washer: Hardened weathering ASTM F436 steel.
- I. Screw Spike: As specified in Section 05658, Track Appurtenances and OTM.
- J. Pandrol Shoulders: As manufactured by Pandrol, Inc. or approved equal.
- K. Joints: As shown; and as specified in Section 05658, Track Appurtenances and OTM.
- L. Rail Brace: Boltless adjustable brace similar to those formerly manufactured by Bethlehem Steel for use with left-hand Pandrol Spring Clips, e2056.

## 2.02 LUBRICATORS

- A. Portec Protector IV Electric Wayside Lubricator including all hoses, clamps, fittings and lubricant distribution system. (No substitute or "or Equal" lubricator will be approved).
  - 1. The lubricator housing shall have two mounting brackets on each side to provide for anchoring with ½" expansion anchors into a concrete base pad.
  - 2. No electrically conductive materials that are a part of the lubricator system shall be installed closer than two feet to any running rail. ~~Non-conducting grease fittings shall be installed on all grease hoses.~~(NOTE: reason for omission: non-conducting grease fittings does not exist per manufacturer).
- B. Concrete: ASTM C94, 3500 psi with entrained air.
- C. Steel Rebar: ASTM A615, Grade 60.
- D. Cast Iron: ASTM A532.
- E. Ductile Iron: ASTM A536
- F. Malleable Iron: ASTM A47.
- G. Stainless Steel 304: ASTM A240, A276.

## 2.03 LUBRICATOR ELECTRICAL WORK

- A. Liquid-tight Flexible Conduit and Fittings: Applicable requirements of UL 360, flexible galvanized steel core, extruded liquid-tight neoprene or PVC jacket overall.
  - 1. Sizes up to 1-1/4 inch provided with continuous copper bonding conductor, spiral wound between convolutions.
  - 2. Sizes 1-1/2 inch and above provided with separate grounding conductor.
- B. Conduit Connector Fittings:
  - 1. UL 514B, material and finish similar to that of conduit with which they are to be used.
  - 2. For enclosures, cabinets, boxes and gutters in electrical rooms: Threaded nylon insulated bushing and locknut.
- C. Cable:
  - 1. UL-labeled as Type RHW-2 or XHHW-2, 600 volts; copper, size as shown; 10AWG and smaller, solid or stranded; 8AWG and larger, Class B stranded.

2. Standards: Except as modified, cable complying in all respects with ICEA S-68-516, NEMA WC8 or ICE S-66-524, NEMA WC7, as appropriate.
  3. Nonmetallic Jacket: Chlorosulfonated polyethylene, cross-linked polyolefin or heavy-duty neoprene, as follows:
    - a. Chlorosulfonated polyethylene complying with ICEA S-68-518, NEMA WC8.
    - b. Cross-linked polyolefin or heavy-duty neoprene with the following requirements when tested in accordance with Part 6 of ICEA S-68-516.
      - 1) Tensile strength: 1800 psi minimum.
      - 2) Elongation at rupture: 150 percent minimum.
      - 3) After air oven aging of 168 hours at 100 deg. C, tensile strength at least 100 percent of unaged value and elongation at least 80 percent of unaged value.
      - 4) After immersion for 18 hours in ASTM D471 Oil No. 2 at 121 deg. C, tensile strength and elongation at least 80 percent of original values.
    - c. Jacket material free of PVC and PVC-based compounds.
  4. Flame Retardancy: Cable passing vertical flame test as described in IEEE 383. Cable size for testing: Smaller than #1/0. Comply with UL and ICEA S-68-516.
  5. Smoke Generation: Single and multi-conductor cable jacket materials demonstrating low-smoke generation when tested in accordance with ASTM E662.
  6. Applied Voltage Testing:
    - a. All cable to be given applied voltage dielectric strength test, after six-hour water-immersion test in accordance with the following test procedures:
      - 1) Polyethylene insulated conductors: In accordance with the paragraphs 6.14.1, 6.14.2, 6.14.5 and 3.5.2 of ICEA S-66-524.
      - 2) Other conductors: In accordance with paragraphs 3.5.2, 6.27.1, and 6.27.2 of ICEA S-68-516.
- D. Connectors and Terminal Lugs: UL 486 with the following additional requirements:
1. For 10 AWG and smaller conductor cable: Pressure type tin-plated copper connectors having nonflammable and self-extinguishing insulation grip with temperature rating equal to that of the conductor insulation.
  2. For 8 AWG to 4/0 AWG conductor cable: Compression type tin-plated copper connectors and terminal lugs having nylon insulating sleeve or heat shrinkable insulator for insulation grip.
  3. Hardware: High strength silicon, bronze, corrosion resistant, non-magnetic, and electrolytic action free when in contact with copper.
- E. Bundling Straps: Self-locking steel barb on one end, with tapered strap of self-extinguishing nylon, temperature rating minus 65 deg. F to plus 250 deg. F.
- F. Insulating Tape:
1. Plastic tape: Vinyl plastic with rubber-based pressure-sensitive adhesive, pliable at zero degree F with the following minimum properties when tested in accordance with ASTM D1000
    - a. Thickness: 8.5 mils.
    - b. Breaking strength: 20 pounds per inch width.
    - c. Elongation: 200 percent.
    - d. Dielectric breakdown: 10,000volts.
    - e. Insulation resistance, indirect method of electrolytic corrosion: 1,000,000 megohms.

- G. Grounding and Bonding Equipment: UL 467, IEEE 80, with the following additional requirements:
1. Grounding conductor: Insulated conductor, size as shown and in accordance with NEC Tables 250-94 and 250-95 as applicable. Insulated conductor complying with the requirements specified for single conductor cable.
  2. Terminal lugs:
    - a. For 4/0 AWG and smaller conductors: Copper compression terminal lugs.
  3. Ground connector:
    - a. Type as shown or equal.
    - b. Copper alloy body and silicon bronze bolt, nut and lock washer with interlocking clamp.
  4. **Jumpers:** Copper braided or leaf-type flexible jumper, size as necessary.
  5. **Equipment ground kits: Insulated/isolated with a minimum up to eight grounded circuits. Install on inside wall of fiberglass enclosure. Secure kits to fiberglass enclosure using bolts and nuts.**
- H. Sealing compound:
1. FS TT-S-227, two component, fast-setting, polymeric sealing compound to provide watertight seal between concrete and conduit, between cable and conduit.
  2. Pour-type for horizontal and gun-grade for vertical or overhead application.
  3. When cured, sealant to have rubber-like flexibility allowing minimum movement of conduit and cable in temperature range of minus 40 deg. F to plus 150 deg. F without loss of watertight seal.
  4. Pot life: 15 minutes.
  5. Minimum ambient temperature for application: 35 deg. F.
  6. Initial cure: 15 minutes.
  7. Final cure: Seven days.
  8. Hardness, Durometer A: 20-35.
  9. Seal between conduit and single-conductor cable to withstand water pressure of 70 psi without leakage.
  10. Fox Industries, Type FX-571-G or equal.
- I. GFI Circuit Breaker:
1. NEMA AB1.
  2. Ground fault interrupter (**GFI**) circuit breaker: As shown and as specified. Overcurrent trip device coordinated to provide selective tripping under overload conditions.
- J. Expansion Bolt Anchors: Stainless Steel 304 in accordance with ASTM A276.
- K. Grounding stud: Manganese bronze ASTM B138, Alloy No. 675 hard, 3/8 inch high; Evedur GSI, American Brass Company or equal.
- L. Cable splice and tap-insulating/sealing kit: Suitable for use on 600-volt, 90C cables, material compatible with cable insulation and jacket, meeting the seal test requirements of ANSI C119.1.
1. Heat-shrinkable tubing UL-approved, flame-retardant, corrosion-resistant thick-wall tubing with factory-applied sealant for field insulation on in-line splices and taps to provide a watertight seal and insulating encapsulation, with the following additional requirements:
    - a. Material: Cross-linked polyolefin.
    - b. Shrink ratio: 3 to 1 (min.)
    - c. Physical properties:
      - 1) Ultimate tensile strength: 2,350 psi, ASTM D41
      - 2) Ultimate elongation: 350% minimum, ASTM D412
      - 3) Hardness, Shore D: 42, ASTM D2240.

- 4) Water absorption: 0.02%, ASTM D570, Method 6.1.
- 5) Specific gravity: 1.2, ASTM D792.
- d. Electrical properties:
  - 1) Dielectric strength: 450 volts per mil, ASTM D149.
  - 2) Volume resistivity:  $1 \times 10^{15}$  ohm cm, ASTM D257.
- e. Thermal properties:
  - 1) Continuous operating temp.: -55 to +135 deg. C.
  - 2) Air oven aging (14 days @ 175 deg. C):
    - a) Tensile strength: 2,680 psi.
    - b) Elongation: 375%.
  - 3) Low temperature flexibility (4 hours @ -55 deg. C): No cracking when flexed.
  - 4) Heat shock (4 hours @ 250 deg. C): No cracking, flowing or dripping.
- f. Chemical properties:
- g. Corrosivity: Non-corrosive, MIL-I-23053/15.
- h. Fungus resistance: Non-nutrient, ASTM G21.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Restraining Rail System
  1. Shop weld rail brace stop block and Pandrol shoulders to base plate.
  2. Install restraining rail system where shown. Install one base plate and bracket on each tie between the end limits of the restraining rail.
  3. Fasten base plate and bracket to the ties in accordance with the requirements of Section 05653, Ballasted Track Construction using six screw spikes, or in accordance with the requirements of Section 05653, Direct Fixation Track Construction as appropriate.
  4. Field drill the running rail and restraining rail to provide holes as required for the installation of spacer blocks and joints.
  5. Holes shall be cylindrical, of the diameter shown and drilled with an approved rail drill.
  6. Use an approved template as a guide for drilling holes.
  7. All holes drilled in the 115 RE running rail and 132 RE restraining rail for spacer blocks or joints shall be cold worked using the Railroad Cold Expansion process by Fatigue Technology, Inc., Seattle, Washington, or approved equal. The process shall be performed in accordance with the manufacturer's instructions by a crew whose supervisor has been trained by the manufacturer.
  8. Cut rail only as necessary to meet the following criteria:
    - a. The minimum rail length between an insulated joint and a standard joint shall be 15 feet.
    - b. The minimum rail length adjacent to a 15 foot rail shall be 24 feet.
    - c. The minimum rail length adjacent to an end section shall be 15 feet.
    - d. The number of intact 39 foot rail lengths shall be maximized.
    - e. End sections shall be the maximum length feasible.
  9. Rails shall be cut square and clean by means of rail saw or abrasive cutting disks. Rail end beveling shall be performed at all rail cuts and shall be in accordance with current AREMA Manual requirements for Beveling or Slotting of Rail Ends and AREMA Portfolio Plan No. 1005 (latest edition).
  10. Locate restraining rail insulated joints between the same fastener plates as the insulated joints in the adjacent running rail. Join rail as illustrated in the contract documents.

11. Assemble all non-insulated joints with thermite welds in accordance with AREMA requirements and the approved weld kit manufacturer's instructions. Four hole strap bars with cast-on fin clearance shall be installed on each side of the rail around the thermite weld.
12. Install bolts and nuts finger tight before tensioning bolts to 20,000 to 25,000 pounds by use of a track wrench or power torque wrench, starting from the center bolts and working to the end bolts. Immediately before the completion and acceptance of work, re-tighten track bolts to a tension of 15,000 to 25,000 pounds.
13. The thermite welded joints shall be centered over a plate. The base of the 132 RE rail shall be ground free of weld fins to fit flush on the plate.
14. Insulated joints shall be assembled with all components shown without rail gaps.
15. Install the restraining rail so that the flangeway is 1-7/8 inches plus or minus 1/8 inch measured 5/8 inch below the top of the running rail. Tighten the restraining rail hold down bolts to 75 percent of the proof load for the size of the bolt used.

B. Lubricators

1. Install lubricator in accordance with the manufacturer's recommendations where shown and as specified herein. **If specific mounting locations for the restraining rail lubricators are not specified, mount as per WMATA Trackwork Standard Drawing ST-TW-RR-006 (Lubricator Location At Grade) or as per the WMATA Engineer's direction.**
2. Mount lubricator to the concrete using expansion anchors and ½ " diameter bolts.
3. Install track assemblies and grease distribution system to the inbound track and outbound track in accordance with the manufacturer's recommendations. **A site visit by the lubricator manufacturer and site diagrams is required to determine the most optimal approach.**
4. The train detection system that initiates the release of lubricant shall be configured to release to the appropriate restraining rail when the train is moving in the normal direction **of traffic for both directions of train movement.**
5. Install grease hoses in accordance with the manufacturer's recommendations. Anchor hoses to ties with appropriate clips at a minimum spacing of 10 feet.
6. Perform electrical work as specified in the technical specification for electrical work.
7. At the completion of installation, the Lubricator Reservoir shall be filled with an appropriate lubricant approved by the **WMATA Engineer.**
8. Test lubricator system for proper application of lubricant as specified by the manufacturer and approved by the **WMATA Engineer.**

C. Lubricator Electrical Work:

1. The Contractor shall carefully examine all contract drawings and specifications and be responsible for the proper fitting of materials and equipment at each location as indicated, without substantial alteration. In as much as the drawings are generally diagrammatic and because of the small scale of the drawings, it is not possible to indicate all offsets, fittings and accessories which may be required. Furnishing such fittings and accessories as may be required to meet such conditions shall be at no additional cost to the Authority.
2. The Contractor shall verify exact location , size and extent of all existing utilities, obstructions, and/or other conditions which may affect the proposed work under the project. The Contractor shall take every precaution to prevent damage to existing work and shall repair any damage as a result of this Work.
3. Conduit:
  - a. Install conduit and fittings where conduit runs are shown.
  - b. Install exposed conduit parallel or perpendicular to the running rails as shown and avoid interference with existing work.

- c. Thread and ream the ends of field-cut conduit to remove rough edges. Use locknuts and bushings at conduit entrance to boxes, cabinets and equipment enclosures.
  - d. Bend conduit so that bends are free from cuts, dents and other damage.
  - e. Support horizontal conduit with one-hole pipe straps or individual pipe hangers.
  - f. Apply lead -free conductive **anti-seize** compound to threaded conduit joints.
  - g. Use minimum of 18-inch long liquid-tight flexible conduit connection to equipment subject to vibration.
  - h. Rod and swab conduit after installation, removing water and foreign matter.
  - i. Waterproof conduit connections.
4. Cable:
- a. Install cable as shown.
  - b. Use nylon straps to bundle and secure wire and cable in panelboards.
  - c. Use a minimum bending radius 12 times outer diameter of cable. Where shown, use shorter bending radius as permitted by NEC, Appendix H of ICEA S-66-524, NEMA WC7 and cable manufacturer.
  - d. To facilitate pulling cable, use UL-listed lubricant recommended by cable manufacturer.
  - e. Connect cables to equipment using integral mechanical connectors or compression connectors.
  - f. Identify feeder terminations to lubricators using nonmetallic fiberboard tags or plastic labels.
  - g. Attach tags to cable with slip-free plastic lacing or nylon bundling straps. Tags shall designate the panelboard name and circuit numbers serving lubricators. **Demonstrate that identification tagging of cabling and panelboard has been field verified with the WMATA Engineer present.**
  - h. Splicing of power cables is not permitted. An exception may be granted by the **WMATA** Engineer only in extraordinary conditions. Authorization for such an exception must be obtained from the Engineer in advance of making a splice. Any such exception must be fully documented and recorded on as-built drawings. The splice must be made watertight as shown.
5. Wire connection accessories:
- a. Secure connections or terminal lugs to the conductor to engage all strands equally.
  - b. Do not rupture insulation nor expose bare conductors.
  - c. Install compression connectors and terminal lugs using tools and pressure recommended by the manufacturer. Indent mark connectors and terminal lugs with number of die used for installation.
  - d. Apply anti-corrosion joint compound to connectors, terminal lugs and bolting pads before installation.
6. Grounding and bonding:
- a. Ground Connections:
    - 1) Use terminal lug to connect grounding conductor to equipment enclosure.
    - 2) Use continuous grounding conductor without splices.
  - b. Equipment grounding conductor: Provide equipment grounding conductor for single-phase branch circuits.
  - c. Bond metallic ac equipment enclosures to equipment grounding conductor in ac power feeder.
7. Connect branch circuit wires as shown.

8. Make power cable connections to circuit breakers, new molded case circuit breakers and neutral and ground bus bars in panelboards and enclosed circuit breakers by means of integral mechanical connectors as shown. If such items are not furnished with integral mechanical connectors, make connections using compression connectors.
9. On cable splices, taps and terminations cover connectors with electrical putty , wrapped with three layers of plastic tape or final layer or rubber tape and then install watertight encapsulation as follows and under the supervision of kit manufacturer's representative or using a factory-certified installation technician, proficient in field installation of heat-shrinkable sealing kits.
10. Use heat-shrinkable tubing for encapsulation of new splices, taps and terminations.
11. Field Quality Control:
  - a. After completion of installation and filling the reservoir with an approved lubricant, demonstrate proper performance of all equipment in the presence of the **WMATA** Engineer.
  - b. Test all metallic equipment enclosures, galvanized rigid steel conduits and liquid-tight flexible conduits for continuity to the grounding system.
  - c. Test non-grounded conductors for insulation resistance to ground of 10 megohms. When cable shows unsteady insulation resistance of less than 10,000 ohms, perform high potential test at 80 percent of factory ac test voltage or as recommended by cable manufacturer.
  - d. Test continuity of conductors using ohmmeter.
  - e. Test circuits for connection in accordance with the wiring diagram.
  - f. Check connections to circuit breakers for tightness.
  - g. Molded Case Circuit Breakers: Perform pole-to-pole and pole-to- ground insulation resistance tests with 1000 volt d.c. megger. Insulation resistance to be 50 megohms minimum.

#### **PART 4 - MEASUREMENT AND PAYMENT**

##### **4.01 MEASUREMENT:**

- A. Measurement of work specified in this Section will be made in the following manner:
  1. No separate measurement.

##### **4.02 PAYMENT:**

- A. Compensation for work specified in this Section will be made in the following manner:
  1. Included in the price of the work of which it is a part.

**END OF SECTION**

## SECTION 05661

### CONTACT RAIL AND APPURTENANCE FOR TRACTION POWER

#### PART 1: GENERAL

##### 1.01 SUMMARY

- A. This section specifies designing, fabricating, testing and furnishing a composite contact rail system, including the composite contact rail, splice joints, expansion joints, end approaches, terminal lugs, and all appurtenances ~~as shown and specified~~.
- B. Related Sections:
  - 1. Section 16127 - Contact Rail System Installation For Traction Power

~~C. Payment and Measurement:~~

- ~~1. Compensation for work specified in this section will be made in the following manner:
  - a. Work performed by the Contractor pursuant to fabricating and delivering contact rail, splice joints, expansion joints, end approaches, terminal lugs, nuts, bolts and miscellaneous hardware: Lump sum.~~

##### 1.02 REFERENCES

- A. Codes, regulations, references standards and specifications:
  - 1. AREA Manual for Railway Engineering for Continuous Cast Rail.
  - 2. ANSI H35.1, Type A6101-T6
  - 3. ASTM B317, Type B.
  - 4. Steel Structure Painting Council, SSPC-SP-10.
  - 5. NEMA CC1.
  - 6. ASTM B117.
  - 7. ASTM A2, Grade 65-35.
  - 8. ASTM A47, Grade 32510
  - 9. ANSI B4.1
  - 10. ASTM A325
  - 11. ASTM B134
  - 12. ANSI B18.8.1
  - 13. ASTM A153
  - 14. ~~ASTM A123~~ B695
  - 15. Steel Structure Painting Council, SSPC-SP-6
  - 16. SAE No. G-18
  - 17. ANSI C37.34

##### 1.03 SYSTEM DESCRIPTION

- A. Composite Contact Rail
  - 1. The composite contact rail shall consist of a steel base rail, with one aluminum extrusion fastened to each side of the web area of the base rail, continuous over the finished length.
- B. Appurtenances
  - 1. Appurtenances include expansion joints, end approaches, cast parts, terminal lugs, disconnect switch, nuts, bolts, and miscellaneous hardware.

## 1.04 SUBMITTALS

- A. Shop Drawings
  - 1. The Contractor shall submit for approval shop drawings for fabrication of the components and assemblies of the composite contact rail and appurtenances. No fabrication or manufacture shall be performed prior to drawing approval.
- B. Certification:
  - 1. Certification that composite contact rail and appurtenances furnished meet or exceed specified requirements
  - 2. Certified test reports.

## 1.05 QUALITY ASSURANCE

- A. Electrical Tests
  - 1. Splice Joint DC Resistance
    - a. Two sections of the composite rail, each 36 inches **or more in length**, shall be joined together. At a constant room temperature the resistance across the joint shall be measured in accordance with NEMA CCI and compared to an equal length of unjointed composite rail at the same temperature.
    - b. If the resistance across the jointed rail exceeds **by more than five percent** the resistance of the unjointed rail the joint design will be rejected.
  - 2. Composite Rail and Splice Joint Thermal Cycle
    - a. Using the same jointed and unjointed sections used in the dc-resistance test, the specimens shall be cycled thermally for a minimum of ten cycles. Each thermal cycle shall consist of lowering the rail temperature to minus 5C and measuring the resistance of the specimens, then raising the temperature of the specimens to plus 117C and measuring the resistance again for a minimum of ten cycles.
    - b. If at any time the resistance of the jointed or unjointed sections exceeds the requirements of these specifications, the design will be rejected.
  - 3. Composite Rail and Splice Joint Assembly Salt-spray Test
    - a. Using the same jointed and unjointed sections used in the dc resistance test, perform a 500-hour salt-spray test in accordance with the requirements of ASTM B117.
    - b. If, at the end of the test, the resistance of either specimen increases by more than five percent, the design will be rejected.
  - 4. Electrical Characteristics
    - a. The assembled composite contact rail shall have an electrical resistance not greater than 0.002 ohms per 1,000 feet at 20C. **The manufacturer shall provide certificates of product conformance.**
    - b. The composite rail shall be capable of conducting 5,000 amperes dc continuous with a temperature rise not to exceed 40C above 30C ambient in still air.
    - c. The rail shall be capable of withstanding a fault current of 135,000 amperes dc, or equivalent ac, for 100 milliseconds without mechanical or thermal damage.
    - d. The Contractor shall submit certification of **all the listed** electrical characteristics of the composite contact rail.
- B. Testing of Terminal Lugs
  - 1. Two assemblies from each lot of terminal lugs shall be tested. Failure of any assembly to pass the following tests will cause rejection of the entire lot.
  - 2. A completed compression connection shall provide electrical resistance not greater than an equivalent length of uncut cable when measured between the **distant** end of the cable and the connector tongue.
  - 3. Bare conductors shall be used for performing tests.

4. Resistance measurement shall be taken before and after the tests specified below.
5. The test connections shall then be subjected to a sustained tension of 5,000 psi of the nominal conductor cross sectional area for a period of three hours. At the end of three hours, there shall be no increase in electrical resistance of the connection beyond that specified. There shall be no slipping of the conductor in the connector nor deformity or loosening of the connection.
6. Provide certificates of product performance.

C. For codes, regulation, references, standards and specifications, refer to Article 1.02 above.

## **PART 2: PRODUCTS**

### **2.01 MATERIALS**

#### **A. Composite Contact Rail**

##### **1. Steel Base Rail**

- a. The steel base rail shall be new No. 1 or No. 2 rail conforming to the current requirements of the AREA Manual for Railway Engineering for continuous cast rail. No. 2 rails will be accepted for not more than 15 percent, by weight, of the total base rail furnished.
- b. The standard length of the steel base rail shall be 39 feet at a temperature of 60F. Shorter lengths, varying in increments of one foot from 39 to 25 feet, will be accepted for a maximum of 11 percent, by weight.
- c. A maximum variation of plus-or-minus ½ inch of the stated length for each rail will be permitted.

##### **2. Aluminum Extrusions**

- a. The aluminum extrusions shall be of a uniform cross section and shall conform to the alloy and temper requirements of ANSI H35.1, Type A6101-T6 and shall also conform to the requirements of ASTM B317, Type B.
- b. The extrusions shall be formed to permit maximum clamping force with the steel base rail and the cable terminal lugs to create the maximum electrical contact area. In addition, they shall permit rail tongs to grasp the head of the steel base rail for lifting the composite rail without damage to the aluminum extrusions.
- c. Sufficient clearance at the base shall be provided to permit mounting of the contact rail protection cover assembly, clearing insulator ears and other appurtenances. Sufficient clearance shall be provided at the rail head to mount the specified contact rail heater supplied in other contract.

##### **3. Splice Joint**

- a. The splice joint assembly shall consist of two aluminum alloy extrusions of the same material specified for composite rail aluminum extrusion, except that the internal contour of the splice joint extrusion shall conform to the external contour of the composite rail aluminum extrusion to ensure proper vertical and horizontal alignment of the composite rail sections.
- b. The splice joint assembly shall provide ample contact surface for the transfer of electrical current across the joint and the joint shall have a resistance no greater than that of an equal length of composite rail.
- c. The splice joint extrusions shall be pre-drilled as required to accept four 7/8-inch diameter steel compression fasteners, as manufactured by the Huck Manufacturing Company, or equal.
- d. The assembled splice joint shall be capable of withstanding a 25,000-pound longitudinal tension force across the joint without exceeding the yield point of its components.

#### **B. Appurtenances**

##### **1. Expansion Joints**

- a. The expansion joint assembly shall consist of the following;

- 1) Two bars of medium carbon steel, ASTM A27, Grade 65-35 or malleable iron, ASTM A47, Grade 32510.
  - 2) Two sections of steel base rail as **required**.
  - 3) Aluminum extrusions.
  - 4) Accessories as **required**.
- b. The aluminum extrusions shall be bolted to each base rail to allow the attachment of a splice joint assembly on each section.
  - c. The internal contour of the expansion joint bars shall conform to the external contour of the modified steel base rail sections to ensure proper alignment horizontally and vertically and to create a smooth passage across the joint for the collector shoe. The assembled modified steel base rail sections shall be pre-drilled as **required**.
  - d. The expansion joint assembly shall be designed to accommodate 12 inches of movement for each 1,000 feet of composite contact rail.
2. End Approaches
    - a. The end approaches shall consist of sections of steel base rail as specified, cut and welded to provide a smooth transition for the collector shoe onto the composite contact rail.
    - b. The end approaches shall be supplied in lengths of 11 feet and five-feet six-inches as shown. The mating end of each end approach shall contain sufficient length of aluminum extrusion bolted to the web to allow the attachment of a splice joint assembly.
    - c. The end approaches shall be **pre-drilled**.
3. Cast Parts
    - a. Cast parts for the composite rail assembly, including expansion joints, shall be manufactured as specified.
    - b. Castings shall be free of cracks, flaws, blemishes, scale, or any other defect that would be detrimental to the service for which they are intended. The finish surface shall be smooth and shall fit all adjoining parts accurately. Grinding will be permitted to ensure the specified fit.
    - c. Medium Steel Castings
      - 1) Steel for casting shall be medium steel made by the open-hearth, basic oxygen or electric-furnace process, ASTM A27, Grade 65-35.
      - 2) All castings shall be fully annealed by heating to a temperature above the transformation range and, after being held for a proper time at this temperature, cooled slowly and uniformly in the furnace.
      - 3) Steel castings shall be free from defects such as cracks, machining flows, porosity or excessive shrinkage and shall be finished to a true and homogenous surface.
    - d. Malleable-iron castings
      - 1) Parts cast from malleable iron shall conform to ASTM A47, Grade 32510.
4. Terminal Lugs
    - a. Terminal lugs shall be compression-type lugs compatible with 1,000-KCMIL, 427-strand cable. Terminal lugs shall be 98 percent pure copper. The entire lug shall be hot-dip, tin-coated, 0.3 mils minimum thickness. Tongues shall not be less than two inches square by ½ inch thick and drilled for a 5/8-inch diameter fastener.
5. Disconnect Switch
    - a. Outdoor, moisture-resistant, single-pole, single-throw, bolted pressure type/no-lead-break, manually operated mechanism for operation on 750 volts dc.
    - b. In accordance with ANSI C37.34.
    - c. Continuous current rating: **4000** ~~1200~~ amperes dc **minimum** as shown with temperature rise not exceeding 50C over 30C ambient.

- d. Dielectric withstand voltage from switch and mounting base across open contacts: 3000 volts dc minimum for one minute.
  - e. Momentary fault current rating: 160,000 amperes dc with rate of rise of 10 amperes per micro-second.
  - f. Terminals equipped with lugs for connection of ~~two~~ **four (4)** 1000 KCMIL, 427 strand, copper cables on each side as shown.
  - g. Designed to prevent opening or closing by gravity or vibration or of its own accord.
  - h. Insulating operating-handle mechanism with mechanical latch to prevent accidental opening or closing and capable of being padlocked in open or closed position.
  - i. Enclosure:
    - 1) NEMA Type 3R in accordance with ICS 6.
    - 2) Capable of withstanding 200-pounds force without damage to switch or enclosure.
    - 3) Minimum three-inch clearance to exposed terminals of switch in open and closed positions.
    - 4) Material: Fiberglass, 1/8-inch minimum thickness.
    - 5) Size: To fit within limits shown on drawing.
    - 6) Cover: Designed to provide easy access to switch. Equipped with stainless steel piano hinge and hasp.
    - 7) Cable openings: Compatible with switch terminals; furnished with Type GRE sealing bushings suitable for 1000 KCMIL cable, O.Z. Electrical Manufacturing Co., Inc., or equal.
    - 8) Flanges and mounting hardware: Furnished as necessary to mount enclosure on concrete base and to mount switch in enclosure.
6. Nuts, Bolts, and Miscellaneous Hardware
- a. All nuts, bolts, and flat washers shall be manufactured in accordance with ASTM A325.
  - b. The dimensional data and type hardware for all nuts, bolts and miscellaneous parts shall be as shown on **the manufacturing** drawings. Steel bolts, nuts, and washers shall be galvanized as specified below.
  - c. Cotter pins shall conform to ASTM B134, and ANSI B18.8.1
7. Galvanizing
- a. **Bolts and miscellaneous hardware to be mechanical zinc coated in accordance with ASTM A695.**
  - c. Before galvanizing, the finished parts shall be pickled or sandblasted and the scale and adhering impurities thoroughly removed. The pickling shall be done in properly diluted sulfuric acid, after which the parts shall be thoroughly cleaned in cold, running water.
  - d. Sand-blasting shall meet or exceed Steel Structure Painting Council SSPC-SP-6, except that the maximum grit size shall be SAE No. G-18.
  - e. The parts shall then be immersed in a solution of either zinc chloride or hydrochloric acid. Immediately following thorough drying, the parts shall be dipped into the zinc bath before corrosion starts again.
8. Tolerances for Fits.
- a. Tolerances for fits shall be in accordance with ANSI B4.1.

## 2.02 FABRICATION

- A. Composite Contact Rail
  - 1. Method of Assembly
    - a. Prior to final assembly of the aluminum extrusions to the steel base rail, the contact surfaces of the steel base rail shall be sandblasted to near white finish in accordance with Steel Structures Painting Council SSPC-SP-10.
    - b. After sandblasting, the surfaces of both the steel base rail and the aluminum extrusions shall be cleaned of all oil, grease and other foreign matter.

- c. The aluminum extrusions shall be free of aluminum oxide at the time of application of the oxide-inhibiting paste.
- d. Following the cleaning process, all mating surfaces shall receive a liberal and evenly distributed coating of oxide-inhibiting paste, Dearborn Chemical Product NO-OX-1D or equal. Oxide-inhibiting paste shall also be applied to all interface surfaces of the fasteners.
- e. After application of the oxide-inhibiting paste, the aluminum extrusions shall be permanently attached to the steel base rail on maximum 19-inch centers with 5/8-inch diameter steel compression fasteners, as manufactured by the Huck Manufacturing Company or equal.
- f. The installed fastener shall provide a minimum 19,000-pound clamping force. The fastening system shall maintain the aluminum extrusions in stable, intimate electrical contact with the steel base rail under all conditions of thermal expansion and contraction from zero degree to 150F.
- g. The assembled composite rail sections shall be **pre-drilled** on each end to accept a splice joint assembly as **required**. After assembly all excess oxide-inhibiting paste shall be removed from each rail.

**PART 3: EXECUTION - Not Used**

**PART 4 - MEASUREMENT AND PAYMENT**

**4.01 MEASUREMENT AND PAYMENT**

- A. Compensation for work specified in this section will be made in the following manner:
  - 1. Work performed by the Contractor pursuant to fabricating and delivering contact rail, splice joints, expansion joints, end approaches, terminal lugs, nuts, bolts and miscellaneous hardware: Lump sum.

**END OF SECTION**

## SECTION 05662

### CONTACT RAIL INSULATOR FOR TRACTION POWER

#### PART 1: GENERAL

##### 1.01 SUMMARY

- A. This section specifies fabricating, testing and furnishing fiberglass contact rail insulator as shown and specified.
- B. Related section: Section 05661 - Composite Contact Rail.

##### 1.02 REFERENCES

- A. Codes, regulations, references, standards and specifications as required.
  - 1. ASTM D149.
  - 2. ASTM D229.
  - 3. ASTM D256.
  - 4. ASTM D495.
  - 5. ASTM D570.
  - 6. ASTM D638.
  - 7. ASTM D648.
  - 8. ASTM D695.
  - 9. ASTM D790.
  - 10. ASTM D2303.
  - 11. ANSI B4.1.
  - 12. ANSI B18.2.1.
  - 13. ANSI B18.2.2.
  - 14. ANSI C29.1.
  - 15. ANSI C29.5.
  - 16. UL 94

##### 1.03 QUALITY ASSURANCE

- A. Testing
  - 1. Perform specified testing by a nationally recognized independent testing laboratory at no additional cost to the Authority.
  - 2. The Contractor shall notify the engineer fourteen (14) days in advance of the commencement of testing, including preparation of the test equipment for testing. Testing shall be performed in the presence of the Engineer unless otherwise approved by the WMATA Engineer in writing.
  - 3. Qualification Test:
    - a. Prior to production of insulators, perform all material and production test shown in this Section, and submit test results to the WMATA Engineer.
    - b. Certification for material tests are acceptable.

- c. In lieu of qualification tests, the contractor may submit prior tests results for the insulator, if the prior test are for fiberglass insulator material previously approved by WMATA.

B. General testing

1. Randomly select a minimum of two percent of each production lot of 500 insulators of each type as test specimens.
2. Subject specimens to the following tests:
  - a. Electrical resistance test:
    - 1) Procedure:
      - a) Immerse each specimen in water at room temperature.
      - b) After 70 hours, remove and dry thoroughly.
      - c) Provide complete contact by use of wet clay pads on top and bottom of specimen.
      - d) Measure resistance to each specimen with 1,000-volt dc megohm meter or other approved device.
    - 2) Acceptance criteria:
      - a) Electrical resistance: Not less than eight megohms.
      - b) If one insulator of a lot fails, entire lot will be rejected.
  - b. Impulse withstand voltage test.
    - 1) Procedure: In accordance with ANSI C29.1.
    - 2) Acceptance criteria:
      - a) Dry withstand voltage: 30 kV at 60 Hertz for one minute.
      - b) Wet withstand voltage: 20 kV at 60 Hertz for ten seconds.
      - c) If one insulator of a lot fails, the entire lot will be rejected.
3. Insulators used as test specimens prohibited as part of quantity furnished.

C. Insulators must meet the following procedures as required or equivalent.

1. Material tests:

TEST ITEM	PROCEDURE	ACCEPTANCE CRITERIA *
Arc resistance	ASTM D495	180 seconds
Dielectric strength	ASTM D149, short-time test	100 volts per mil
Water absorption	ASTM D570, 24 hours at 23C	Weight increase: 0.3 percent maximum
Flammability	UL 94	Class 94V-O
Flame resistance	ASTM D229, Method II	Ignition time: 80 seconds minimum Burning time: 60 seconds maximum
Heat distortion	ASTM D648	Deflection temperature 390F at 264 psi
Izod Impact	ASTM D256, Method A or equivalent for other materials.	Average impact strength: 16 foot-pounds per inch width of specimen
Flexural strength	ASTM D790 or equivalent for other materials.	24,000 psi
Tensile strength	ASTM D638 or equivalent for other materials.	12,000 psi
Compressive strength	ASTM D695 or equivalent for other materials.	20,000 psi
Tracking resistance	ASTM D2303	Time to track: at 2,500 volts ac 600 minutes

\* Minimum unless otherwise specified.

2. Production testing:

a. General Requirements:

- 1) Production testing specified constitutes minimum requirements.
- 2) All insulators subject to full or partial testing at the discretion of the WMATA Engineer.

- 3) Insulators used for testing are not to be included in quantities furnished.
  - 4) All facets of production testing, particularly location of facility and repair, capacity and calibration of test equipment, subject to approval.
  - 5) Notify the WMATA Engineer fourteen calendar days prior to scheduled testing dates.
  - 6) If one insulator of a lot fails, the entire lot will be rejected.
- b. Randomly select a minimum of two percent of each lot of 500 insulators as test specimens.
- c. Load test:
- 1) Procedure:
    - a) Mount 50% of the specimens on a rigid vertical support with centerline of holes on a horizontal plane.
    - b) Mount 50% of the specimens on a rigid vertical support with centerline of holes on a vertical plane.
    - c) Vertically apply a steady, even, downward pressure on the insulator head until it fails.
    - d) Record pressure being exerted when first crack occurs in specimen.
    - e) Record pressure being exerted when specimen fails.
  - 2) Acceptance criteria:
    - a) Withstand:
      - (1) To first visual crack: 1,200 pounds minimum.
      - (2) To failure: 2,400 pounds minimum.
- d. Compressive load test:
- 1) Procedure:
    - a) Mount insulator on flat horizontal surface.
    - b) Mount steel plate one-inch thick by 4-1/2 inches diameter on top of insulator.

- 2) Acceptance criteria:
    - a) Withstand:
      - (1) To first visual crack: 10,000 pounds minimum.
      - (2) To failure: 20,000 pounds minimum.
  - e. Dielectric strength test:
    - 1) Procedure:
      - a) ASTM D149, Short-time Test.
    - 2) Acceptance criteria:
      - a) Dielectric strength:
        - (1) Perpendicular chair 100 volts per mil.
        - (2) Perpendicular cap: 100 volts per mil.
  - f. Insulators used for testing are not to be included in quantities furnished.
3. Mechanical test:
- a. Randomly select a minimum of one percent of each lot of 500 insulators as test specimens.
  - b. Procedure:
    - 1) Attach each insulator and mounting base to oak block.
    - 2) Mount each assembly on rigid foundation simulating service conditions.
    - 3) Place on top of each insulator one of the following type pads:
      - a) Lead: 1/4 inch thick
      - b) Canvas: 1/16 inch thick
    - 4) Attach to malleable iron cap a hardened steel disc ½ inch thick and equal in diameter to cap. Place both atop each insulator pad.
    - 5) Subject each test specimen to 10 blows of 15-pound spherical iron weight dropped from height of 36 inches.
  - c. Acceptance criteria:
    - 1) No visible cracks or fractures.
    - 2) If 50 percent or more of specimens fail, entire lot represented by specimens tested will be rejected.

## **1.04 SUBMITTALS**

### **A. Shop Drawings:**

1. The Contractor shall submit for approval shop drawings for fabrication of the component and assemblies of the contact rail insulators, showing tolerances for all dimensions. No fabrication or manufacture shall be performed prior to drawing approval.

### **B. Samples:**

1. One complete insulator assembly for each type.

### **C. Documentation:**

1. Certification that all insulator assemblies furnished meet or exceed specified requirements.
2. Detailed engineering data on materials used in the manufacture of insulator assemblies.
3. Fabrication details.
4. Name of proposed independent testing laboratory.
5. Detailed description of quality control program. Work performed prior to approval is undertaken at the Contractor's risk.
6. Calibration certificates for quality control testing equipment.
7. Certified test reports. Submit no later than seven days after completion of tests.
8. Method of packaging. Submit prior to packaging and shipping.

## **PART 2: PRODUCT**

### **2.01 MATERIALS**

#### **A. Furnish contact rail insulator in accordance with the following requirements:**

1. General Requirements
  - a. New and undamaged.
  - b. Symmetrical
  - c. Free of cracks, voids, air pockets, lamination, metallic substances or other defects rendering them unsuitable for intended service.
  - d. Meeting or exceeding acceptance criteria of specified tests.
  - e. Indelibly marked on underside with model number and identification of manufacturer.
  - f. Rated for a nominal voltage of 750 volts dc.

- g. Minimum creepage distance over external surface of insulator from energized metal components to ground or to insulator fasteners: Eight inches minimum.
- h. Resistant to weathering and sudden changes in atmospheric temperature from plus 150F to minus 20F.
- i. Impervious to moisture, acid and alkali.
- j. Suitable for use on wood ties and for direct fixation to concrete invert.
- k. Color: Gray.
- l. Designed for composite rail specified in Section 05661 with free-end-to-anchor distance of 500 feet and temperature range of plus 150F to minus 20F.

2. Insulators

- a. Fiberglass reinforced thermoset polyester , material grade 46-16-60 or approved equal.
- b. Compression molded.
- c. Dimensions: As shown.
- d. Tolerance: As shown in the drawing.
- e. Appearance: Smooth and uniform.

**PART 3 - MEASUREMENT AND PAYMENT**

**3.01 MEASUREMENT**

No separate measurement of work specified in this section will be made.

**3.02 PAYMENT**

Compensation for work specified in this section will be made in the following manner:

- 1. Materials: Lump sum, no separate measurement.

\* \* \*

## SECTION 05700

### ORNAMENTAL METAL

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing ornamental (architectural) metalwork.
- B. Related Work Specified Elsewhere:
  - 1. Not used.
  - 2. Hydraulic elevator: Section 14200.

##### 1.02 PERFORMANCE REQUIREMENTS FOR HANDRAILS AND RAILINGS:

- A. Structural Performance of Handrails and Railings: Provide handrails and railings complying with requirements of ASTM E 985 for structural performance, based on testing performed according to ASTM E 894 and ASTM E 935.
- B. Thermal Movements: Provide handrails and railings that allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
  - 1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.
- C. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings: Show fabrication and installation of ornamental metal. Include plans, elevations, component details, and attachments to other Work. Indicate materials and profiles of each ornamental metal member, fittings, joinery, finishes, fasteners, anchorages, and accessory items.
    - a. Include setting drawings, templates, and directions for installing anchor bolts and other anchorages.
    - b. Obtain approval for minor variations in detail for the purpose of improving fabrication and installation procedures, but not affecting general design for structural stability.
  - 2. Samples for Verification: Three of each of the following in each finish to be used in the work. For each profile and pattern of fabricated metal and for each type of metal finish required, prepared on metal of same thickness and alloy indicated for the Work.
    - a. Include 6-inch long samples of linear shapes, tubing and extrusions
    - b. Include 4-inch square samples of plates and sheet metal.
    - c. Welded joints: For color matching.
    - d. Brazed joints: Typical for work involved.
  - 3. Certification:
    - a. Welding Certificates: Copies of certificates for welding procedures and

- personnel.
- b. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.
- c. Certified test reports: Certified test reports verifying that epoxy grout conforms to specified requirements.
- d. Certification that adhesive is appropriate for the long-term intended use.

#### **1.04 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. AWS: A5.7, A5.8, D1.1, D1.3.
  - 3. PEI: S-100.
  - 4. MS: MIL-C-18480.
  - 5. ASTM: A36, A48, A153, A276, A312, A366, A413, A424, A500, A501, A536, A554, A653, A666, A743, B43, B135, B455, B584, C307, C413, C552, C579, C580, D1187, D3656, E527.
  - 6. ANSI: A156.18.
  - 7. FS TT-P-664.
  - 8. SSPS-Paint 5, Paint 12.
  - 9. NAAMM.
- B. Installer Qualifications: Arrange for installation of ornamental metal specified in this Section by the same firm that fabricated it.
- C. Fabricator Qualifications: A firm experienced in producing ornamental metal similar to that indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.
- D. Welding Standards: Qualify procedures and personnel according to the following:
  - 1. AWS D1.1, "Structural Welding Code--Steel."
  - 2. AWS D1.3, "Structural Welding Code--Sheet Steel."

#### **1.05 DELIVERY, STORAGE, AND HANDLING:**

- A. Store ornamental metal inside a well-ventilated area, away from uncured concrete and masonry, and protected from weather, moisture, soiling, abrasion, extreme temperatures, and humidity.
- B. Deliver and store cast-metal products in wooden crates surrounded by sufficient excelsior to ensure that products will not be cracked or otherwise damaged.

#### **1.06 PROJECT CONDITIONS:**

- A. Field Measurements: Where ornamental metal is indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.
  - 1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating ornamental metal without field measurements. Coordinate other construction to ensure that actual dimensions correspond to established dimensions.

## 1.07 COORDINATION

- A. Coordinate installation of anchorages for ornamental metal items. Furnish Setting Drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

## PART 2 - PRODUCTS

### 2.01 MATERIALS, GENERAL:

- A. Insofar as practicable, furnish products of a single manufacturer.

### 2.02 METALS:

- A. General: Provide metals free from surface blemishes where exposed to view in finished unit. Exposed-to-view surfaces exhibiting pitting, seam marks, roller marks, stains, discolorations, or other imperfections on finished units are not acceptable.
- B. Bronze: Provide copper alloy of type and form indicated to comply with the following requirements:
  - 1. Extruded Shapes: ASTM B455, Alloy UNS No. C38500 (extruded architectural bronze).
  - 2. Plate, Sheet, Strip, and Bars: ASTM B36, Alloy UNS No. C28000 (muntz metal, 60 percent copper).
  - 3. Seamless Pipe: ASTM B43, Alloy UNS No. C23000.
  - 4. Seamless Tubes: ASTM B135, Alloy UNS No. C23000 (red brass, 85 percent copper).
  - 5. Delete subparagraph above or below. Verify availability and color match with other copper-alloy forms. See Evaluations.
  - 6. Sand Castings: ASTM B584, Alloy UNS No. C86500 (No. 1 manganese bronze).
  - 7. Stainless Steel: Grade and type designated below for each form required:
  - 8. Pipe: ASTM A312, Grade TP 304.
  - 9. Castings: ASTM A743, Grade CF 8 or Grade CF 20.
  - 10. Sheet, Strip, Plate, and Flat Bar: ASTM A666, Type 304.
  - 11. Bars and Shapes: ASTM A276, Type 304. Select subparagraph above or below.
- C. Steel: Provide steel in form indicated to comply with the following requirements:
  - 1. Tubing: Cold formed, ASTM A500.
  - 2. Steel Plate, Shapes, and Bars: ASTM A36.
  - 3. Steel Sheet:
    - a. Commercial-quality, cold-rolled, stretcher-leveled, carbon-steel sheet complying with ASTM A 366, Class I, matte finish.
    - b. ASTM A653, mild-annealed, leveled, cold-rolled, galvanized, 16-gauge.
- D. Base Metal for Porcelain Enamel: ASTM A424, vitreous enameling steel of low metalloid and copper content, manufactured and processed for the production of architectural porcelain enamel units, 16-gauge.
- E. Porcelain Enamel Panel Liners: ASTM A653, hot dipped galvanized steel sheet, G90 zinc coating, 20-gauge.

### 2.03 MISCELLANEOUS MATERIALS:

- A. Welding Electrodes and Filler Metal: Type and alloy of filler metal and electrodes as

recommended by producer of metal to be welded, complying with applicable AWS specifications, and as required for color match, strength, and compatibility in fabricated items.

- B. Fasteners: Use fasteners of same basic metal as fastened metal, unless otherwise indicated. Do not use metals that are corrosive or incompatible with materials joined.
  - 1. Provide concealed fasteners for interconnecting ornamental metal components and for attaching them to other work, unless otherwise indicated.
  - 2. Provide concealed fasteners for interconnecting ornamental metal components and for attaching them to other work, unless exposed fasteners are unavoidable or are the standard fastening method.
  - 3. Provide Phillips flat-head machine screws for exposed fasteners, unless otherwise indicated.
  
- C. Cast-in-Place and Postinstalled Anchors: Anchors of type indicated below, fabricated from corrosion-resistant materials with capability to sustain, without failure, a load equal to six times the load imposed when installed in unit masonry and equal to four times the load imposed when installed in concrete as determined by testing per ASTM E 488 conducted by a qualified independent testing agency.
  - 1. Cast-in-place anchors
  - 2. Chemical anchors.
  - 3. Expansion anchors.
  
- D. Insect Screen: ASTM D3656, with aluminum or galvanized steel frame as shown.
  
- E. Epoxy Grout: Nonshrink, nonstaining, 100-percent solids, two-component or three-component epoxy-resin system, that has been in successful use for an equivalent application for a minimum of five years.
  - 1. On horizontal applications: Self-leveling type.
  - 2. On vertical and overhead surface application: Non-sag type.
  - 3. Physical properties:

Property	Requirement	ASTM Test Method
Tensile strength	1,800-psi minimum in seven days	C307
Compressive strength	13,500-psi minimum in 28 days	C579
Modulus of rupture	13,500 psi	C580
Water absorption	One-percent maximum, two hours at 212F	C413

- F. Panel Core: Cellular glass, ASTM C552, Type IV, one-inch thick.
  
- G. Shop Primer for Ferrous Metal: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with performance requirements of FS TT-P-664; selected for good resistance to normal atmospheric corrosion, compatibility with finish paint systems indicated, and capability to provide a sound foundation for field-applied topcoats despite prolonged exposure.
  
- H. Shop Primer for Galvanized Steel: Zinc-dust, zinc-oxide primer formulated for priming zinc-coated steel and for compatibility with finish paint systems indicated, and complying with SSPC-Paint 5.

- I. Bituminous Paint: Cold-applied asphalt mastic complying with SSPC-Paint 12, except containing no asbestos fibers, or cold-applied asphalt emulsion complying with ASTM D1187
- J. Adhesive: Hot spray contact cement, certified by fabricator as appropriate for the long-term intended use

#### **2.04 FABRICATION, GENERAL:**

- A. Form ornamental metal to required shapes and sizes, with true curves, lines, and angles. Provide components in sizes and profiles indicated, but not less than that needed to comply with requirements indicated for structural performance.
- B. Provide necessary rebates, lugs, and brackets to assemble units and to attach to other work. Drill and tap for required fasteners, unless otherwise indicated. Use concealed fasteners where possible.
- C. Comply with AWS for recommended practices in shop welding and brazing. Provide welds and brazes behind finished surfaces without distorting or discoloring exposed side. Clean exposed welded and brazed joints of all flux, and dress all exposed and contact surfaces.
  - 1. Type, size and spacing of welds: As shown on approved shop drawings.
  - 2. Remove weld spatter and welding oxides from finished surfaces by descaling and grinding.
  - 3. Use oxyacetylene method for welding joints of extruded architectural bronze, 16-B&S gauge or heavier.
  - 4. To ensure color match at exposed joints, insert pieces of the base metal or low-fuming bronze, conforming to AWS A5.7, Classification R Cu Zn C as filler material. Adjust oxidizing flame to minimize porosity of joint.
  - 5. Grind and polish welded beads on exposed polished surfaces to match and blend with finish on adjacent parent metal.
- D. Mill joints to a tight, hairline fit. Cope or miter corner joints. Form joints exposed to weather to exclude water penetration.
- E. Provide castings that are sound and free of warp, cracks, blowholes, or other defects that impair strength or appearance. Grind, wire brush, sandblast, and buff castings to remove seams, gate marks, casting flash, and other casting marks.
- F. Finish exposed surfaces to smooth, sharp, well-defined lines and arris.
- G. Assemble items in the shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation. Use connections that maintain structural value of joined pieces.
- H. Cleaning metal surfaces:
  - 1. After grinding and polishing or where subject to severe forming operations, remove extraneous material from metal surfaces, thoroughly rinse with clear water and dry.
  - 2. Remove lubricants used in fabrication before work leaves shop.
  - 3. Match-mark materials for field assembly as necessary. Arrange sequence of shipments to expedite erection and to minimize field handling of material.

#### **2.05 FABRICATING HANDRAILS AND RAILINGS:**

- A. Nonwelded Connections: Fabricate handrails and railings to interconnect members with concealed mechanical fasteners and fittings, unless otherwise indicated. Fabricate members

and fittings to produce flush, smooth, rigid, hairline joints.

1. Fabricate splice joints for field connection using an epoxy structural adhesive where this is fabricator's standard splicing method.
- B. Welded Connections: Fabricate handrails and railings for connecting members by welding. Cope components at perpendicular and skew connections to provide close fit, or use fittings designed for this purpose. Weld connections continuously to comply with the following:
1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
  2. Obtain fusion without undercut or overlap.
  3. Remove flux immediately.
  4. At exposed connections, finish exposed surfaces smooth and blended so no roughness shows after finishing and welded surface matches contours of adjoining surfaces
  5. Provide welded connections for stainless-steel handrails and railings.
  6. Provide welded connections for ferrous handrails and railings.
- C. Retain paragraph and subparagraphs below if required for brazing copper-alloy railings. See Evaluations. Brazed Connections: Fabricate bronze handrails and railings for connecting members by brazing. For connections made during fabrication, braze corners and seams continuously to comply with the following:
1. Use materials and methods that match color of base metal, minimize distortion, and develop maximum strength and corrosion resistance.
  2. Remove flux immediately.
  3. Where exposed field connections are necessary, insert inside sleeves and secure at bottom with flush screws to provide hairline joint. Finish exposed surfaces smooth and blended so no roughness shows after finishing and brazed surface matches contours of adjoining surfaces.
- D. Form changes in direction of railing members as follows shown on approved shop drawings. Retain one of seven subparagraphs below; if retaining more than one, also retain last subparagraph. If there is a need to limit specific methods to selected locations or to railings of different metals, select method that predominates as default by adding phrase ", unless otherwise indicated," and qualify other methods retained by adding phrase "where indicated."
- E. Form simple and compound curves by bending members in jigs to produce uniform curvature for each repetitive configuration required; maintain profile of member throughout entire bend without buckling, twisting, or otherwise deforming exposed surfaces of handrail and railing components
- F. For handrails and railings with nonwelded connections that are exposed to exterior or to moisture from condensation or other sources, provide weep holes or another means to drain water entrapped in hollow sections of railing members.
- G. Provide wall returns at ends of wall-mounted handrails, unless otherwise indicated; close ends of returns.
- H. Close exposed ends of handrail and railing members with manufacturer's standard prefabricated end fittings.
- I. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, flanges, miscellaneous fittings, and anchors to interconnect handrail and railing members to other work, unless otherwise indicated.
1. Furnish inserts and other anchorage devices for connecting handrails and railings to concrete or masonry work. Fabricate anchorage devices capable of withstanding loads imposed by handrails and railings. Coordinate anchorage devices with

- supporting structure.
2. For railing posts set in concrete, provide preset sleeves of steel, not less than 6 inches long and inside dimensions not less than 1/2 inch greater than outside dimensions of post, with steel plate forming bottom closure.

**2.06 FABRICATING BRONZE CLADDING:**

- A. Brake-formed as shown on approved shop drawings. Laminate to backup material to achieve permanent bond and as recommended by bronze manufacturer.
- B. Fit and braze exposed joints in cladding with copper-phosphorous alloy or silver alloy, conforming to AWS A5.8, Classification B Cu P-5 and B Ag 1, respectively. Clean joints and apply flux properly before brazing. After brazing, remove excess brazing metal from face of work.

**2.07 FABRICATING STEEL CLADDING:**

- A. Formed of steel sheet ASTM 366, with baked-enamel finish.
- B. Weld and fill seams and joints before finishing.

**2.08 INSULATED PANELS FOR ELEVATOR HOISTWAYS:**

- A. Consisting of exposed face of bronze or stainless steel sheet, back face of steel sheet, panel core and adhesive.
- B. Fabricated as specified for bronze or stainless steel cladding.

**2.09 PORCELAIN ENAMEL PANELS:**

- A. Laminated type in sizes and shapes shown conforming with PEI standards specified.

**2.10 FINISHES, GENERAL:**

- A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

**2.11 BRONZE FINISHES:**

- A. Base-metal finish: Medium satin wheel-polished or belt-polished with aluminum oxide or silicon carbide abrasives of 80-120 grit, using a peripheral wheel speed of 6,000 fpm to a smooth dull finish with a directional pattern.
- B. Applied finish: ANSI A156.18 finish number 613, dark oxidized satin bronze, oil rubbed; oxide or sulfide chemical process using immersion or brushed on application as recommended by the manufacturer.
  1. Color of finish: Match sample on file with the Authority's Representative.

**2.12 STAINLESS-STEEL FINISHES:**

- A. Remove or blend tool and die marks and stretch lines into finish.

- B. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.
- C. Satin, Directional Polish: ANSI A156.18 finish number 654, satin stainless steel.
- D. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

### **2.13 STEEL FINISHES:**

- A. Galvanizing: Hot-dip galvanize products made from rolled, pressed, and forged steel shapes, castings, plates, bars, and strips indicated to be galvanized to comply with ASTM A 123.
  - 1. Hot-dip galvanize iron and steel hardware indicated to be galvanized to comply with ASTM A 153.
- B. Fill vent and drain holes that will be exposed in finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.
- C. Preparation for Shop Priming: After galvanizing, thoroughly clean ornamental metal of grease, dirt, oil, flux, and other foreign matter, and treat with metallic-phosphate process.
- D. Preparation for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with minimum requirements indicated below for SSPC surface-preparation specifications and environmental exposure conditions of installed ornamental metal:
  - 1. Exteriors (SSPC Zone 1B): SSPC-SP 6, "Commercial Blast Cleaning."
  - 2. Interiors (SSPC Zone 1A): SSPC-SP 7, "Brush-off Blast Cleaning."
- E. Factory-Primed Finish: Apply air-dried primer immediately after cleaning and pretreatment, to provide a minimum dry film thickness of 2 mils per applied coat, to surfaces that will be exposed after assembly and installation, and to concealed, nongalvanized surfaces.
- F. Baked-Enamel Finish:
  - 1. Primer: Kem Hi-Temp Heat-Flex II 450 Primer by Sherwin-Williams, or equal.
  - 2. Finish coat: Kem Hi-Temp Heat-Flex 450 Finish by Sherwin-Williams, or equal.
  - 3. Porcelain Enamel Finish: PEI S-100, Specification for Architectural Porcelain Enamel on Steel for Exterior Use: Class AA or Class A.

## **PART 3 - EXECUTION**

### **3.01 PREPARATION:**

- A. Remove foreign substances and irregularities from surfaces against which metalwork is to be placed.

### **3.02 INSTALLATION, GENERAL:**

- A. Coordinate installation of ornamental metalwork with work of other trades. Provide anchorage devices and fasteners where necessary for securing ornamental metal to in-place construction.
- B. Perform cutting, drilling, and fitting required to install ornamental metal. Set products accurately in location, alignment, and elevation; measured from established lines and levels. Provide temporary bracing or anchors in formwork for items to be built into concrete, masonry, or similar construction.

- C. Fit exposed connections accurately together to form tight, hairline joints or, where indicated, with uniform reveals and spaces for sealants and joint fillers. Where cutting, welding, and grinding are required for proper shop fitting and jointing of ornamental metal, restore finishes to eliminate any evidence of such corrective work.
- D. Do not cut or abrade finishes that cannot be completely restored in the field. Return items with such finishes to the shop for required alterations, followed by complete refinishing, or provide new units as required.
- E. Fasten metalwork in place so that items will not be distorted, finish will not be impaired, nor fasteners over stressed from expansion and contraction of metal.
- F. Protect exposed metalwork throughout work to prevent scratches, stains, discoloration and other damage. Restore protective coverings that have been damaged during shipment or installation. Remove protective coverings only when there is no possibility of damage from other work yet to be performed at same location.
  - 1. Retain protective coverings intact; remove coverings simultaneously from similarly finished items to preclude nonuniform oxidation and discoloration.
- G. Field Welding: Comply with applicable AWS specification for procedures of manual shielded metal arc welding, for appearance and quality of welds, and for methods used in correcting welding work. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Grind exposed welded joints smooth and restore finish to match finish of adjacent surfaces.
- H. Provide protection against galvanic action between dissimilar metals by completely covering contact surfaces with heavy brush-coat of bituminous paint or by separating contact surfaces with preformed tape.
- I. Apply heavy brush-coat of bituminous paint to contact surfaces of ornamental metals, except stainless steel, which come into contact with concrete, mortar or other masonry. Do not apply paint onto concrete or masonry surfaces. Apply to metal, let cure, then apply metal fabrication to concrete or masonry.

### **3.03 INSTALLING HANDRAILS AND RAILINGS:**

- A. Adjust handrails and railings before anchoring to ensure alignment at abutting joints.
- B. Concrete-Anchored Posts in Sleeves: Insert posts in preset sleeves, cast into concrete, and fill annular space between posts and sleeve with epoxy grout.
  - 1. Remove contaminants from surfaces receiving and coming into contact with the grout. Remove surface contaminants such as curing compounds from holes that receive grout. Ensure that surfaces to receive grout are dry at the time of grouting.
  - 2. Prime surfaces in accordance with grout manufacturer's recommendations.
  - 3. Mix and place epoxy grout for locations shown or specified as recommended by grout manufacturer. Level exposed surfaces of grout joints with adjacent surfaces. Grind rough or raised projections smooth and flush with adjacent surfaces. Retain paragraph above or below or delete both if no posts in concrete.
- C. Anchor posts to metal surfaces with fittings designed for this purpose.
- D. Non-welded Connections: Use mechanical or adhesive joints for permanently connecting railing components. Use wood blocks and padding to prevent damage to railing members and fittings. Seal recessed holes of exposed locking screws using plastic cement filler colored to match finish of handrails and railing

- E. Welded Connections: Use fully welded joints for permanently connecting railing components by welding. Cope or butt components to provide 100 percent contact or use fittings designed for this purpose.
- F. Anchor railing ends into concrete or masonry with fittings designed for this purpose.
- G. Anchor railing ends to metal surfaces with fittings using concealed fasteners.
- H. Anchor railing ends to metal surfaces by welding.
- I. Expansion Joints: Provide expansion joints at locations indicated or, if not indicated, at intervals not to exceed 40 feet. Provide slip-joint internal sleeve extending 2 inches beyond joint on either side, fasten internal sleeve securely to one side, and locate joint within 6 inches of post.

**3.04 CLEANING:**

- A. Upon completion of installation, clean surfaces of metalwork by procedure recommended by metalwork manufacturer.
- B. Clean up rubbish and debris caused by this work and remove from the site.

**3.05 PROTECTION:**

- A. Protect finishes of ornamental metal from damage during construction period with temporary protective coverings approved by ornamental metal fabricator. Remove protective covering at the time of Substantial Completion.
- B. Restore finishes damaged during installation and construction period so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop; make required alterations and refinish entire unit, or provide new units.

**END OF SECTION**

## SECTION 05810

### EXPANSION JOINT COVER ASSEMBLIES

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing expansion joint cover assemblies.
- B. Related Work Specified Elsewhere:
  - 1. Cast-In-Place Structural Concrete: Section 03300.
  - 2. Expansion Joint Systems: Section 05811.
  - 3. Flashing and Sheet Metal: Section 07600.
  - 4. Seals and Sealants: Section 07900.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements specified for each:
  - 1. Product data for each type of expansion joint cover assembly specified, including manufacturer's product specifications, installation instructions, details of construction relative to materials, dimensions of individual components, profiles, and finishes.
  - 2. Shop drawings showing fabrication and installation of expansion joint cover assembly including plans, elevations, sections, details of components, joints, splices, and attachments to other units of Work.
  - 3. Samples for initial selection purposes in the form of manufacturer's color charts, actual units, or sections of units showing full range of colors, textures, and patterns available for each exposed metal and elastomeric material of expansion joint cover assembly indicated.
  - 4. Samples for verification purposes in full-size units of each type of expansion joint cover assembly indicated; in sets for each finish, color, texture, and pattern specified, showing full range of variations expected in these characteristics.
    - a. Install elastomeric material for joints samples to verify color selected.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ADA: Americans with Disabilities Act.
  - 3. AAMA: 603.8, 605.2, 606.1, 607.1, 608.1
  - 4. ANSI/UL: 263.
  - 5. ASTM: A167, B209, B221, B455, C920, D2000, E119, E1399.
  - 6. NAAMM: Metal Finishes Manual.
  - 7. NFPA: 251.
  - 8. UBC: 43-1.
- B. Single-Source Responsibility: Where practical, obtain expansion joint cover assemblies specified in this Section from one source from a single manufacturer. Coordinate compatibility with expansion joint cover assemblies specified in other sections.
- C. Fire-Test-Response Characteristics: Where indicated, provide expansion joint cover assemblies identical to those assemblies whose fire resistance has been determined per ANSI/UL 263, NFPA 251, U.B.C. 43-1, or ASTM E119, including hose stream test of vertical wall assemblies, by a testing and inspecting agency acceptable to authorities having jurisdiction.
  - 1. Fire-Resistance Ratings: Not less than the rating of adjacent construction.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS:**

- A. Aluminum: ASTM B221, alloy 6063-T5 for extrusions; ASTM B209, alloy 6061-T6, sheet and plate.
  - 1. Protect aluminum surfaces to be placed in contact with cementitious materials with a protective coating.
- B. Bronze: ASTM B455, alloy C38500 for extrusions; alloy C28000 Muntz Metal for plates.
- C. Brass: UNS alloy C26000 for half hard sheet and coil.
- D. Stainless Steel: ASTM A167, Type 304 with 2B finish, unless indicated otherwise, for plates, sheet, and strips.
- E. Extruded Preformed Seals: Single or multicellular elastomeric profiles as classified under ASTM D2000, designed with or without continuous, longitudinal, internal baffles. Formed to fit compatible frames, in color indicated or, if not indicated, as selected by the Engineer from manufacturer's standard colors.
- F. Preformed Sealant: Manufacturer's standard elastomeric sealant complying with ASTM C920, Use T, factory-formed and -bonded to metal frames or anchor members; in color indicated or, if not indicated, as selected by the Engineer from manufacturer's standard colors.
  - 1. Joints 2 Inches Wide and Less: Withstand plus or minus 35 percent movement of the joint width without failure.
  - 2. Joints Greater Than 2 Inches to 4 Inches Wide: Withstand plus or minus 50 percent movement of the joint width without failure.
- G. Seismic Seals: Typically for exterior application, two single-layered elastomeric profiles, one interior and one exterior, as classified under ASTM D2000; retained in a set of compatible frames, in color indicated or, if not indicated, as selected by the Engineer from manufacturer's standard colors. At manufacturer's option, omit interior profile for interior application.
- H. Fire Barriers: Designed for indicated or required dynamic structural movement without material degradation or fatigue when tested according to ASTM E1399. Tested in maximum joint width condition with a field splice as a component of an expansion joint cover per ANSI/UL 263, NFPA 251, U.B.C. 43-1, or ASTM E119, including hose stream test of vertical wall assemblies by a nationally recognized testing and inspecting agency acceptable to authorities having jurisdiction.
- I. Accessories: Manufacturer's standard anchors, fasteners, set screws, spacers, flexible moisture barrier and filler materials, drain tubes, lubricants, adhesive, and other accessories compatible with material in contact, as indicated or required for complete installations.

### **2.02 EXPANSION JOINT COVER ASSEMBLIES:**

- A. General: Provide expansion joint cover assemblies of design, basic profile, materials, and operation indicated on approved shop drawings. Provide units comparable to those indicated or required to accommodate joint size, variations in adjacent surfaces, and dynamic structural movement without material degradation or fatigue when tested according to ASTM E1399. Furnish units in longest practicable lengths to minimize number of end joints. Provide hairline mitered corners where joint changes directions or abuts other materials. Include closure materials and transition pieces, tee-joints, corners, curbs, cross-connections, and other accessories as required to provide continuous joint cover assemblies.

- B. Moisture Barrier: Provide manufacturer's continuous, standard, flexible vinyl moisture barrier under covers at locations indicated on approved shop drawings.
- C. Fire-Rated Joint Covers: Provide expansion joint cover assemblies with manufacturer's continuous, standard, flexible fire barrier seals under covers at locations indicated on approved shop drawings to provide fire-resistive rating not less than the rating of adjacent construction.
- D. Coverless Fire Barrier: Provide manufacturer's continuous standard flexible fire barrier seals at locations indicated on approved shop drawings to provide fire-resistive rating not less than the rating of adjacent construction.
- E. Metal Floor-to-Floor Joint Cover Assemblies: Provide continuous extruded metal frames of profile indicated with seating surface and raised floor rim or exposed trim strip to accommodate flooring and concealed bolt and anchors embedded in concrete. Provide assemblies formed to receive cover plates of design indicated and to receive filler materials (if any) between raised rim of frame and edge of plate. Furnish depth and configuration to suit type of construction and to produce a continuous flush wearing surface with adjoining finish floor surface.
  - 1. Partially Concealed Cover: Provide one frame on each side of joint, designed to accommodate manufacturer's floor cover plate and filler.
  - 2. Exposed Cover: Provide one frame on each side of joint, designed to support floor plate and filler
  - 3. Flat Cover Plates: Provide cover plates of profile and wearing surface indicated. Extend flat plates to lap each side of joint.
    - a. Filler Insert: Furnish abrasive-resistant flexible gasket filler between edge of cover plate and raised rim of frame to accommodate required movement
  - 4. Fixed Cover Plates: Attach one side of the cover plate to a frame or finished wearing surface, with other side resting on other frame or finished wearing surface to allow free movement.
  - 5. Self-Centering Cover Plates: Concealed centering device with the cover plate secured in or on top of frames as to have free movement on both sides.
  - 6. Floor Cover Plate Wearing Surfaces: Provide cover plates with the following type of wearing surfaces.
    - a. Plain.
    - b. Fluted.
    - c. Recessed to receive full thickness of flooring material.
    - d. Abrasive plate.
    - e. Adhesive filled plate.
    - f. Adhesive strip plate.
- F. Floor-to-Wall Joints: Provide one frame on floor side of joint only. Provide wall side frame where required by manufacturer's design.
  - 1. Angle Cover Plates: Attach angle cover plates for floor-to-wall joints to wall with countersunk, flat-head exposed fasteners secured to drilled-in-place anchor shields, unless otherwise indicated, at spacing recommended by joint cover manufacturer.
- G. Wall, Ceiling, and Soffit Joint Cover Assemblies: Provide interior wall and ceiling expansion joint cover assemblies of same design and appearance. Provide exterior wall and soffit expansion joint cover assemblies of same design and appearance. Provide wall expansion joint cover assemblies compatible with floor expansion joint cover assemblies design and appearance.
  - 1. Fixed Metal Cover Plates: Provide a concealed, continuously anchored frame fastened to wall, ceiling, or soffit only on one side of joint. Extend cover to lap each side of joint and to permit free movement on one side. Attach cover to frame with cover in close contact with adjacent finish surfaces.

2. Floating Metal Cover Plates: Cover plate secured in or on top of frames to permit free movement on both sides.
  3. Self-Centering Cover Plates: Concealed centering device with the cover plate secured in or on top of frames to permit free movement on both sides.
  4. Flexible Filler: Secure the approved flexible filler between frames to compress and expand with movement.
- H. Joint Cover Assemblies with Preformed Seals: Provide joint cover assemblies consisting of continuously anchored aluminum extrusions and continuous extruded preformed seals of profile indicated or required to suit types of installation conditions shown. Furnish extrusions designed to be embedded in or attached to concrete with lugs. Vulcanize or heat-weld splices (if any) to ensure hermetic joint condition.
1. Cover Plate: Include extruded aluminum cover plate fastened to one side of joint and extend plate to lap each side of joint to permit free movement with cover in close contact with adjacent contact surfaces.
- I. Joint Cover Assemblies with Elastomeric Sealant: Provide continuous cover joint assemblies consisting of elastomeric sealant factory-bonded to extruded aluminum frames of profile indicated or required to suit types of installation conditions shown. Provide frames for floor joints with means for embedding in or anchoring to concrete without using exposed fasteners and that will result in exposed surfaces of sealant and aluminum frames finishing flush with adjacent finished floor surface without exposing anchors.
- J. Compression Seals: Preformed, elastomeric extrusions having internal baffle system in sizes and profiles shown or as recommended by the manufacturer. Provide lubricant and adhesive for installation recommended by the manufacturer.
- K. Foam Seal: Nonextruded, low-density, cross-linked, nitrogen-blown ethylene vinyl acetate polyethylene copolymer foam. Provide adhesive for installation recommended by the manufacturer.

### **2.03 METAL FINISHES:**

- A. General: Comply with NAAMM "Metal Finishes Manual" for finish designations and application recommendations, except as otherwise indicated. Apply finishes to products in factory after fabrication. Protect finishes on exposed surfaces before shipment.
- B. Aluminum Finishes: Finish designations prefixed by AA conform to the system established by the Aluminum Association for designating aluminum finishes.
1. Mill Finish: AA-M10 (unspecified mill finish).
  2. Class II, Clear-Anodized Finish: AA-M12C22A31 [Mechanical Finish: as fabricated, nonspecular; Chemical Finish: etched, medium matte; Anodic Coating: Class II Architectural, clear film thicker than 0.4 mil].
  3. Class I, Clear-Anodized Finish: AA-M12C22A41 [Mechanical Finish: as fabricated, nonspecular; Chemical Finish: etched, medium matte; Anodic Coating: Class I Architectural, clear film thicker than 0.7 mil] complying with AAMA 607.1.
  4. Class II, Color-Anodized Finish: AA-M12C22A32/A34 [Mechanical Finish: as fabricated, nonspecular; Chemical Finish: etched, medium matte; Anodic Coating: Class II Architectural, film thicker than 0.4 mil with integral color or electrolytically deposited color].
  5. Class I, Color-Anodized Finish: AA-M12C22A42/A44 [Mechanical Finish: as fabricated, nonspecular; Chemical Finish: etched, medium matte; Anodic Coating: Class I Architectural, film thicker than 0.7 mil with integral color or electrolytically deposited color] complying with AAMA 606.1 or AAMA 608.1.
    - a. Color: As selected by the Engineer from within standard industry colors and color density range.
  6. Baked Enamel Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited

chemicals; Chemical Finish: chemical conversion coating, acid chromate-fluoride-phosphate pretreatment; Organic Coating: as specified below). Apply baked enamel complying with paint manufacturer's specifications for cleaning, conversion coating, and painting.

- a. Organic Coating: Thermosetting modified acrylic enamel primer/topcoat system complying with AAMA 603.8 except with minimum dry film thickness of 1.5 mils, medium gloss
  - b. Color: As selected by the Engineer from manufacturer's standard colors.
7. High-Performance Organic Coating: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: chemical conversion coating, acid chromate-fluoride-phosphate pretreatment; Organic Coating: as specified below). Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturer's instructions.
- a. Fluoropolymer Two-Coat Coating System: Manufacturer's standard two-coat thermocured system, composed of specially formulated inhibitive primer and fluoropolymer color topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight; complying with AAMA 605.2.
  - b. Fluoropolymer Three-Coat Coating System: Manufacturer's standard three-coat thermocured system composed of specially formulated inhibitive primer, fluoropolymer color coat, and clear fluorocarbon topcoat, with both color coat and clear topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight; complying with AAMA 605.2.
    - 1) Resin Manufacturers: Subject to compliance with requirements, provide fluoropolymer coating systems containing resins produced by one of the following manufacturers:
      - a) Ausimont USA, Inc. (Hylar 5000).
      - b) Elf Atochem North America, Inc. (Kynar 500).
      - c) Or equal.
    - 2) Color and Gloss: As selected by the Engineer from manufacturer's standard choices for color and gloss. Retain below for covers in contact with masonry or concrete.
8. Factory-Primed Concealed Surfaces: Protect concealed metal surfaces to be placed in contact with concrete or masonry with a shop coat of manufacturer's standard primer on the contact surfaces.
- C. Bronze Finish: Comply with NAAMM "Metal Finishes Manual" for recommendations relative to application and designations of finishes.
1. Natural Satin Finish: CDA Designation M32, mechanical finish, directional textured, medium satin.
- D. Stainless Steel Finishes: Comply with NAAMM "Metal Finishes Manual" for recommendations relative to application and designations of finishes.
1. Bright, Cold-Rolled Unpolished Finish: AISI No. 2B finish.
  2. Bright, Directional Polish: AISI No. 3 finish.
- E. Factory Finish: Manufacturer's standard factory finish.

## **PART3 - EXECUTION**

### **3.01 PREPARATION:**

- A. Manufacturer's Instructions: In addition to requirements of these specifications, comply with manufacturer's instructions and recommendations for phases of Work, including preparing substrate, applying materials, and protecting installed units.
- B. Coordinate and furnish anchorages, setting drawings, templates, and instructions for installation of expansion joint cover assemblies to be embedded in or anchored to concrete

or to have recesses formed into edges of concrete slab for later placement and grouting-in of frames.

- C. **Fastening to In-Place Construction:** Provide anchorage devices and fasteners where necessary to secure expansion joint cover assemblies to in-place construction, including threaded fasteners with drilled-in expansion shields for masonry and concrete where anchoring members are not embedded in concrete. Provide fasteners of metal, type, and size to suit type of construction indicated and provide for secure attachment of expansion joint cover assemblies.

### **3.02 INSTALLATION:**

- A. **Cutting, Fitting, and Placement:** Perform cutting, drilling, and fitting required to install expansion joint covers. Install joint cover assemblies in true alignment and proper relationship to expansion joints and adjoining finished surfaces measured from established lines and levels. Allow adequate free movement for thermal expansion and contraction of metal to avoid buckling. Set floor covers at elevations to be flush with adjacent finished floor materials. Locate wall, ceiling, roof, and soffit covers in continuous contact with adjacent surfaces. Securely attach in place with required accessories. Locate anchors at interval recommended by manufacturer, but not less than 3 inches from each end and not more than 24 inches on center.
- B. **Continuity:** Maintain continuity of expansion joint cover assemblies with a minimum number of end joints and align metal members mechanically using splice joints. Cut and fit ends to produce joints that will accommodate thermal expansion and contraction of metal to avoid buckling of frames. Adhere flexible filler materials (if any) to frames with adhesive or pressure-sensitive tape as recommended by manufacturer.
- C. **Extruded Preformed Seals:** Install seals complying with manufacturer's instructions and with minimum number of end joints. For straight sections provide preformed seals in continual lengths. Vulcanize or heat-weld field splice joints in preformed seal material to provide watertight joints using procedures recommended by manufacturer. Apply adhesive, epoxy, or lubricant-adhesive approved by manufacturer to both frame interfaces before installing preformed seal. Seal transitions according to manufacturer's instructions.
- D. **Elastomeric Sealant Joint Assemblies:** Seal end joints within continuous runs and joints at transitions according to manufacturer's directions to provide a watertight installation.
- E. **Seismic Seals:** Install interior seals in continual lengths; vulcanize or heat-weld field splice joints in interior seal material to provide watertight joints using manufacturer's recommended procedures. Install exterior seal in standard lengths. Seal transitions and end joints according to manufacturer's instructions.
- F. **Fire Barriers:** Install fire barriers, including transitions and end joints, according to manufacturer's instructions so that fire-rated construction is continuous.

### **3.03 CLEANING AND PROTECTION:**

- A. Do not remove protective covering until finish work in adjacent areas is complete. When protective covering is removed, clean exposed metal surfaces to comply with manufacturer's instructions.

**END OF SECTION**

## SECTION 05811

### EXPANSION JOINT SYSTEMS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing exterior (pedestrian and vehicular) traffic joints, exterior (wall and ceiling) joints, exterior soffit joints, interior (pedestrian and vehicular) traffic joints, interior (wall and ceiling) joints and interior soffit joints.
- B. Related Work Specified Elsewhere:
  - 1. Cast-In-Place Structural Concrete: Section 03300.
  - 2. Expansion Joint Cover Assemblies: Section 05810.
  - 3. Flashing and Sheet Metal: Section 07600.
  - 4. Seals and Sealants: Section 07900.

##### 1.02 DEFINITIONS:

- A. Architectural Joint System: Any filler or cover used to span, fill, cover, or seal a joint, except expanding foam seals and poured or foamed in-place sealants.
- B. Cyclic Movement: Periodic change between widest and narrowest joint widths in an automatically mechanically controlled system.
- C. Fire Barriers: Any material or material combination, when fire tested after cycling, designated to resist passage of flame and hot gases through a movement joint.
- D. Maximum Joint Width: Widest linear gap a joint system tolerates and performs its designed function without damaging its functional capabilities.
- E. Minimum Joint Width: Narrowest linear gap a joint system tolerates and performs its designed function without damaging its functional capabilities.
- F. Movement Capability: Value obtained from the difference between widest and narrowest widths of a joint opening typically expressed in numerical values (inches) or a percentage of nominal value of joint width.
- G. Nominal Joint Width: Width of linear gap indicated as representing the conditions existing when architectural joint systems will be installed or, if no nominal joint width is indicated, a width equal to the sum of maximum and minimum joint widths divided by two

##### 1.03 PERFORMANCE REQUIREMENTS:

- A. General: Provide factory-fabricated architectural joint systems capable of withstanding the types of loads and of accommodating the kinds of movement, and the other functions for which they are designed including those specified below, without failure. Types of failure include those listed in Appendix X3 of ASTM E1399.
  - 1. Vehicular Traffic Joints: Support vehicular traffic across joint.
  - 2. Pedestrian Traffic Joints: Support pedestrian traffic across joint.
  - 3. Exterior Joints: Maintain continuity of weather enclosure.
  - 4. Joints in Fire-Resistance-Rated Assemblies: Maintain fire-resistance ratings of assemblies.
  - 5. Joints in Smoke Barriers: Maintain integrity of smoke barrier.

6. Joints in Acoustically Rated Assemblies: Inhibit passage of airborne noise.
7. Other Joints: Where indicated, provide joint systems that prevent penetration of water, moisture, and other substances deleterious to building components or content.
8. Seismic Joints: Remain in place on exposure to seismic activity (movement).
9. Joints in Surfaces with Architectural Finishes: Serve as finished architectural joint closures.

## **1.02 SUBMITTALS:**

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  1. Product Data: Include manufacturer's product specifications, construction details, material and finish descriptions, and dimensions of individual components and seals.
  2. Shop Drawings: For each joint system specified, provide the following:
    - a. Placement Drawings: Include line diagrams showing entire route of each joint system, plans, elevations, sections, details, joints, splices, locations of joints and splices, and attachments to other Work. Where joint systems change planes, provide Isometric Drawings depicting how components interconnect to achieve continuity of joint covers and fillers.
  3. Samples for Initial Selection: Manufacturer's color charts consisting of units or sections of units showing the full range of colors, textures, and patterns available for each exposed metal and elastomeric material of joint system indicated.
    - a. Include similar Samples of material for joints and accessories involving color selection.
  4. Samples for Verification: Full-size units 6 inches long of each type of joint system indicated; in sets for each finish, color, texture, and pattern specified, showing the full range of variations expected in these characteristics.
  5. Product Test Reports: From a qualified testing agency indicating architectural joint systems comply with requirements, based on comprehensive testing of current products.

## **1.05 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
  1. Comply with codes and regulations of the jurisdictional authorities.
  2. AAMA: 606.1, 607.1, 608.1, 2603, 2604, 2605.
  3. ADA: Americans with Disabilities Act.
  4. ASTM: A666, B36, B209, B221, B455, E119, E814, E1399, E1612, E1783.
  5. NAAMM: Metal Finishes Manual for Architectural and Metal Products.
  6. UL: 2079.
- B. Source Limitations: Where practical, obtain architectural joint systems through one source from a single manufacturer. Coordinate compatibility with adjoining joint systems specified in other Sections.
- C. Fire-Test-Response Characteristics: Where indicated, provide joint systems incorporating fire barriers that are identical to those of assemblies tested for fire resistance per **[ASTM E 119] [and] [ASTM E 814] [UL 2079]**, including hose-stream test of vertical wall assemblies, by a testing and inspecting agency acceptable to authorities having jurisdiction.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS:**

- A. Aluminum: ASTM B221, alloy 6063-T5 for extrusions; ASTM B209, alloy 6061-T6 for sheet and plate.
  - 1. Apply manufacturer's standard protective coating on aluminum surfaces to be placed in contact with cementitious materials.
- B. Bronze: ASTM B455, alloy C38500 for extrusions; alloy C23000 Red Brass for plates.
- C. Brass: ASTM B36/B36M, UNS alloy C26000 for half hard sheet and coil.
- D. Stainless Steel: ASTM A666, Type 304 with No. 2B finish, unless otherwise indicated, for plates, sheet, and strips.
- E. Preformed Seals: Single or multicellular extruded elastomeric seals designed with or without continuous, longitudinal, internal baffles. Formed to be installed in frames or with anchored flanges, in color indicated or, if not indicated, as selected by the Engineer from manufacturer's standard colors.
- F. Preformed Silicon-Foam Sealant System: Section 07900.
- G. Strip Seals: Elastomeric membrane or tubular extrusions with a continuous longitudinal internal baffle system throughout complying with ASTM E 1783; used with compatible frames, flanges, and molded-rubber anchor blocks.
- H. Compression Seals: Preformed, elastomeric extrusions having internal baffle system complying with ASTM E1612 in sizes and profiles indicated or as recommended by manufacturer.
- I. Preformed Cellular Foams: [Nonextruded, low-density, crosslinked, nitrogen-blown ethylene-vinyl-acetate copolymer] [Neoprene] [or] [polyurethane] extruded, compressible foam.
- J. Fire Barriers: Any material or material combination, when fire tested after cycling, designated to resist the passage of flame and hot gases through a movement joint.
- K. Accessories: Manufacturer's standard anchors, clips, fasteners, set screws, spacers, flexible moisture barrier and filler materials, drain tubes, lubricants, adhesives, and other accessories compatible with material in contact, as indicated or required for complete installations.

## **2.02 EXPANSION JOINT SYSTEMS:**

- A. General: Provide joint systems of design, basic profile, materials, and operation indicated on approved shop drawings. Provide units with the capability to accommodate joint widths indicated and variations in adjacent surfaces.
  - 1. Furnish units in longest practicable lengths to minimize number of end joints. Provide hairline mitered corners where joint changes directions or abuts other materials.
  - 2. Include closure materials and transition pieces, tee-joints, corners, curbs, cross-connections, and other accessories as required to provide continuous joint systems.
  - 3. Frames for Strip Seals: Designed with semiclosed cavity that provides a mechanical lock for seals of type indicated.
  - 4. Public Arena Seals: Non-slip seals designed for installation on treads and risers and to lie flat with adjacent surfaces, and complying with ADA guidelines for public areas.

5. Cyclic-Movement-Test-Response Characteristics: No evidence of visual fatigue, inability to cycle between designated joint widths, or other types of failure as determined by testing products identical to those indicated per ASTM E1399 including Appendix X3.
6. Fire-Resistance Ratings: Provide manufacturer's standard fire barrier with a rating not less than that of adjacent construction.
7. Moisture Barrier: Provide manufacturer's standard unit.

### **2.03 FINISHES, GENERAL:**

- A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

### **2.04 ALUMINUM FINISHES:**

- A. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
- B. Mill Finish: AA-M10 (Mechanical Finish: as fabricated; no other applied finish unless buffing is required to remove scratches, welding, or grinding produced in fabrication process).
- C. Class II, Clear Anodic Finish: AA-M12C22A31 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class II, clear coating 0.010 mm or thicker) complying with AAMA 607.1.
- D. Class I, Clear Anodic Finish: AA-M12C22A41 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 607.1.
- E. Class II, Color Anodic Finish: AA-M12C22A32/A34 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class II, integrally colored or electrolytically deposited color coating 0.010 mm or thicker).
- F. Class I, Color Anodic Finish: AA-M12C22A42/A44 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 606.1 or AAMA 608.1.
  1. Color: As selected by the Engineer from the full range of industry colors and color densities.
- G. Baked-Enamel Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; Organic Coating: as specified below). Apply baked enamel complying with paint manufacturer's specifications for cleaning, conversion coating, and painting.
  1. Organic Coating: Thermosetting, modified-acrylic enamel primer/topcoat system complying with AAMA 2603 except with a minimum dry film thickness of 1.5 mils, medium gloss.
  2. Color: As selected by the Engineer from manufacturer's full range.
- H. High-Performance Organic Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; Organic

Coating: as specified below). Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

1. Fluoropolymer Two-Coat System: Manufacturer's standard two-coat, thermocured system consisting of specially formulated inhibitive primer and fluoropolymer color topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight; complying with AAMA 2604.
2. Fluoropolymer Three-Coat System: Manufacturer's standard three-coat, thermocured system consisting of specially formulated inhibitive primer, fluoropolymer color coat, and clear fluoropolymer topcoat, with both color coat and clear topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight; complying with AAMA 2605.
  - a. Color and Gloss: As selected by the Engineer from manufacturer's full range.

## **2.05 STAINLESS STEEL FINISHES:**

- A. Remove tool and die marks and stretch lines or blend into finish.
- B. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.
- C. Bright, Cold-Rolled, Unpolished Finish: No. 2B finish.
- D. Bright, Directional Polish: No. 4 finish.
- E. Satin, Directional Polish: No. 6 finish.
- F. Mirrorlike Reflective, Nondirectional Polish: No. 8 finish.
- G. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

## **2.06 COPPER ALLOY FINISHES:**

- A. Finish designations prefixed by CDA comply with the system established by the Copper Development Association for designating copper-alloy finish systems, as defined in NAAMM's "Metal Finishes Manual for Architectural and Metal Products."
  1. Remove tool and die marks and stretch lines or blend into finish.
  2. Grind and polish surfaces to produce uniform, directionally textured polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.
- B. Standard Finish Designation: CDA M32 (Mechanical Finish: directionally textured, medium satin).

## **PART 3 - EXECUTION**

### **3.01 PREPARATION:**

- A. Prepare substrates according to architectural joint system manufacturer's written instructions.
- B. Coordinate and furnish anchorages, Placement Drawings, and instructions for installing joint systems to be embedded in or anchored to concrete or to have recesses formed into edges of concrete slab for later placement and grouting-in of frames.

- C. **Fastening to In-Place Construction:** Provide anchorage devices and fasteners where necessary to secure joint systems to in-place construction, including threaded fasteners with drilled-in expansion shields for masonry and concrete where anchoring members are not embedded in concrete. Provide fasteners of metal, type, and size to suit type of construction indicated and to provide for secure attachment of joint systems.

### **3.02 INSTALLATION:**

- A. Comply with manufacturer's written instructions for handling and installing architectural joint assemblies and materials, unless more stringent requirements are indicated.
- B. Coordinate installation of architectural joint assembly materials and associated work so complete assemblies comply with assembly performance requirements.
- C. Terminate exposed ends of exterior architectural joint assemblies with factory-fabricated termination devices to maintain waterproof system.
- D. Install factory-fabricated transitions between building expansion joint cover assemblies and roof expansion joint assemblies to provide continuous, uninterrupted, watertight construction.
- E. Coordinate the size of joint opening at the time joint segments are set in position (distance between joint segments) with the temperature of the structure and the designed joint movement.
- F. **Cutting, Fitting, and Placement:** Perform cutting, drilling, and fitting required to install joint systems.
  - 1. Install joint cover assemblies in true alignment and proper relationship to joints and adjoining finished surfaces measured from established lines and levels.
  - 2. Allow adequate free movement for thermal expansion and contraction of metal to avoid buckling.
  - 3. Set covers in horizontal surfaces at elevations that place exposed surfaces flush with adjoining finishes.
  - 4. Locate covers in continuous contact with adjacent surfaces.
  - 5. Securely attach in place with required accessories.
  - 6. Locate anchors at interval recommended by manufacturer, but not less than 3 inches from each end and not more than 24 inches o.c.
- G. **Continuity:** Maintain continuity of joint systems with a minimum number of end joints and align metal members. Cut and fit ends to produce joints that will accommodate thermal expansion and contraction of metal to avoid buckling of frames. Adhere flexible filler materials, if any, to frames with adhesive or pressure-sensitive tape as recommended by manufacturer.
- H. **Extruded Preformed Seals:** Install seals to comply with manufacturer's written instructions and with minimum number of end joints.
  - 1. For straight sections, provide preformed seals in continuous lengths.
  - 2. Vulcanize or heat-weld field splice joints in preformed seal material to provide watertight joints using procedures recommended by manufacturer.
  - 3. Apply adhesive, epoxy, or lubricant adhesive approved by manufacturer to both frame interfaces before installing preformed seals.
  - 4. Seal transitions according to manufacturer's written instructions.
  - 5. Install foam seals with adhesive recommended by manufacturer and heat seal all splices.

- I. Joint Systems with Seals: Seal end joints within continuous runs and joints at transitions according to manufacturer's written instructions to provide a watertight installation.
- J. Seismic Seals: Install interior seals in continuous lengths. Install exterior seal in standard lengths and vulcanize or heat-weld field splice joints to provide watertight joints using manufacturer's recommended procedures. Seal transitions and end joints according to manufacturer's written instructions.
- K. Fire Barriers: Install fire barriers to provide continuous, uninterrupted fire resistance throughout length of joint, including transitions and end joints.

**3.03 CLEANING AND PROTECTION:**

- A. Do not remove protective covering until finish work in adjacent areas is complete. When protective covering is removed, clean exposed metal surfaces to comply with manufacturer's written instructions.

**END OF SECTION**

## SECTION 05840

### BEARINGS

#### PART 1 - GENERAL

##### 1.02 DESCRIPTION:

- A. This section specifies spherical and elastomeric bearings, fixed and sliding types, as shown. Pot Bearings shall not be used.
- B. Related Work Specified Elsewhere:
  - 1. Structural Steel: Section 05120.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Codes and regulations of the jurisdictional authorities.
  - 2. AWS: C-2.2, D 1.1.
  - 3. AASHTO: Standard Specifications for Highway Bridges, including supplement and M235. Where conflict occurs between AWS and AASHTO, AASHTO governs.
  - 4. AISC:
    - a. Specification for the Design, Fabrication and Erection of Structural Steel for Buildings.
    - b. Code of Standard Practice for Steel Buildings and Bridges.
    - c. Specifications for Structural Joints using ASTM A325 and A490 Bolts.
  - 5. AISI: C1018, C1020.
  - 6. ANSI: B18.2, B27.2.
  - 7. ASTM: A167, A240, A 709, C287, D621, D1777, D2256.
  - 8. ASNT: Recommended Practice SNT-TC-1A.
  - 9. MS: MIL P23236
- B. Source Quality Control:
  - 1. Testing and inspection:
    - a. Nondestructive-test requirements for welded members:
      - 1) Perform the following:
      - 2) For all fillet-weld connections: 10 percent of welds inspected by magnetic particle inspection.
      - 3) The Engineer may designate additional items to be inspected by radiography.
    - b. Bolts: The Engineer will randomly select at least five bolts for test purposes from each bin of bolts furnished.
- C. Qualification of Welding Personnel and Procedures:
  - 1. Prior to qualifying welding personnel and welding procedures, confirm an agreement with the Engineer as to procedural details, sequence of welding, handling of materials to be inspected, and approval of electrodes, wire, flux and other welding materials and equipment.
  - 2. Employ welding personnel whose qualification is certified in accordance with AWS Standard D1.1. Such certification is to remain in force for the duration of the welding operations under this Contract.
  - 3. Do not start fabrication until qualification has been successfully completed.
- D. Qualification of Nondestructive-Testing Personnel:

1. Nondestructive testing of fracture-critical members to be conducted by personnel qualified as NDT Level II or Level III in accordance with ASNT SNT-TC-1A.
  2. Level-II technicians to be supervised by Level III-personnel.
- E. Stock Material:
1. For qualification of welding personnel and procedures and for quality-assurance testing, use only stock materials which can be identified as having been rolled from a given heat and for which certified mill tests can be produced.
  2. When stock material is proposed, inform the Engineer of such intention at least 10 days in advance of commencing fabrication to permit sampling and testing. Select identified material from as few heats as possible.
- F. Welder's Identification Mark:
1. Assign each welder and welding operator an identification mark to stamp on pieces he has welded.
  2. Have welder or welding operator place his identification mark by metal-die stamp in letters 3/8-inch high in position that identification of welder or operator will appear adjacent to each of his welds in finally assembled members for ready reference to radiographic films and for identification by the Engineer.
- G. Bearing Manufacturer:
1. Qualification of Bearing Manufacturer: The Contractor shall demonstrate that the selected bearing manufacturer has a successful performance record for at least ten (10) years in the design and fabrication of spherical bearings in structures similar to the Work herein. The manufacturer shall also be capable of ensuring a close control over the materials, workmanship and quality within his facilities.
  2. Certification of Bearing Quality: The Contractor shall submit the following certification for approval by the Engineer:
    - a. Bearing certificate of conformance.
    - b. Test reports and certification of all materials included in the construction of all the bearings.
  3. Inspection Facilities: The manufacturer shall be required to furnish facilities for the testing and inspection of the complete bearings and/or representative samples in his plant or at an independent test facility.
- H. Testing of Bearings:
1. Sampling:
    - a. Select at random at least one sample from each "lot" of completed bearings at the manufacturer's plant.
    - b. One "lot" consists of one of the following:
      - 1) No more than 24 fixed or modified fixed bearings of one "load category".
      - 2) No more than 25 expansion bearings of one "load category".
    - c. One "load category" may consist of bearings of differing vertical load capacity but not to exceed a range of capacity differing by more than 300 kips.
  2. Friction Test:
    - a. Specially made bearings are not to be used; only actual bearings to be used in the project are to be tested. Test in accordance with the requirements of Section 18.8.3 of the current addition of AASHTO "Standard Specifications for Highway Bridges". A sample from each lot of expansion bearing is to be tested.
  3. Proof Load Test:
    - a. Test one bearing from each production "lot" of fixed and expansion bearings.

- b. Apply a load to the test bearings equal to 150% of the rated design capacity of the bearing simultaneously rotated 0.02 radians or the design rotation, which is greater, for one hour.
  - c. During the test or subsequently upon disassembly, the bearing shall show no sign of deformation or extrusion of the PTFE.
- 4. Material Tests:
  - 5. One sample of PTFE is to be taken from each "lot".

### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Structural details: Include the following:
      - 1) Bills of materials giving complete information for fabrication and erection of component parts of structures including material and finish information.
      - 2) Details of location, type, sizes of bolts and welds and for welded structures details of welding as specified.
      - 3) Structural computations for Contractor-designed work certified by a professional engineer registered in the area where the work is to be performed.
    - b. Match marks:
      - 1) Provide diagram showing match marks for connecting structural parts assembled in shop for purpose of drilling or reaming holes in field connections.
    - c. Welding:
      - 1) Complete shop details of qualification test specimens.
      - 2) Include information on specimen identification, number of pieces and welding procedure specification, type of material, sizes of pieces and welds and other variables affecting detail or tests.
    - d. Manufacturer's test procedures for bolts.
    - e. Bearings:
      - 1) The manufacturer is to submit detailed assembly drawings and any attachments in sufficient detail for proper review of the contract and this specification.
      - 2) Shop drawings are to include but not be limited to the following information:
        - a) Plan view and section elevation including all relative dimensions.
        - b) Details of all components and sections showing all materials incorporated into the bearing.
        - c) All ASTM, AASHTO and other material designations.
        - d) Vertical, horizontal, rotation and movement capacity.
        - e) A schedule of all bearing offsets if required by the project.
        - f) Paint or coating requirements.
        - g) Complete design calculations verifying conformance with the provisions of this specification and certified by a professional engineer registered in the jurisdiction where the work is performed. Do not proceed until approval has been received
- B. Certification:
  - 1. Certified mill test reports of structural steel at least 10 days prior to start of fabrication.

2. Certified quality-assurance testing and inspection reports.
3. Certification verifying that welding personnel have been qualified in accordance with AWS D1.1.
4. Manufacturer's certification that bolts meet approved testing.
5. Spherical-type bearings:
  - a. The certification package is to contain the following:
    - 1) Materials test reports for all steels used except AISI C1018 and C1020 for which a mill conformance certificate is acceptable.
    - 2) Certificate of Compliance for all non-ferrous metals.
    - 3) Certificate of Compliance for PTFE and any adhesives used. A certificate of compliance for the bearings executed by an officer of the manufacturer's company.
    - 4) Certificate of Compliance for any dowels or bolts supplied
    - 5) Test reports for the performance tests.

#### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. General:
  1. Load, transport, unload and store structural materials so as to keep them clean and free from damage
- B. Steelwork: See section 05120.
- C. Bolts and Nuts: See section 05120.
- D. Paint: See section 05120.
- E. Bearings:
  1. Bearings are to be securely banded together as units so that they may be shipped to the jobsite and stored without relative movement of the bearing parts or disassembly at any time. Bearings are to be wrapped in moisture resistance and dust resistant material to protect against shipping and jobsite conditions.
  2. Take care to ensure that bearings at the jobsite are stored in a dry sheltered area free from dirt or dust until installation.
  3. When bearings are to be inspected on site, they are to be inspected within one week of arrival and may not be disassembled except under the supervision of the manufacturer or his representative or with the written approval of the manufacturer. Following inspection, the wrapping is to be reapplied and the bearings kept clean until installation.
  4. Removal of sole and top plates of bearings for separate attachment to the structure is not permitted except under the direct supervision of the manufacturer.

#### **1.05 JOB CONDITIONS:**

- A. Environmental Requirements:
  1. Welding: See section 05120.
  2. Painting: See section 05120.

### **PART 2- PRODUCTS**

#### **2.01 MATERIALS:**

- A. PTFE sliding surfaces conforming to the material requirements of AASHTO Section 18.8. Reprocessed material shall not be used.

- B. Stainless Steel sliding surfaces conforming to ASTM A167 or A240 Type 304 with a surface finish 20 micro-inches rms. or less. Welded stainless steel overlay produced using Type 309L electrodes.
- C. Solid Stainless Steel stock for spherical bearings core conforming to ASTM A 240, Type 318 or Type 304 or to ASTM A167, Type 304, with a minimum yield strength of  $F_y$  equal 30,000 psi.
- D. Steel in Bearings:
  - 1. Bearings for Aerial Line Sections
  - 2. Bearing assemblies used in the line sections of the aerial structure with span lengths of 80 feet or more, shall be self lubricating bearing assemblies to provide rotation and longitudinal movement as needed for expansion joints. The bearing assembly shall be an integral unit composed of:
    - a. Spherical bearings plates - A convex solid stainless steel plate with surface of woven PTFE fabric mechanically interlocked to the substrate plate, and a mating concave solid stainless steel plate with finished bearing surface. The spherical interface shall provide rotational movement in any direction.
    - b. Flat bearing plates - A flat plate with the PTFE material similarly fixed on the sliding surface, and a solid stainless steel concave mating plate, as described in [1] above, with a flat finished sliding surface, to provide longitudinal translation movement. The relative movement between these two flat surfaces is to be restricted to the longitudinal direction.
      - 1) The PTFE fabric shall have a minimum thickness of 1/16" and is to meet the following requirements:
        - a) Hardness at 78°F per ASTM D676 - 50-65 Durometer D
        - b) Tensile strength per ASTM D638 - 2800 psi (Min. Avg.)
        - c) Elongation per ASTM D1708 - 200% (Min. Avg.)
        - d) The coefficient of friction between the steel plate and the PTFE surface shall be no greater than .06 at 800 psi compressive loading.
      - 2) The stainless steel surfaces shall have a finish of 20 RMS.
  - 3. Elastomeric bearings for Aerial Stations:
    - a. Criteria for the design shall be governed by AASHTO Section 14 "Elastomeric bearings". Method A or B is to be used as applicable. The compressive strain should not exceed 7%.
    - b. Bearing assemblies to be used in aerial stations shall be the sliding plate type bearing which allows translation by sliding of a self lubricating surface across a smooth hard solid stainless steel mating surface. The assembly is to have solid stainless steel bearing plate on the upper unit with sole plate and a preformed fabric pad with a rigidly confined PTFE bearing surface in the lower unit with masonry plate.
    - c. The preformed fabric pad shall meet AASHTO Specifications 10.3.12 "Preformed Fabric Pads" and capable of withstanding loads of 10 ksi perpendicular to the plane of lamination.
    - d. The metal bearing plate shall be fabricated from minimum of 13 gage stainless steel, and have a mirror finish with a minimum 20 micro inches RMS on the PTFE bearing side.
    - e. The coefficient of friction between the steel plate and the PTFE surface shall be no greater than .06 at 800 psi compressive loading.
  - 4. Expansion bearings shall be sized and set at the time of construction to allow for the following:
    - a. The maximum temperature movement based on the mean 48 hour prior temperature.

- b. The anticipated rotation and movement due to creep, shrinkage and elastic shortening from time of setting through day 400. These computed rotation and movements shall be increased by a factor of 1.3.
  - 5. Materials and fabrication for all type bearings, shall be in accordance with AASHTO, Section 18, Division II, and with the contract specifications.
- E. All steel, except stainless steel, used in fabrication of structural bearings, including masonry, sole plates, hold-down bolts and plates, etc., to be in accordance with ASTM A709, Grade 50W, unless otherwise shown in the Contract Drawings.
  - 1. All steel surfaces exposed to the atmosphere (except stainless) may at the manufacturer's option, be either shop painted with a coat of epoxy coal-tar protective coating system or zinc metalized.
    - a. Epoxy coal-tar coating in accordance with the requirement of Military Specification MIL-P23236, Class 2, and be applied at a minimum wet-film thickness of 10 mils.
    - b. Apply the metalized coatings in accordance with industry standards and AWS C-2.2.
  - 2. Prior to application of the protective coating, the surfaces to be coated or metalized are to be cleaned in accordance with the recommendations of the manufacturer of the system.
- F. Bolts and Nuts: ANSI B18.2.1 and B18.2.2.
- G. Round Washers Other Than Those In Contact With High-Strength Bolt Heads And Nuts: ANSI B27.2, Type B.
- H. Beveled Washers:
  - 1. Square, smooth and sloped to make contact surfaces of bolt head and nut parallel.
  - 2. Diameter of hole in square beveled washers as follows:
    - a. For bolts less than one-inch diameter: 1/16-inch larger than bolt size.
    - b. For bolts larger than one-inch diameter: 1/8-inch larger than bolt size.
- I. For all other materials, see section 05120.

## 2.02 DESIGN OF BEARINGS:

- A. General:
  - 1. Multi-Rotational bearings are to be designed to accommodate the loads, forces and movements specified in the bearing schedule.
  - 2. Maximum design stresses for all bearing components are not to exceed the allowable design stresses of the applicable issue of the AASHTO "Standard Specifications for Highway Bridges" and the applicable sections of this specification.
  - 3. Minimum "Design Rotation" capacity is .015 radians or as specified in the contract plans.
  - 4. Minimum horizontal capacity is 10% of the vertical capacity.
  - 5. Bearings are to be designed for 1 inch additional total movement capacity in each direction specified under "Design Movement" in the "Bearing Schedule". Spacing between the guides of the bearing do not require this additional movement capacity.
  - 6. Bearings are to be designed so that all rotational and sliding elements can be replaced with a minimum of jacking.
  - 7. All dimensions in this specification are in the customary units of the United States.
- B. Design of Rotational Elements:
  - 1. Spherical Element-Concave Surface-PTFE/Woven Teflon Fabric Pad:

- a. The spherical radius shall be determined such that the resulting geometry of the bearing is capable of withstanding the greatest ratio of horizontal force to vertical load under all loading conditions to prevent unseating the concave element.
  - b. If required during construction, mechanical safety restraints shall be incorporated to prevent overturning.
  - c. Maximum design rotation of the structure itself plus 0.03 radians shall be considered in the bearing design to prevent overturning or uplift.
  - d. Calculations showing the determination of the radius shall be submitted for approval. The projected area of sheet PTFE shall be designed for a maximum working stress of 3500 psi at the full load of the structure.
  - e. The projected area of woven fiber PTFE shall be designed for a maximum working stress of 6000 psi at the full load of the structure.
  - f. The concave surface shall face down whenever possible.
  - g. The minimum edge and center thickness shall be 3/4".
  - h. For sheet PTFE the minimum thickness shall be 1/8" and recessed for 1/16" in the spherical element.
  - i. PTFE fabric shall be a minimum of 1/16" thick when measured in accordance with ASTM D1777.
  - j. PTFE woven fabric shall be mechanically interlocked with the stainless steel substrate in accordance with the requirements of Section 18.8.2.1.3 of AASHTO.
2. Rotational Elements-Spherical Convex Surfaces
- a. The convex element shall be designed for the following service rotation in radians:
    - 1) Service rotation = "Design Rotation" + 0.03: where Design Rotation refers to the rotation of the structure itself.
  - b. When convex elements are connected to masonry or distribution plates it shall be by means of a fillet weld around the entire perimeter or set into a cavity and sealed by welding or other acceptable means.
  - c. The minimum edge thickness shall be 3/4".
  - d. For PTFE/Stainless and sliding surfaces, the stainless surface shall be one of the following:
    - 1) ASTM A240 Type 304, 13 gage thick with a 20 micro-inch rms finish.
    - 2) Solid stainless steel ASTM A240 Type 304 or 304L shall be equal to or less than a 20 micro-inch rms finish.
    - 3) Stainless steel weld overlay a minimum of 3/32" thick with a 20 micro-inch rms finish.
  - e. If sheet PTFE is used for guided surfaces, it shall be pigmented.
- C. Design of Non-Rotational Elements:
- 1. PTFE Sliding Surfaces:
    - a. Sheet PTFE sliding surfaces, filled or unfilled, are to be designed for 3500 psi average maximum working stress at the fully factored dead and live load of the structure.
    - b. Sheet PTFE is to be minimum of 1/8 inch thick, epoxy-bonded into a square-edge recess 1/16 inch deep.
    - c. Fabric PTFE sliding surfaces are to be designed for 6000 psi average maximum working stress at the fully factored dead and live load of structure.
    - d. Fabric PTFE is to have a minimum thickness of 1/16 inch and be epoxy-bonded to the substrate using a system that prevents migration of epoxy through the fabric. Any edges, other than the selvage are to be oversown or recessed so that no cut fabric edges are exposed.
    - e. PTFE used on guide bars shall be pigmented
  - 2. Stainless Steel Sliding Surfaces:

- a. The stainless steel surface is to cover the mating surface in all operating positions plus one inch in each direction of movement. This is to conform with the requirements of Article 2.2.A.5.
  - b. Sheet stainless steel is to be minimum of 13 gage thick and connected to the substrate by a continuous weld around the entire perimeter. The sheet is to be in full contact with the substrate.
  - c. Stainless steel sliding surfaces are to be, preferably, face down.
  - d. Stainless steel welded overlay is to be a minimum of 3/32 inches thick after welding, grinding and polishing and be produced using Type 309L electrodes.
3. Guide Bars:
- a. May be integral by machining from the solid, welded or connected with high strength fasteners. High strength fasteners are to be designed using .25 X Ultimate Strength in shear.
  - b. Guide bars are to be designed for the specified horizontal forces, but not for less than 10 percent of the vertical capacity of the bearing.
  - c. The total space between the guide bars and guided members (both sides) is to be, preferably, 1/16 inch or as specified.
  - d. Guided members must have their contact area within the guide bars in all operating positions.
  - e. Guiding off the fixed base or any extensions of it where transverse rotation is anticipated is to be avoided.

## 2.03 FABRICATION:

- A. Rotational Elements:
- 1. Spherical bearing machined diameters shall be + or - 0.015". Convex radius dimensions shall be + 0.000" - 0.010". Concave radius dimensions shall be + 0.010" - 0.000"
  - 2. Mating surfaces shall be as in Design section, external edges may be "as cast" or flame-cut.
    - a. Lower surface of convex element shall be Class "C" tolerance.
- B. Non-Rational Elements:
- 1. Masonry and distribution plate tolerances:
    - a. Plan dimensions under 30 inches, minus 0-inch plus 3/16 inch.
    - b. Plan dimensions over 30 inches, minus 0-inch plus 1/4 inch.
    - c. Thickness tolerance shall be minus 0.030-inch plus 0.060-inch. Masonry plates used with Spherical Bearings, Class "C" for the underside and Class "A" for the upperside.
  - 2. PTFE sliding surface tolerance:
    - a. Plan dimensions "total design area" plus 5 percent minus 0 percent.
    - b. Substrate flatness Class "B" Spherical Bearings.
  - 3. Stainless steel sheet is to be seal-weld around the entire perimeter using techniques which ensure it remains in contact with the backing plate. Finish, 20 micro-inches rms or better. Flatness to Class "A" tolerance
  - 4. Sole plates conforming to:
    - a. Plan dimensions under 30 inches minus 0-inch plus 3/16-inch.
    - b. Plan dimensions over 30 inches minus 0-inch plus 1/4-inch.
    - c. Center line Thickness, minus 1/32-inch plus 1/8-inch.
    - d. Flatness of surface in contact with poured in place concrete, none, in contact with stainless steel sliding surface, Class "A", in contact with another steel plate, Class "B".
    - e. No edge shall be thinner than 3/4-inch.

- f. Bevels shall be machined to an angular tolerance of plus-or-minus 0.002 radians.
  - g. Flatness of beveled surfaces shall be Class "A".
  - 5. Guide bar tolerances:
    - a. Length, unless integral with plate plus-or-minus 1/8-inch.
    - b. Section dimensions, plus-or-minus 1/16-inch.
    - c. Flatness where it bears on another plate Class "A".
    - d. Bar-to-bar, nominal dimensions plus-or-minus 1/32-inch.
    - e. Not more than 1/32-inch out of parallel.
  - 6. Overall bearing height is to be not more than 3/16-inch or less than 1/16-inch under nominal dimension. All edges shall be broken and not sharp.
- C. Determination of Flatness and Tolerances:
- 1. Flatness of bearings is determined by the following method:
    - a. A precision straightedge, longer than the nominal dimension to be measured, shall be placed in contact with the surface to be measured or as parallel to it as possible.
    - b. Select a feeler gage having a tolerance of plus or minus 0.001 inch and attempt to insert it under the straightedge. Since layering of feeler gages tends to degrade accuracy, the least number of blades shall be used.
    - c. Flatness is acceptable if the feeler does not pass under the straightedge.
    - d. Flatness tolerances are arranged in the following classes:
      - 1) Class "A" 0.0005 inch X "Nominal Dimension".
      - 2) Class "B" 0.001 inch X "Nominal Dimension".
      - 3) Class "C" 0.002 inch X "Nominal Dimension".
    - e. "Nominal Dimension" will be interpreted as a actual dimension of the plate, in inches, under the straightedge.
    - f. In determining flatness, the straightedge may be located in any position on the surface to be evaluated and not necessarily at 90 degrees to the edges.
    - g. A 1-inch border around the plate is to be ignored in determining flatness.

### PART 3 - EXECUTION

#### 3.01 FABRICATION: See Section 05120.

- A. Bearings:
  - 1. The manufacturer of the bearing is also to furnish all details pertaining to the bearing assemblies including the following:
    - a. Masonry and sole plates.
    - b. Anchor studs and pins.
    - c. Guide bars or shear blocks.
    - d. High-Strength bolts.
    - e. Stainless steel sheets and PTFE sheets.
    - f. Shipping straps or retaining clamps. Miscellaneous details.
  - 2. Sizes, dimensions and details pertaining to the spherical bearing core that are not shown on the Drawings are to be designed and determined by the bearing manufacture for the loading and movements shown on the Drawings and in the Contract Specification.
  - 3. Details shown on the Drawings for the bearings, outside of the actual spherical-bearing core, may have to be adjusted to suit actual dimensions and requirements of the spherical-bearing furnished by the manufacturer. See Bearing Notes on the Drawings.
  - 4. Bolts in guide bars or shear blocks, and sole and masonry plates are to be capable of being removed in the field for bearing replacement. Studs on masonry and sole

plates are to be positioned as shown and to clear reinforcement in pier columns, abutment beamseats and box girders.

**3.02 WELDING:** See Section 05120.

**3.03 BOLTING:** See Section 05120.

**3.04 ERECTION:**

- A. Set bearing assemblies to lines and grades shown and adjust to horizontal position shown.
- B. Bearings Installation:
  - 1. Bearings are to be evenly supported over their upper and lower surfaces under all erection and service conditions.
  - 2. Bearings are to be lifted by their undersides only or by specially designed lifting lugs.
  - 3. When installing bearings, care is to be taken to avoid damage to and contamination of bearings surfaces.
  - 4. Align the centerlines of the bearing assembly with those of the substructure and superstructure. On guided bearings, special care must be taken to properly align the guiding mechanism with the designated expansion direction of the structure.
  - 5. Bearings straps or retaining clamps are to be left in place as long as possible to ensure parts of bearings are not inadvertently displaced relative to each other. Care must be taken to remove straps or clamps before any normal structural movement takes place, such as post-tensioning, etc.
  - 6. Set offsets of upper and lower bearing parts as required by Contract Drawings.
  - 7. Provide blockouts in concrete for placement of the bearings. Do not cut any reinforcement in pier columns or abutment beam seats. Studs on masonry and sole plates may be shifted slightly from dimensions shown on the bearings to clear reinforcement in substructures and the box girders. Set bearings on a level plane and fill blockout in accordance with the following:
    - a. Clean entire blockout surfaces, concrete and reinforcement of rust, misplaced mortar and other foreign materials.
    - b. Immediately following the cleaning operation, dry the entire surfaces, concrete and reinforcement, and uniformly coat both with an epoxy bonding compound conforming to AASHTO Specification M235, Class III, in accordance with the manufacturer's recommendations.
    - c. Set and level the bearings to the correct elevations.
    - d. Fill the blockout with cement grout of a type which exhibits zero shrinkage when tested in accordance with ASTM C287. Grout to contain no aluminum powder, iron particles, chlorides, sulphites, fluorides or nitrates.

**END OF SECTION**

**DIVISION 6 - WOOD AND PLASTICS**

06075 WOOD PRESERVATIVE TREATMENT  
06100 ROUGH CARPENTRY  
06130 TIMBER TIES  
06131 COMPOSITE (PLASTIC) TIES  
06132 TIMBER GRADE CROSSING)  
06402 INTERIOR ARCHITECTURAL WOODWORK

**END OF SECTION**

## SECTION 06075

### WOOD PRESERVATIVE TREATMENT

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies preservative treatment of timber and lumber where shown.
- B. Unless otherwise shown, apply preservative treatments as follows:
  - 1. Creosote: Apply creosote treatment to wood which meets all of the following :
    - a. Is to be in contact with water or earth.
    - b. Is to be exposed to weather but not painted.
    - c. Is not subject to handling after installation.
  - 2. Pentachlorophenol and copper naphthenate: Apply pentachlorophenol and copper naphthenate treatment to wood which meets all of the following:
    - a. Is exposed to the weather.
    - b. May or may not be painted.
    - c. Is subject to handling after installation.
  - 3. Water-borne preservatives:
    - a. Use in approved locations.
- C. Definitions:
  - 1. PPT: Pressure-preservative treated.
  - 2. FRT: Fire-retardant treated.
  - 3. MSDS: Material safety data sheets.

##### 1.02 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Product Data: Manufacturer's product data and MSDS, including instructions for handling, storing, installing and finishing treated material.
- B. Certification: Submit certification that furnished meet specified requirements with each shipment of treated timber and lumber.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. AWPA Standards: C2, C3, C9, C20, C27, C35, M4, P1, P2, P5, P8, P17.
- B. Source Quality Control:
  - 1. Use only preservative treatment materials which have been tested and approved.
  - 2. After treatment have each piece of material stamped with the American Wood Preserver's Institute Quality Mark to indicate compliance with specified requirements.
  - 3. Inform the Engineer when treated wood is ready for inspection.
  - 4. Ship treated wood only after inspection and approval.

#### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Handling:
  - 1. Handle treated items with rope slings or other approved means. Do not drop, bruise, break outer fibers or penetrate surface with sharp tools.
  - 2. When stacking timber, avoid use of sharp tools for handling or turning in leads.
- B. Storage:
  - 1. Ensure that storage area has been cleared of debris and vegetation to at least four feet beyond limits of stored materials.
  - 2. Provide drainage away from stored materials.
  - 3. Store piles of timber and lumber so as to permit ready access and free air circulation.
  - 4. Store treated timber and lumber at least 12 inches above surface of ground.
  - 5. Stack ties no more than 20 layers high nor 10 feet wide.

#### **PART 2 MATERIALS:**

##### **2.01 MATERIALS:**

- A. Creosote: AWPA P1.
- B. Creosote and Coal-Tar Solution: Coal-tar distillate or solution of coal tar in coal-tar distillate conforming to AWPA P2.
- C. Pentachlorophenol: AWPA P8.
- D. Copper Naphthenate: AWPA P8..
- E. Waterborne Preservatives: AWPA P5.
- F. Fire Retardant Formulations: AWPA P17.

#### **PART 3 - EXECUTION**

##### **3.01 TREATMENT:**

- A. General:
  - 1. Prior to treating timber and lumber, perform fitting, cutting, drilling and mortising of joints.
  - 2. After treatment, kiln-dry lumber and plywood to a maximum moisture content of 19 and 15 respectively.
- B. Pressure treat timber and lumber in accordance with AWPA C2. For creosote, creosote solutions and oil-borne preservatives, use empty-cell treatment. If retention specified is greater than can be obtained by empty-cell process, inject water-borne preservative by full-cell process.
- C. Piles: Unless otherwise shown, apply creosote treatment to timber piles in accordance with AWPA C3.
- D. Poles: Unless otherwise shown, apply creosote treatment to timber poles in accordance with AWPA C35.

- E. Plywood (PPT): Pressure preservative treat plywood where indicated in accordance with AWPA C9.
- F. Plywood (FRT): Pressure fire retardant treat plywood where indicated in accordance with AWPA C27.
- G. Miscellaneous Wood Framing: Treat indicated items and the following in accordance with AWPA C2.
  - 1. Wood cants, nailers, curbs , equipment support bases, blocking stripping and similar members in connection with roofing, flashing, vapor barriers and waterproofing.
  - 2. Wood sills, sleepers, blocking, furring, stripping and similar concealed membrane in contact with masonry or concrete.
  - 3. Wood framing members less than 18 inches above grade.
  - 4. Wood floor plates installed over concrete slabs directly in contact with earth.
- H. Fire-Retardant Treatment for Lumber (FRT): Fire-retardant wood treatment in accordance with AWPA C20.
- I. Incising:
  - 1. For lumber with least dimension between two inches and three inches, incise wide faces by means of suitable power-driven machine prior to treatment.
  - 2. For timber with least dimension in excess of three inches, incise all four faces.

### **3.02 TREATMENT OF FIELD CUTS:**

- A. Treat bare surfaces resulting from drilling, cutting, tapping or damage of timber and lumber in accordance with AWPA M4.
- B. Apply same treatment to cutoff surfaces of timber piles not embedded in concrete.

**END OF SECTION**

## SECTION 06075

### WOOD PRESERVATIVE TREATMENT

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies preservative treatment of timber and lumber where shown.
- B. Unless otherwise shown, apply preservative treatments as follows:
  - 1. Creosote: Apply creosote treatment to wood which meets all of the following :
    - a. Is to be in contact with water or earth.
    - b. Is to be exposed to weather but not painted.
    - c. Is not subject to handling after installation.
  - 2. Pentachlorophenol and copper naphthenate: Apply pentachlorophenol and copper naphthenate treatment to wood which meets all of the following:
    - a. Is exposed to the weather.
    - b. May or may not be painted.
    - c. Is subject to handling after installation.
  - 3. Water-borne preservatives:
    - a. Use in approved locations.
- C. Definitions:
  - 1. PPT: Pressure-preservative treated.
  - 2. FRT: Fire-retardant treated.
  - 3. MSDS: Material safety data sheets.

##### 1.02 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Product Data: Manufacturer's product data and MSDS, including instructions for handling, storing, installing and finishing treated material.
- B. Certification: Submit certification that furnished meet specified requirements with each shipment of treated timber and lumber.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. AWWA Standards: C2, C3, C9, C20, C27, C35, M4, P1, P2, P5, P8, P17.
- B. Source Quality Control:
  - 1. Use only preservative treatment materials which have been tested and approved.
  - 2. After treatment have each piece of material stamped with the American Wood Preserver's Institute Quality Mark to indicate compliance with specified requirements.
  - 3. Inform the Engineer when treated wood is ready for in
  - 4. spection.
  - 5. Ship treated wood only after inspection and approval.

#### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Handling:
  - 1. Handle treated items with rope slings or other approved means. Do not drop, bruise, break outer fibers or penetrate surface with sharp tools.
  - 2. When stacking timber, avoid use of sharp tools for handling or turning in leads.
- B. Storage:
  - 1. Ensure that storage area has been cleared of debris and vegetation to at least four feet beyond limits of stored materials.
  - 2. Provide drainage away from stored materials.
  - 3. Store piles of timber and lumber so as to permit ready access and free air circulation.
  - 4. Store treated timber and lumber at least 12 inches above surface of ground.
  - 5. Stack ties no more than 20 layers high nor 10 feet wide.

#### **PART 2 MATERIALS:**

##### **2.01 MATERIALS:**

- A. Creosote: AWPA P1.
- B. Creosote and Coal-Tar Solution: Coal-tar distillate or solution of coal tar in coal-tar distillate conforming to AWPA P2.
- C. Pentachlorophenol: AWPA P8.
- D. Copper Naphthenate: AWPA P8..
- E. Waterborne Preservatives: AWPA P5.
- F. Fire Retardant Formulations: AWPA P17.

#### **PART 3 - EXECUTION**

##### **3.01 TREATMENT:**

- A. General:
  - 1. Prior to treating timber and lumber, perform fitting, cutting, drilling and mortising of joints.
  - 2. After treatment, kiln-dry lumber and plywood to a maximum moisture content of 19 and 15 respectively.
- B. Pressure treat timber and lumber in accordance with AWPA C2. For creosote, creosote solutions and oil-borne preservatives, use empty-cell treatment. If retention specified is greater than can be obtained by empty-cell process, inject water-borne preservative by full-cell process.
- C. Piles: Unless otherwise shown, apply creosote treatment to timber piles in accordance with AWPA C3.
- D. Poles: Unless otherwise shown, apply creosote treatment to timber poles in accordance with AWPA C35.

- E. Plywood (PPT): Pressure preservative treat plywood where indicated in accordance with AWPA C9.
- F. Plywood (FRT): Pressure fire retardant treat plywood where indicated in accordance with AWPA C27.
- G. Miscellaneous Wood Framing: Treat indicated items and the following in accordance with AWPA C2.
  - 1. Wood cants, nailers, curbs , equipment support bases, blocking stripping and similar members in connection with roofing, flashing, vapor barriers and waterproofing.
  - 2. Wood sills, sleepers, blocking, furring, stripping and similar concealed membrane in contact with masonry or concrete.
  - 3. Wood framing members less than 18 inches above grade.
  - 4. Wood floor plates installed over concrete slabs directly in contact with earth.
- H. Fire-Retardant Treatment for Lumber (FRT): Fire-retardant wood treatment in accordance with AWPA C20.
- I. Incising:
  - 1. For lumber with least dimension between two inches and three inches, incise wide faces by means of suitable power-driven machine prior to treatment.
  - 2. For timber with least dimension in excess of three inches, incise all four faces.

### **3.02 TREATMENT OF FIELD CUTS:**

- A. Treat bare surfaces resulting from drilling, cutting, tapping or damage of timber and lumber in accordance with AWPA M4.
- B. Apply same treatment to cutoff surfaces of timber piles not embedded in concrete.

**END OF SECTION**

## SECTION 06100

### ROUGH CARPENTRY

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies rough carpentry for wood blocking, roof sheathing, rooftop equipment bases and support curbs, miscellaneous lumber and accessories.
- B. Related Work Specified Elsewhere:
  - 1. Wood Preservative Treatment: Section 06075.
  - 2. Roof Accessories: Section 07730.
  - 3. Flashing and Sheet Metal: Section 07600.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
- B. Product Data for metal framing anchors and construction adhesives.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
- B. Comply with codes and regulations of the jurisdictional authorities.
  - 1. ALSC: NGR.
  - 2. DOC PS20.
  - 3. AWPA C2, C9, C20, C27, M4.
  - 4. UL.
  - 5. APA.
  - 6. FS FF-N-105.
  - 7. CAB NER-272.
  - 8. ASME A153, A307, A563, A653, B18.6.1, B18.2.1

##### 1.04 DELIVERY, STORAGE, AND HANDLING:

- A. Keep materials under cover and dry. Protect from weather and contact with damp or wet surfaces. Stack lumber, plywood, and other panels. Provide for air circulation within and around stacks and under temporary coverings.
  - 1. For lumber and plywood pressure treated with waterborne chemicals, place spacers between each bundle to provide air circulation.

#### PART 2 - PRODUCTS

##### 2.01 LUMBER, GENERAL:

- A. Lumber Standards: Comply with DOC PS 20, "American Softwood Lumber Standard," and with applicable grading rules of inspection agencies certified by American Lumber Standards Committee's (ALSC) Board of Review.

- B. Dressed sizes of green lumber are larger than dry lumber under DOC PS 20. Where nominal sizes are indicated, provide actual sizes required by DOC PS 20 for moisture content specified. Where actual sizes are indicated, they are minimum dressed sizes for dry lumber.

## **2.02 WOOD-PRESERVATIVE-TREATED MATERIALS:**

- A. General: Where lumber or plywood is indicated as preservative treated or is specified to be treated, comply with applicable requirements of AWWA C2 (lumber) and AWWA C9 (plywood). Mark each treated item with the Quality Mark Requirements of an inspection agency approved by ALSC's Board of Review.
  - 1. Do not use chemicals containing chromium or arsenic.
- B. Pressure treat aboveground items with waterborne preservatives to a minimum retention of 0.25 lb/cu. ft.. After treatment, kiln-dry lumber and plywood to a maximum moisture content of 19 and 15 percent, respectively. Treat indicated items and the following:
  - 1. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, and waterproofing.
  - 2. Wood sills, sleepers, blocking, furring, stripping, and similar concealed members in contact with masonry or concrete.
  - 3. Wood framing members less than 18 inches above grade.
  - 4. Complete fabrication of treated items before treatment, where possible. If cut after treatment, apply field treatment complying with AWWA M4 to cut surfaces. Inspect each piece of lumber or plywood after drying and discard damaged or defective pieces.

## **2.03 FIRE-RETARDANT-TREATED MATERIALS:**

- A. General: Where fire-retardant-treated wood is indicated, comply with applicable requirements of AWWA C20 (lumber) and AWWA C27 (plywood). Identify fire-retardant-treated wood with appropriate classification marking of UL; U.S. Testing; Timber Products Inspection, Inc.; or another testing and inspecting agency acceptable to authorities having jurisdiction.
  - 1. Research or Evaluation Reports: Provide fire-retardant-treated wood acceptable to authorities having jurisdiction and for which a current model code research or evaluation report exists that evidences compliance of fire-retardant-treated wood for application indicated.
- B. Interior Type A: For interior locations, use chemical formulation that produces treated lumber and plywood with the following properties under conditions present after installation:
  - 1. Bending strength, stiffness, and fastener-holding capacities are not reduced below values published by manufacturer of chemical formulation under elevated temperature and humidity conditions simulating installed conditions when tested by a qualified independent testing agency.
  - 2. No form of degradation occurs due to acid hydrolysis or other causes related to treatment.
  - 3. Contact with treated wood does not promote corrosion of metal fasteners.

## **2.04 DIMENSION LUMBER:**

- A. General: Provide dimension lumber of grades indicated according to the ALSC National Grading Rule (NGR) provisions of the inspection agency indicated.

## **2.05 MISCELLANEOUS LUMBER:**

- A. General: Provide lumber for support or attachment of other construction, including rooftop equipment curbs and support bases, cant strips, bucks, nailers, blocking, furring, grounds, stripping, and similar members.
- B. Fabricate miscellaneous lumber from dimension lumber of sizes indicated and into shapes shown.
- C. Moisture Content: 19 percent maximum for lumber items not specified to receive wood preservative treatment.

**2.06 ROOF SHEATHING:**

- A. General: Where structural-use panels are indicated for the following concealed types of applications, provide American Plywood Association (APA)-performance-rated panels complying with requirements designated under each application for grade, span rating, exposure durability classification, and edge detail (where applicable).
  - 1. Thickness: Provide panels meeting requirements specified but not less than thickness indicated.
  - 2. Span Ratings: Provide panels with span ratings required to meet "Code Plus" provisions of APA Form No. E30, "APA Design/Construction Guide: Residential & Commercial."

**2.07 FASTENERS:**

- A. General: Provide fasteners of size and type indicated that comply with requirements specified in this Article for material and manufacture.
  - 1. Where rough carpentry is exposed to weather, in ground contact, or in area of high relative humidity, provide fasteners with a hot-dip zinc coating per ASTM A 153 or of Type 304 stainless steel.
- B. Nails, Wire, Brads, and Staples: FS FF-N-105.
- C. Power-Driven Fasteners: CABO NER-272
- D. Wood Screws: ASME B18.6.1
- E. Lag Bolts: ASME B18.2.1.
- F. Bolts: Steel bolts complying with ASTM A 307, Grade A; with ASTM A 563 hex nuts and, where indicated, flat washers.

**2.08 METAL FRAMING ANCHORS:**

- A. General: Provide galvanized steel framing anchors of structural capacity, type, and size indicated and as follows:
  - 1. Research or Evaluation Reports: Provide products for which model code research or evaluation reports exist that are acceptable to authorities having jurisdiction and that evidence compliance of metal framing anchors for application indicated with building code in effect for Project.
  - 2. Allowable Design Loads: Provide products with allowable design loads, as published by manufacturer, that meet or exceed those indicated. Manufacturer's published values shall be determined from empirical data or by rational engineering analysis, and demonstrated by comprehensive testing performed by a qualified independent testing agency.

- B. Galvanized Steel Sheet: Hot-dip, zinc-coated steel sheet complying with ASTM A 653, G60 coating designation; structural, commercial, or lock-forming quality, as standard with manufacturer for type of anchor indicated.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION, GENERAL:**

- A. Discard units of material with defects that impair quality of rough carpentry and that are too small to use with minimum number of joints or optimum joint arrangement.
- B. Set rough carpentry to required levels and lines, with members plumb, true to line, cut, and fitted.
- C. Fit rough carpentry to other construction; scribe and cope as required for accurate fit. Correlate location of furring, nailers, blocking, grounds, and similar supports to allow attachment of other construction.
- D. Apply field treatment complying with AWPA M4 to cut surfaces of preservative-treated lumber and plywood.
- E. Securely attach rough carpentry work to substrate by anchoring and fastening as indicated, complying with the following:
  - 1. Counsel of American Building Officials: CABO NER-272 for power-driven staples, P-nails, and allied fasteners.
  - 2. Published requirements of metal framing anchor manufacturer.
- F. Use common wire nails, unless otherwise indicated. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood; predrill as required.
- G. Use hot-dip galvanized or stainless-steel nails where rough carpentry is exposed to weather, in ground contact, or in area of high relative humidity.

#### **3.02 WOOD GROUNDS, NAILERS, BLOCKING, AND SLEEPERS:**

- A. Install wood nailers, blocking, and sleepers where shown and where required for screeding or attaching other work. Form to shapes shown and cut as required for true line and level of attached work. Coordinate locations with other work involved.
- B. Attach to substrates to support applied loading. Recess bolts and nuts flush with surfaces, unless otherwise indicated. Build into masonry during installation of masonry work. Where possible, anchor to formwork before concrete placement.

**END OF SECTION**

## SECTION 06130

### TIMBER TIES

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. The section specifies furnishing timber cross ties, contact rail ties and switch ties as shown and specified.

##### 1.02 RELATED SECTIONS

- A. Section 05651 - General Track Construction
- B. Section 05652 - Ballasted Track Construction
- C. Section 05654 - Special Trackwork Construction - Ballasted
- D. Section 05659 - Special Trackwork
- E. Section 05660 - Restraining Rail and Lubricators

##### 1.03 REFERENCES

- A. American Railway Engineering and Maintenance-of-Way Association (AREMA), **latest edition:**
  - 1. AREMA Manual for Railway Engineering
  - 2. AREMA Portfolio of Trackwork Plans
  - 3. AREMA Specifications for Ties
  - 4. AREMA Specification for Preservatives
  - 5. AREMA Specification for Treatment
  - 6. AREMA Records of Treatment and Reports of Inspection.
- B. American Wood Preserver 's Association (AWPA)
  - 1. AWPA Standard C6
  - 2. AWPA Standard M3

##### 1.04 SUBMITTALS

- A. Submittals shall be made on accordance with Section 01300, Submittals
- B. Documentation
  - 1. Proposed method of delivery. Submit not late than 60 days prior to delivery.
  - 2. Proposed anti-splitting devices and location in tie.
  - 3. Proposed manner of marking treated ties to indicate compliance with specifications.
  - 4. Certificate of Compliance with AWPA Standard M3 for tie treatment.

##### 1.05 QUALITY ASSURANCE

- A. Inspection:
  - 1. The Engineer will inspect in accordance with pertinent sections of the AREMA Manual (**latest edition**), as modified herein.

2. Acceptance criteria: Failure to meet any pertinent part of AREMA requirements (latest edition) or these specifications constitutes cause for rejection. AREMA inspection requirements are to include, but not limited to, the physical requirement inspection criteria as outlined in Chapter 30, Section 3.1.1.4 (decay, holes, knots, shake, split, checks, slope of grain, bark seams and manufacturer defects).
3. Averaging of dimensions, with respect to measurement for size acceptance, is not permitted.
4. Provide suitable equipment, facilities and assistance required by the Engineer to effect inspections.
5. Inform the Engineer when treated wood is ready for inspection.
6. Do not deliver material until inspected and approved for shipment by the Engineer.
7. Final inspection and approval of ties will occur as a part of the final inspection of installed ballasted track.
8. WMATA, or its representatives, reserve the right to visit the producers facility during usual business hours unscheduled to: a) observe sampling and inspection procedures, b) obtain samples of the prepare material being produced and shipped, and c) review plant inspection methods, quality control procedures, equipment and examine inspection test results of current and previous tests.

#### **1.06 DELIVERY, STORAGE AND HANDLING**

- A. It shall be the Contractor's responsibility to make all arrangements for storage, shipment and handling of the ties.
- B. Tie stacks shall not exceed 20 layers each.
- C. Ties will be stacked with branding visible.
- D. Ties shall be handled in a manner that prevents damage.
- E. Ties shall not be dropped or dragged on the trackbed.

### **PART 2 - PRODUCTS**

#### **2.01 TIMBER**

- A. Furnish ties in accordance with the requirements as specified in this section:

### **PART 3 - EXECUTION**

#### **3.01 REQUIREMENTS**

- A. General Requirements:
  1. All ties shall be new.
  2. Physical requirements in accordance with the AREMA manual, as modified herein. (Reference the physical requirement criteria as outlined in Chapter 30, Section 3.1.1.4 - decay, holes, knots, shake, split, checks, slope of grain, bark seams and manufacturer defects).
  3. AREMA 7" Grade.
  4. All ties shall be Oak wood species.
  5. Sawed top, bottom and sides.
  6. Free of checks over two inches deep or extending more than eight inches from end of tie.

- B. Anti-splitting devices shall be nail plates in accordance with the AREMA Manual, as modified herein.
1. Minimum size 5 - ½ inches x 7 inches.
  2. Nail plates shall be installed by a method or machine that presses them into the end of the tie. Hammer installation of nail plates is not allowed and will be a cause for the rejection of the ties.
  3. Incise all sides prior to treatment to a depth of 3/4 inch. Thickness of incisor teeth shall not exceed 7/32 inch.
  4. Free of knots greater than ½ inch diameter for areas indicated in the AREMA Manual.
- C. Individual Requirements:
1. Cross ties:
    - a. Length: Eight feet six inches.
    - b. Straightness: A cross tie will be considered straight when a line along a side from the middle of one end to the middle of one end to the other end is everywhere more than 2-3/4 inches from the top and bottom of the tie.
  2. Contact rail ties:
    - a. Length: Ten feet.
    - b. Free of knots greater than ½ inch diameter in area of contact rail insulator, i.e., 100 through 110 inches from line end.
    - c. AREMA Size 5 requirements apply to contact rail insulator area.
    - d. Straightness: A contact rail tie will be considered straight when a line along the tip from the middle of one end to the middle of the other end is everywhere more than two inches from both sides.
  3. Switch ties:
    - a. Switch ties within Special Trackwork, as shown on the drawings.
    - b. Length: As shown in the contract documents.
    - c. Free of knots greater than ½ inch diameter for areas indicated in the AREMA Manual.
    - d. Straightness: A contact rail tie will be considered straight when a line along the top from the middle of one end to the middle of the other end is everywhere more than two inches from both sides.
- D. Preservative Treatment:
1. All timbers shall be bored for screw spikes. The holes shall be treated with copper naphthenate.
  2. Ties shall be treated in accordance with the requirements of AWPA Standard C6 for Cross Ties and Switch Ties. Conditioning prior to treatment shall be in accordance with Paragraph 3.2, Boulton Drying Process, of the above standard.
  3. Immediately following conditioning, the ties shall be pressure treated. Because of the environmental problems and other reasons, alternative preservative used shall be copper naphthenate. The minimum quality control requirements shall be in accordance with AWPA Standard M3. The treating company shall furnish a Certificate of Compliance with this standard, and shall certify the treatment according to the foregoing Specification.
  4. The Authority Engineer will determine when ties are ready for treatment.
  5. Use only tested and approved preservatives.
  6. Stamp each treated tie to indicate compliance with these specifications.
  7. Complete AREMA or AWPA forms for treatment of ties.

**PART 4 - MEASUREMENT AND PAYMENT**

**4.01 MEASUREMENT:**

- A. Measurement of work specified in this section will be made in the following manner:
  - 1. No separate measurement.

**4.02 PAYMENT:**

- A. Compensation for work specified in this section will be in the following manner:
  - 1. Included in the price of the work of which it is a part.

**END OF SECTION**

## SECTION 06131

### COMPOSITE (PLASTIC) TIES

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This section specifies furnishing composite (plastic) cross ties, contact rail ties and switch ties as shown and specified.

##### 1.02 RELATED SECTIONS

- A. Section 05651 - General Track Construction
- B. Section 05652 - Ballasted Track Construction
- C. Section 05654 - Special Trackwork Construction - Ballasted
- D. Section 05659 - Special Trackwork
- E. Section 05660 - Restraining Rail and Lubricators

##### 1.03 REFERENCES

- A. American Railway Engineering and Maintenance-of-Way Association (AREMA), **latest edition:**
  - 1. AREMA Manual for Railway Engineering
  - 2. AREMA Portfolio of Trackwork Plans
  - 3. AREMA Specifications for Ties
- B. ASTM D696
- C. ASTM D6108
- D. ASTM D6109
- E. ASTM D6111
- F. ASTM D6117

##### 1.04 DESIGN REQUIREMENTS

- A. The tie shall be designed to resist rail seat positive, rail seat negative, tie center negative and tie center positive bending moments. Refer to the AREMA Manual (**latest edition**) for design considerations for the composite tie.
- B. Tie design shall be based on American railroad 100 ton capacity freight car and train operations. The Contractor must submit documentation indicating that the plastic or composite railroad tie which is to be provided to the Authority has been successfully tested in such railroad application. The railroad tie shall have safely functioned under railroad conditions without failure.

- C. Anticipated service life of the tie shall be 50 years. Tie shall support the weight and dynamic forces of the rail and trains without failure requiring the tie to be replaced during the anticipated service life.

#### **1.05 SUBMITTALS**

- A. Submittals shall be made on accordance with Section 01300, Submittals
- B. Documentation
  - 1. Proposed method of delivery. Submit to the Engineer at least 60 days prior to delivery.
  - 2. Proposed damage protection and treatment.
- C. The manufacturer shall submit sealed calculations of the design.
- D. The manufacturer shall submit MSDS data for the tie.
- E. The manufacturer shall provide certified test reports, **and any other documents to substantiate certification**, that the ties being provided meet or exceed the specified physical properties.

#### **1.06 QUALITY ASSURANCE**

- A. Inspection:
  - 1. In accordance with pertinent sections of the AREMA Manual as modified herein.
  - 2. Acceptance criteria: Failure to meet any pertinent part of AREMA requirements **(latest edition)** or these specifications constitutes cause for rejection.
  - 3. Averaging of dimensions, with respect to measurement for size acceptance, is not permitted.
  - 4. Provide suitable equipment, facilities and assistance required by the Engineer to effect inspections.
  - 5. Inform the Engineer when composite (plastic) ties are ready for inspection.
  - 6. Do not deliver material until inspected and approved for shipment by the Engineer.
  - 7. Final inspection and approval of composite (plastic) ties will occur as a part of the final inspection of installed ballasted track.
  - 8. **WMATA, or its representatives, reserve the right to visit the producers facility during usual business hours unscheduled to: a) observe sampling and inspection procedures, b) obtain samples of the prepare material being produced and shipped, and c) review plant inspection methods, quality control procedures, equipment and examine inspection test results of current and previous tests.**

#### **1.07 DELIVERY, STORAGE AND HANDLING**

- A. It shall be the Contractor's responsibility to make all arrangements for storage, shipment and handling of the ties.
- B. Ties shall be handled in a manner that prevents damage.
- C. Ties shall not be dropped or dragged on the trackbed.

### **PART 2 - PRODUCTS**

## 2.01 MATERIALS

### A. Properties

1. Composition: plastic composite formulation of foamed, colored, recycled polyolefin plastic reinforced with materials such as fiber glass or styrene. No wood or rubber material over 3% is allowed.
2. Color shall be black.
3. Ties shall not require use of toxic preservatives.
4. Ties shall resist decay and insect attack. Water absorption shall not cause loss of strength requiring the tie to be replaced.
5. Ties shall be non-conductive electrically.
6. Ties shall be non-hazardous and non-leaching.

## 2.02 REQUIREMENTS

### A. General Requirements:

1. All ties shall be new.
2. Physical requirements, design and manufacture: Pertinent sections of the AREMA manual (**latest edition**), as modified herein.
3. Ties shall interact with the ballast and distribute the weight of the train to the underlying roadbed. Tie surface shall provide resistance to lateral movement, equal to or better than a wood tie of the same dimensions.
4. Ties shall hold gauge of track on tangent and curves similar to the wood tie of the same dimensions.
5. Ties shall permit the application of standard rail, tie plate and hold-down fasteners, such as screw spikes or cut spikes, without requiring special procedures for installation other than ordinary predrilling of the tie. The hole diameter shall be of sufficient size to prevent splitting of the tie during installation of the track screw spike but shall not permit the track screw spike to back-out after installation due to vibration from passing trains.
6. Ties shall provide rail seat loading (compression) without failure. Ties shall be stiff enough to support the weight but flexible enough to absorb the vibration of passing trains.
7. All tie surfaces shall be non-skid.
8. Tie surfaces shall have slip resistance equal to or better than a wood tie.
9. Ties shall not be prone to failure due to extreme weather related heat or freezing temperatures.
10. Ties shall not warp or sag to the level of permanent deformation which would require replacement of the tie.
11. Ties shall not require end caps. Ties shall not split or crack requiring the tie to be replaced.
12. Tie surface degradation due to sunlight (UV radiation) exposure shall not exceed 0.003" per year.
13. Tie surface deterioration due to abrasion shall not exceed that of a wood tie.
14. Tie surface flatness in the area of the tie plate, 11" from each end and for a distance of 20", shall be within 0.125".
15. All ties shall have a thickness tolerance +1/8", -0". Width tolerance +/-1/4". Length tolerance +1/2", -0".
16. Ties for installation in ballasted track shall have three (3) sides (two - 7" sides and one - 9" side) knurled to resist lateral movement in the ballast.
17. Straightness: All ties will be considered straight when a line along a side from the middle of one end to the middle of one end to the other end is everywhere more than 2-3/4 inches from the top and bottom of the tie.
18. **Ties should not split or crack in anyway requiring the tie to be replaced.**

19. Material surface degradation due to solar ultraviolet (UV) radiation exposure shall not exceed 0.003 inch (0.076 mm) per year.

- B. Individual Requirements:
1. Cross ties:
    - a. Length: Eight feet six inches.
  2. Contact rail ties:
    - a. Length: Ten feet.
    - b. AREMA Size 5 requirements apply to contact rail insulator area.
  3. Switch ties:
    - a. Switch ties within Special Trackwork, as shown on the drawings.
    - b. Length: As shown.

**2.03 TESTING AND TECHNICAL DATA**

- A. Mechanical Properties and Test Method
1. Composite railroad tie samples shall be tested per the appropriate ASTM test standards for the mechanical properties listed in the table below by an independent testing agency.
  2. Actual test results shall be submitted on a form similar to Exhibit A.
  3. The typical values shown in the following table represent anticipated material parameters based on "as manufactured" plastic tie specimens measuring 7"x 9" or 4'x 6" in cross-section. Strength values shown are at failure. Design allowable values shall have a minimum factor of safety against failure of 2.5.

Mechanical Properties/Test Method	Typical Value	Size of Test Specimen
Specific Gravity ASTM D6111-97	0.90	7" x 9"
Density - ASTM D6111-97	45.0 lbs. per cu ft	7" x 9"
Coefficient of Thermal Expansion - ASTM D696-91	0.00007 in/in per degree F (Max.)	7" x 9"
Compressive Strength - ASTM D6108-97 (Compression Parallel to Grain)	3,000 psi minimum	4" x 6"
Compressive Strength - ASTM D6108-97 (Compression Perpendicular to Grain)	1,000 psi minimum	7" x 9"
Permanent Deformation Under Load ASTM D6108-97 (Compression Perpendicular to Grain)	0.0015 inch (Max.)	7" x 9"
Modulus of Elasticity (Compression) ASTM D6108-97	170,000 psi minimum	4" x 6"
Flexural Strength - ASTM D6109- 97	2,500 psi minimum	4" x 6"

Modulus of Elasticity (Flexure) ASTM D6109-97	200,000 psi minimum	4" x 6"
Shear Strength - ASTM D6109-97 (Calc.)	1,000 psi minimum	4" x 6"
Mechanical Fasteners - ASTM D6117-97 Screw Spike Pullout	2,500 lbs. minimum	7" x 9"

- B. Rail Seat Compression Test shall be as follows:
1. Test specimen(s) shall be from as manufactured plastic ties with 7" x 9" in cross-section and cut to thirty inches in length.
  2. The tie shall rest on a flat surface, on it's nine inch face, shall be loaded from the top through a one foot section of AREMA 115 RE rail secured to the tie with a Pandrol tie plate and "e" clip and two screw spikes. The Pandrol tie plate shall be 7 3/4" by 14 7/8" dimension (standard dimensional tolerances apply). The tie plate shall be centered on the plastic tie segment in a Universal Test Machine (200,000 pound hydraulic).
  3. The head of the rail shall be loaded in 10,000 pound increments beginning at 70,000 pounds.
  4. Loading shall increase until tie failure or deformation of 0.125 inches.
  5. The load at failure shall be recorded and the compressive (bearing) stress under the tie plate shall be calculated using the tie plate dimension.
  6. Deformation to the tie shall be measured and recorded. Tie deformation shall not exceed 0.125 inches.
- C. Permanent Deformation Under Load Test:
1. Test specimen(s) shall be from as manufactured plastic ties with a 7" x 9" cross-section and cut to thirty inch length.
  2. The tie shall rest on a flat surface, on it's nine inch face, shall be loaded from the top thru a one foot section of AREMA 115 RE rail secured to the tie with a Pandrol tie plate and "e" clip and two screw spikes. The Pandrol tie plate shall be 7 3/4" by 14 7/8" dimension (standard dimensional tolerances apply). The tie plate shall be centered on the plastic tie segment in a Universal Test Machine (200,000 pound hydraulic).
  3. The head of the rail shall be loaded for one hour at each 5,000 pound increment
  4. Unload the rail and record the amount of permanent deformation.
  5. The permanent deformation after the load is removed shall not exceed 0.0015 inches.
  6. Screw spike withdrawal resistance testing:
  7. Standard uncoated Style "U" track screw spike, 3/4" diameter, 5-1/2" length and 1/4" end taper.
  8. Predrilling of the crosstie shall be permitted. The hole diameter shall be of sufficient size to prevent splitting of the tie during installation of the track screw spike but shall not permit the track screw spike to back-out after installation due to vibration from passing trains.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. The composite (plastic) ties shall be installed in compliance with the Ballasted Track Construction: Section 05652.

## **PART 4 - MEASUREMENT AND PAYMENT**

### **4.01 MEASUREMENT**

- A. Measurement of work specified in this section will be made in the following manner:
  - 1. No separate measurement.

### **4.02 PAYMENT**

- A. Compensation for work specified in this section will be in the following manner:
  - 1. Included in the price of the work of which it is a part.

**EXHIBIT A**

**SAMPLE OF MECHANICAL PROPERTIES TABLE**

PROPOSAL INCLUDES MECHANICAL PROPERTIES TABLE TO BE FILLED WITH  
TEST RESULT VALUES BY SUPPLIER

**MECHANICAL PROPERTIES TABLE - VALUES TO BE WRITTEN BY SUPPLIER**

<b>Mechanical Properties/Test Method</b>	<b>Typical Value</b>	<b>Size of Test Specimen</b>
Specific Gravity - ASTM D6111-97	<b>VALUES TO BE WRITTEN BY SUPPLIER</b>	7" x 9"
Density - ASTM D6111-97		7" x 9"
Coefficient of Thermal Expansion -ASTM D696-91		7" x 9"
Compressive Strength - ASTM D6108-97 (Compression Parallel to Grain)		4" x 6"
Compressive Strength - ASTM D6108-97 (Compression Perpendicular to Grain)		7" x 9"
Permanent Deformation Under Load ASTM D6108-97 (Compression Perpendicular to Grain)		7" x 9"
Modulus of Elasticity (Compression) ASTM D6108-97 (170,000 psi minimum)		4" x 6"
Flexural Strength - ASTM D6109-97		4" x 6"
Modulus of Elasticity (Flexure) ASTM D6109-97		4" x 6"
Shear Strength - ASTM D6109-97 (Calc.)		4" x 6"
Mechanical Fasteners - ASTM D6117-97 Screw Spike Pullout		7" x 9"

**END OF SECTION**

## SECTION 06132

### TIMBER GRADE CROSSINGS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. The section specifies furnishing solid timber panel grade crossings as shown on the Contract Drawings. Solid timber panel grade crossings shall be in accordance with the current requirements of the AREMA "Guidelines for the Construction or Reconstruction of Highway - Railway Crossings" except as modified herein.

##### 1.02 RELATED SECTIONS

- A. General Track Construction: Section 05651
- B. Ballasted Track Construction: Section 05652

##### 1.03 REFERENCES

- A. American Railway Engineering and Maintenance-of-Way Association (AREMA), **latest edition**:
  - 1. AREMA Manual for Railway Engineering
  - 2. AREMA Portfolio of Trackwork Plans
  - 3. AREMA "Guidelines for the Construction or Reconstruction of Highway - Railway Crossings"
  - 4. AREMA Specification for Preservatives
  - 5. AREMA Specification for Treatment
  - 6. AREMA Records of Treatment and Reports of Inspection
- B. American Wood Preserver 's Association (AWPA)
  - 1. AWPA Standard C6
  - 2. AWPA Standard M3

##### 1.04 SUBMITTALS

- A. Submittals shall be made on accordance with Section 01300, Submittals
- B. Documentation
  - 1. Proposed method of delivery. Submit prior to delivery.
  - 2. Proposed anti-splitting devices and location in timbers.
  - 3. Proposed manner of marking treated timbers to indicate compliance with specifications.
  - 4. Certificate of Compliance with AWPA Standard M3 for timber treatment.

##### 1.05 QUALITY ASSURANCE

- A. Inspection:
  - 1. In accordance with pertinent sections of the AREMA Manual (**latest edition**), as modified herein.

2. Acceptance criteria: Failure to meet any pertinent part of AREMA requirements (latest edition) or these specifications constitutes cause for rejection. AREMA inspection requirements are to include, but not limited to, the physical requirement inspection criteria (decay, holes, knots, shake, split, checks, slope of grain, bark seams and manufacturer defects).
3. Averaging of dimensions, with respect to measurement for size acceptance, is not permitted.
4. Provide suitable equipment, facilities and assistance required by the Engineer to effect inspections.
5. Inform the Engineer when treated wood is ready for inspection.
6. Do not deliver material until inspected and approved for shipment by the Engineer.
7. Final inspection and approval of ties will occur as a part of the final inspection of installed ballasted track.
8. WMATA, or its representatives, reserve the right to visit the producers facility during usual business hours unscheduled to: a) observe sampling and inspection procedures, b) obtain samples of the prepare material being produced and shipped, and c) review plant inspection methods, quality control procedures, equipment and examine inspection test results of current and previous tests.

## **PART 2 - PRODUCTS**

### **2.01 GENERAL REQUIREMENTS**

- A. Furnish timbers in accordance with the requirements, as specified in this section:
- B. Crossing timbers shall be sawed, treated oak made into panels approximately 8 feet in length. Field side sections shall be 20 inches wide consisting of two 10 inch timbers and gauge side sections shall be 25-1/2 inches wide consisting of three 8-1/2 inch timbers.
- C. Each gauge section shall have a filler block of such size and shape as to provide a snug fit against the rail web and a flangeway 2-1/2 inches wide and 3 inches deep.
- D. Each section shall be made up using three 3/4 inch spiral dowel pins.
- E. Each section shall have 8 holes for use in anchoring the section to the ties with lag screws. These holes shall be 13/16 inches in diameter and shall have a 2-5/8 inches counter bore 1-1/4 inches deep in the top side.
- F. Each section shall be anchored in place with 10 inches long, 3/4 inch diameter lag screws. After the lag screw is in place, the counter bore shall be filled with a mastic material.
- G. Sections shall be full depth with the top surface in the plane of the top of rail and the bottom of the section resting directly on the cross tie.

## **PART 3 - EXECUTION**

### **3.01 REQUIREMENTS**

- A. The Contractor shall construct the crossings as shown on the Contract Drawings.
- B. Grade crossing track shall be ballasted track using standard AREMA Tie Plates, Plan No. 8, Punching A and Cut Spikes, with ties spaced at 19-1/4 inch centers.

- C. Prior to place timbers, grade crossing track shall be brought to final alignment and grade within the tolerances for ballasted yard and secondary track as specified in Section 05651, General Track Construction.
- D. Ballast shall be added to provide full cribs and level shoulders.
- E. Ties shall be swept clean of all loose ballast and debris prior to placing timbers. The timbers shall then be properly located, so that the heart wood will be on the bottom side.
- F. No shims shall be used between timbers and cross ties.
- G. The outside ends of end timbers shall be beveled. The bevel shall have dimensions of 4 inches measured horizontally and vertically.
- H. All bored holes and bevels shall be treated with pentachlorophenol or creosote immediately after boring and beveling.
- I. Two field sections and two gauge sections shall constitute one grade crossing panel.

#### **PART 4 - MEASUREMENT AND PAYMENT**

##### **4.01 MEASUREMENT:**

- A. Measurement of work specified in this section will be made in the following manner:
  - 1. No separate measurement.

##### **4.02 PAYMENT:**

- A. Compensation for work specified in this section will be in the following manner:
  - 1. Included in the price of the work of which it is a part.

**END OF SECTION**

## SECTION 06402

### INTERIOR ARCHITECTURAL WOODWORK

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This Section specifies providing wood cabinets, plastic-laminate cabinets, wood countertops, plastic-laminate countertops, solid-surfacing-material countertops.
  - 1. Related Work Specified Elsewhere:
    - a. Rough Carpentry: Section 06100.
    - b. Seals and Sealants: Section 07900.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
- B. Product Data: For each type of product indicated, including cabinet hardware and accessories, and finishing materials and processes.
- C. Shop Drawings: Show location of each item, dimensioned plans and elevations, large-scale details, attachment devices, and other components.
  - 1. Show locations and sizes of furring, blocking, and hanging strips, including concealed blocking and reinforcement specified in Section 06100.
  - 2. Show locations and sizes of cutouts and holes for installed in architectural woodwork.
- D. Samples for Initial Selection: Manufacturer's color charts consisting of units or sections of units showing the full range of colors, textures, and patterns available for each type of material indicated.
  - 1. Plastic laminates.
  - 2. Solid-surfacing materials.
- E. Samples for Verification: For the following:
  - 1. Plastic-laminate-clad panel products, 8 by 10 inches, for each type, color, pattern, and surface finish.
  - 2. Solid-surfacing materials, 6 inches square.
  - 3. Exposed cabinet hardware and accessories, one unit for each type.
- F. Certification: Signed by manufacturers of woodwork certifying that products furnished comply with requirements.
- G. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. AWI: Section 400 & 700, AGS.

3. Builders Hardware Manufacturer's Association (BHMA): A156.9, A256.11, A156.18, B01361, B01521, B02011, B03141, B04071, B04081, B04013, B05091, E07121, E7041, 613, 630, 640
  4. ANSI A208.2, Z124.3
  5. NEMA LD 3.
- B. Installer Qualifications: An experienced installer who has completed architectural woodwork similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.
- C. Fabricator Qualifications: A firm experienced in producing architectural woodwork similar to that indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.
- D. Quality Standard: Unless otherwise indicated, comply with AWI's "Architectural Woodwork Quality Standards" for grades of interior architectural woodwork, construction, finishes, and other requirements.
1. Provide AWI Quality Certification Program certificate indicating that woodwork complies with requirements of grades specified.

#### **1.04 DELIVERY, STORAGE, AND HANDLING:**

- A. Do not deliver woodwork until painting and similar operations that could damage woodwork have been completed in installation areas. If woodwork must be stored in other than installation areas, store only in areas where environmental conditions comply with requirements specified in "Project Conditions" Article.

#### **1.05 PROJECT CONDITIONS:**

- A. Environmental Limitations: Do not deliver or install woodwork until building is enclosed, wet work is complete, and HVAC system is operating and maintaining temperature and relative humidity at occupancy levels during the remainder of the construction period.
- B. Field Measurements: Where woodwork is indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.
1. Locate concealed framing, blocking, and reinforcements that support woodwork by field measurements before being enclosed and indicate measurements on Shop Drawings.
  2. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating woodwork without field measurements. Provide allowance for trimming at site, and coordinate construction to ensure that actual dimensions correspond to established dimensions.

#### **1.06 COORDINATION:**

- A. Coordinate sizes and locations of framing, blocking, furring, reinforcements, and other related units of Work specified in other Sections to ensure that interior architectural woodwork can be supported and installed as indicated.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS:**

- A. General: Provide materials that comply with requirements of the AWI quality standard for each type of woodwork and quality grade specified, unless otherwise indicated.
- B. Wood Products: Comply with the following:
  - 1. Medium-Density Fiberboard: ANSI A208.2, Grade MD-Exterior Glue.
- C. High-Pressure Decorative Laminate: NEMA LD 3, grades as indicated, or if not indicated, as required by woodwork quality standard.
  - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering high-pressure decorative laminates that may be incorporated into the Work include, but are not limited to, the following:
    - a. Formica Corporation.
    - b. International Paper; Decorative Products Div.
    - c. Wilsonart International; Div. of Premark International, Inc.
- D. Adhesive for Bonding Plastic Laminate: Unpigmented contact cement.
- E. Solid-Surfacing Material: Homogeneous solid sheets of filled plastic resin complying with material and performance requirements in ANSI Z124.3, for Type 5 or Type 6, without a precoated finish.
  - 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
    - a. Corian; DuPont Polymers.
    - b. Surell; Formica Corporation.
    - c. Fountainhead; International Paper, Decorative Products Div.
    - d. Gibraltar; Wilsonart International, Div. of Premark International, Inc.

### **2.02 CABINET HARDWARE AND ACCESSORIES:**

- A. Butt Hinges: 2-3/4-inch, 5-knuckle steel hinges made from 0.095-inch- thick metal, and as follows:
  - 1. Semiconcealed Hinges for Flush Doors: BHMA A156.9, B01361.
  - 2. Semiconcealed Hinges for Overlay Doors: BHMA A156.9, B01521.
- B. Back-Mounted Pulls: BHMA A156.9, B02011.
- C. Wire Pulls: Back mounted, 5 inches long, 2-1/2 inches deep, and 5/16 inches in diameter.
- D. Catches: Magnetic catches, BHMA A156.9, B03141.
- E. Adjustable Shelf Standards and Supports: BHMA A156.9, B04071; with shelf rests, B04081.
- F. Shelf Rests: BHMA A156.9, B04013.
- G. Drawer Slides: Side-mounted, full-extension, zinc-plated steel drawer slides with steel ball bearings, BHMA A156.9, B05091, and rated for the following loads:
  - 1. Box Drawer Slides: 100 lbf.
  - 2. File Drawer Slides: 200 lbf.
- H. Door Locks: BHMA A156.11, E07121.

- I. Drawer Locks: BHMA A156.11, E07041.
- J. Grommets for Cable Passage through Countertops: 2-inch OD, black, molded-plastic grommets and matching plastic caps with slot for wire passage.
- K. Exposed Hardware Finishes: For exposed hardware, provide finish that complies with BHMA A156.18 for BHMA finish number indicated. Dark, Oxidized, Satin Bronze, Oil Rubbed: BHMA 613 for bronze base; BHMA 640 for steel base; match Architect's sample.
  - 1. Satin Stainless Steel: BHMA 630.
- L. For concealed hardware, provide manufacturer's standard finish that complies with product class requirements in BHMA A156.9.

### **2.03 INSTALLATION MATERIALS:**

- A. Furring, Blocking, Shims, and Hanging Strips: Softwood or hardwood lumber, kiln-dried to less than 15 percent moisture content.
- B. Anchors: Select material, type, size, and finish required for each substrate for secure anchorage. Provide nonferrous-metal or hot-dip galvanized anchors and inserts on inside face of exterior walls and elsewhere as required for corrosion resistance. Provide toothed-steel or lead expansion sleeves for drilled-in-place anchors.

### **2.04 FABRICATION, GENERAL:**

- A. Interior Woodwork Grade: Provide [**Premium**] [**Custom**] grade interior woodwork complying with the referenced quality standard.
- B. Wood Moisture Content: Comply with requirements of referenced quality standard for wood moisture content in relation to ambient relative humidity during fabrication and in installation areas.
- C. Complete fabrication, including assembly, finishing, and hardware application, to maximum extent possible, before shipment to Project site. Disassemble components only as necessary for shipment and installation. Where necessary for fitting at site, provide ample allowance for scribing, trimming, and fitting. Retain subparagraph below if Architect will visit woodwork shop and examine work before it is shipped to Project site.
- D. Shop cut openings, to maximum extent possible, to receive hardware, appliances, plumbing fixtures, electrical work, and similar items. Locate openings accurately and use templates or roughing-in diagrams to produce accurately sized and shaped openings.

### **2.05 PLASTIC-LAMINATE CABINETS AND COUNTERTOPS:**

- A. Quality Standard: Comply with AWI Section 400 requirements for laminate cabinets.
- B. AWI Type of Cabinet Construction: Flush overlay.
- C. Laminate Cladding for Exposed Surfaces: High-pressure decorative laminate complying with the following requirements:
  - 1. Horizontal Surfaces Other Than Tops: HGS.
  - 2. Vertical Surfaces: HGS.
  - 3. Edges: HGS.

- D. Materials for Semiexposed Surfaces: Provide surface materials indicated below:
  - 1. Surfaces Other Than Drawer Bodies: Thermoset decorative overlay.
- E. Colors, Patterns, and Finishes: Provide materials and products that result in colors and textures of exposed laminate surfaces complying with the following requirements:
  - 1. Provide selections from laminate manufacturer's full range of colors and finishes in the following categories:
    - a. Solid colors.
    - b. Patterns.

## **2.06 SOLID-SURFACING-MATERIAL COUNTERTOPS:**

- A. Quality Standard: Comply with AWI Section 400 requirements for countertops.
- B. Solid-Surfacing-Material Thickness: 3/4 inch.
- C. Colors, Patterns, and Finishes: Provide materials and products that result in colors of solid-surfacing material complying with the following requirements:
  - 1. Provide selections from manufacturer's full range of colors and finishes.
- D. Fabricate tops in one piece with shop-applied backsplashes and edges, unless otherwise indicated. Comply with solid-surfacing-material manufacturer's written recommendations for adhesives, sealers, fabrication, and finishing.
- E. Drill holes in countertops for plumbing fittings in shop.

## **PART 3 - EXECUTION**

### **3.01 PREPARATION:**

- A. Condition woodwork to average prevailing humidity conditions in installation areas before installation.
- B. Before installing architectural woodwork, examine shop-fabricated work for completion and complete work as required, including removal of packing and backpriming.

### **3.02 INSTALLATION:**

- A. Quality Standard: Install woodwork to comply with AWI Section 1700 for the same grade specified
- B. Install woodwork level, plumb, true, and straight. Shim as required with concealed shims. Install level and plumb (including tops) to a tolerance of 1/8 inch in 96 inches.
- C. Scribe and cut woodwork to fit adjoining work, and refinish cut surfaces and repair damaged finish at cuts.
- D. Cabinets: Install without distortion so doors and drawers fit openings properly and are accurately aligned. Adjust hardware to center doors and drawers in openings and to provide unencumbered operation. Complete installation of hardware and accessory items as indicated.
  - 1. Install cabinets with no more than 1/8 inch in 96-inchsag, bow, or other variation from a straight line.

2. Fasten wall cabinets through back, near top and bottom, at ends and not more than 16 inches o.c. with No. 10 wafer-head screws sized for 1-inch penetration into wood, blocking, or hanging strips.
- E. Countertops: Anchor securely by screwing through corner blocks of base cabinets or other supports into underside of countertop.
1. Align adjacent solid-surfacing-material countertops and form seams to comply with manufacturer's written recommendations using adhesive in color to match countertop. Carefully dress joints smooth, remove surface scratches, and clean entire surface.
  2. Install countertops with no more than 1/8 inch in 96-inch sag, bow, or other variation from a straight line.
  3. Secure backsplashes to walls with adhesive.
  4. Caulk space between backsplash and wall with sealant specified in Section 07900.

### **3.03 ADJUSTING AND CLEANING**

- A. Repair damaged and defective woodwork, where possible, to eliminate functional and visual defects; where not possible to repair, replace woodwork. Adjust joinery for uniform appearance.
- B. Clean, lubricate, and adjust hardware.

**END OF SECTION**

**DIVISION 7 - THERMAL AND MOISTURE PROTECTION**

07110	DAMPPROOFING
07125	MEMBRANE WATERPROOFING
07137	TUNNEL WATERPROOFING (TWO-PASS SYSTEM)
07138	TUNNEL WATERPROOFING (NATM SYSTEM)
07165	METALLIC WATERPROOFING
07170	BENTONITE WATERPROOFING
07180	TRAFFIC COATINGS
07210	BUILDING INSULATION
07411	SHEETMETAL ROOFING SYSTEMS
07515	BUILT-UP ROOFING
07553	SELF-ADHERING MODIFIED BITUMINOUS MEMBRANE WATERPROOFING
07600	FLASHING AND SHEET METAL
07730	ROOF ACCESSORIES
07815	SPRAYED FIREPROOFING
07841	FIRESTOPPING
07900	SEALS AND SEALANTS

**END OF SECTION**

## SECTION 07110

### DAMPPROOFING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing dampproofing.
- B. Related Work Specified Elsewhere:
  - 1. Cast-in-Place Structural Concrete: Section 03300.
  - 2. Cast-in-Place Architectural Concrete: Section 03331

##### 1.02 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Product data for each type of product specified, including data substantiating that materials comply with requirements for each dampproofing material specified. Include recommended method of application, recommended primer, number of coats, coverage or thickness, and recommended protection course.
- B. Certification:
  - 1. Certification that materials furnished meet specified requirements and are compatible with each other.
  - 2. Certification by dampproofing manufacturer that products supplied comply with local regulations controlling use of volatile organic compounds (VOCs).

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Codes and regulations of the jurisdictional authorities.
  - 2. ASTM: D41, D449.
- B. Demonstration Area:
  - 1. Prepare 100-square foot specimen of typical dampproofing application using specified methods and materials.
  - 2. Location of demonstration area as directed. Dampproofing will be visually and physically examined by the Engineer.
  - 3. If demonstration area is disapproved, prepare additional demonstration area. Do not proceed with dampproofing until demonstration area has been approved. Approved demonstration area will serve as the standard of quality and workmanship for dampproofing work specified in this section.
- C. Installer Qualifications: Engage an experienced Installer who has completed bituminous dampproofing similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.

##### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver products to the jobsite in their original unopened containers clearly labeled with manufacturer's name, brand designation, referenced specification number, type and class, as applicable.
- B. Store products in approved dry area, protected from contact with soil and from exposure to the elements. Keep products dry.

- C. Handle products so as to prevent breakage of containers and damage to products.

**1.05 JOB CONDITIONS:**

- A. Environmental Requirements:
  - 1. Application of dampproofing to unprotected surfaces in wet weather or to surfaces on which ice, frost, water or dampness is visible is prohibited.
  - 2. Application of dampproofing when ambient temperature is below 40F is prohibited.
- B. Substrate: Proceed with dampproofing only after substrate construction and penetrating work have been completed.

**PART 2 - PRODUCTS**

**2.01 MATERIALS:**

- A. Asphalt Primer: ASTM D41.
- B. Asphalt: ASTM D449, Type A.
- C. Portland Cement Grout: Section 04050.

**PART 3 - EXECUTION**

**3.01 PREPARATION:**

- A. Do not start dampproofing until requirements for curing concrete have been completed and surfaces have thoroughly dried.
- B. Clean surfaces to be dampproofed of loose and foreign material, concrete fins and dirt.
- C. Moisten and point holes, honeycombs, cracks, cavities and concrete fill with portland cement grout and allow to cure completely before covering. See Section 03300 for curing and protection.

**3.02 APPLICATION:**

- A. Apply dampproofing, consisting of two prime coats and one seal coat of dampproofing materials, to surfaces shown to receive dampproofing.
  - 1. Apply two coats of primer to surfaces to be dampproofed at rate of one gallon per 100 square feet. Allow first coat to dry thoroughly before second coat is applied.
  - 2. Do not heat prime-coat material for application.
  - 3. After second prime coat has thoroughly dried, brush one coat of hot asphalt as applicable over primed surface at minimum rate of 15 pounds per 100 square feet of surface; fill cracks, voids and crevices.
  - 4. Do not heat asphalt in excess of 400F.
  - 5. Apply dampproofing coat so as to ensure continuous surface free of dull or porous spots. Give dull or porous spots additional coating of hot asphalt.
  - 6. Perform finished work to conform to dimensions shown; do not disfigure other areas or parts of structure by dripping or spreading of materials.

**3.03 PROTECTING AND CLEANING:**

- A. Protect finish work during application of dampproofing and repair damage.

- B. Remove spots and spattering of the damproofing from finish work and leave the entire work area in first-class condition.
- C. Remove damproofing rubbish from the premises and leave spaces in broom-clean condition.

**END OF SECTION**

## SECTION 07125

### MEMBRANE WATERPROOFING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing fluid-applied membrane waterproofing, rubberized-asphalt sheet membrane waterproofing and protection courses.
- B. Related Work Specified Elsewhere:
  - 1. Cast-in-Place Structural Concrete: Section 03300.
  - 2. Cast-in-Place Architectural Concrete: Section 03331.
  - 3. Brick: Section 04215.
  - 4. Concrete block: Section 04220.
  - 5. Mortar: Section 04050.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Product Data: Include manufacturer's written instructions for evaluating, preparing, and treating substrate, technical data, and tested physical and performance properties of waterproofing.
  - 2. Shop Drawings: Show locations and extent of waterproofing. Include details for substrate joints and cracks, sheet flashings, penetrations, inside and outside corners, tie-ins to adjoining waterproofing, and other termination conditions.
    - a. Include joint and anchorage details, materials and description of sequence of operation.
  - 3. Samples: Four of each type of the following materials used in the work:
    - a. Membrane: 12 inches square.
    - b. Adhesive: Half-pint containers.
    - c. Butyl gum tape: Small rolls.
    - d. Hardboard: 12 inches square.
    - e. Protection board: 12 inches square.
- B. Certification:
  - 1. Certification that materials furnished meet specified requirements and are compatible with each other.
  - 2. Certification that the applicator is approved by the manufacturer.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. American Hardboard Association Industry: AHAI Standard 1.
  - 3. FS: TT-S-230.
  - 4. ASTM: A123, C42, C78, C90, C171, C192, C272, C293, E96, D41, D146, D226, D412, D449, D572, D638, D790, D1621, D1668, D4586, E96, E154.
- B. Qualifications of Waterproofing Applicator:
  - 1. Use applicator who is approved by the manufacturer.

2. Employ workers who have had experience in waterproofing of specified type on jobs of similar size and comparable structures. Have approved full-time superintendent or foreman supervise and direct waterproofing operations.
  3. Inform the Engineer of proposed schedules and locations of waterproofing work.
- C. Obtain waterproofing materials, sheet flashings, and protection course through one source from a single manufacturer.
- D. Pre-installation Conference: Conduct conference at Project site. Review requirements for waterproofing, including surface preparation specified under other Sections, substrate condition and pretreatment, minimum curing period, forecasted weather conditions, special details and sheet flashings, installation procedures, testing and inspection procedures, and protection and repairs.

#### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Deliver products to job site in original unopened containers clearly labeled with manufacturer's name and brand designation, referenced specification number, type and class, as applicable.
- B. Store products in approved dry area with roll goods standing on ends. Protect from contact with soil and from exposure to the elements. Keep products dry.
- C. Handle products so as to prevent breakage of containers and damage to products.

#### **1.05 JOB CONDITIONS:**

- A. Environmental Requirements:
1. Application of waterproofing to unprotected surfaces in wet weather or to surfaces on which ice, frost or dampness is visible is prohibited.
  2. Unless otherwise approved, application of waterproofing unless ambient temperature is at least 40F and rising is prohibited.
  3. Maintain rolls of material at a temperature of at least 50F for a period of not less than 24 hours prior to installation.
- B. Provide ventilation in accordance with specified safety requirements.

### **PART 2 - PRODUCTS**

#### **2.01 MATERIALS:**

- A. Asphalt: ASTM D449, Type A.
- B. Asphaltic Primer: ASTM D41
- C. Glass Fabric: ASTM D1668, Type I or III.
- D. Asphalt-Saturated Felt: ASTM D226, Type I.
- E. Asphalt Cement (Asbestos-Free): ASTM D4586.
- F. Waterproof Building Paper: ASTM C171, Regular.

- G. Rubberized-Asphalt Sheet Membrane Waterproofing: Tough, pliable self-adhering waterproofing sheet of polyethylene film, coated on one side with a layer of adhesive-consistency rubberized asphalt, with the following additional requirements:

Characteristic	Value	Test Method
Thickness:		
a. Polyethylene film	4 mils	-
b. Rubberized asphalt	56 mils	-
c. Rubberized asphalt membrane total	60 mils	-
Permeance	0.1 perm	ASTM E96 Method B
Pliability, 180-degree bend over 1/4-inch mandrel at minus 30F	Unaffected	ASTM D146
Peel adhesion, 7 days dry plus 7 days at 120F plus 7 days dry or 7 days wet	5.0 pounds per inch, minimum	FS TT-S-230 Modified
Cycling over crack 15F, crack opened and closed from 0 inches to 1/4 inch	No effect 100 cycles	-
Puncture resistance, membrane	40 pounds minimum	ASTM E154
Tensile strength, membrane	250 pounds per square inch minimum	ASTM D412 Die C Modified

- H. Asphaltic Mastic:
1. Solvent-base, containing synthetic rubber, asphalt and other components, suitable for troweling, as recommended by membrane manufacturer.
  2. Dry-film requirements:
    - a. Aging: No cracking, flowing, crazing, blistering, or delamination when subjected to 192 hours in oxygen bomb at 158F and 300-psi oxygen pressure in accordance with ASTM D572.
    - b. Water permeability: 0.05-perm maximum when applied 1/32-inch thick over kraft paper and tested in accordance with ASTM E96.
    - c. Stress: No cracking or delamination when 1/64-inch thick layer is applied on metal and bent five times 360 degrees at zero F on 1/16-inch mandrel.
- I. Bonding and Joining Materials for Butyl Membrane:
1. Adhesive: For bonding butyl membrane to adjacent surfaces, as recommended by manufacturer of sheeting material.
  2. Butyl compound: Self-vulcanizing for splicing joints in butyl membrane, as recommended by manufacturer.

3. Butyl gum tape: Unvulcanized butyl-gum rubber with polyethylene-backing material for splicing tape, as recommended by membrane manufacturer.
  4. Flexible butyl-sheet rubber for flashings: As recommended by membrane manufacturer and as specified.
- J. Protection Course Materials:
1. Concrete: Section 03300, class as shown.
  2. Concrete block: Section 04220, ASTM C90, Type I.
  3. Common brick: Section 04215, type and grade as shown
  4. Concrete plank: Lightweight, reinforced-concrete plank, tongue-and-groove sides and ends, 16 inches wide, two inches thick, 10 feet long.
  5. Protection board:
    - a. Semi-flexible board, five ply or more, composed of asphaltic core sealed under heat and pressure between two liners of asphalt-saturated kraft paper or felt bonded to independent waterproofing during manufacturing process. Thickness as recommended by manufacturer.
    - b. Extruded, rigid polystyrene-foam board, one-inch thick. Compressive strength 25-psi minimum, ASTM D1621; water absorption 0.1 percent, ASTM C272.
    - c. Portland-cement mortar: Section 04050.
- K. Epoxy-Injection Material for Repair of Leaks: Two-part epoxy-adhesive materials, containing 100-percent solids, having aromatic curing-agent surface M-phenylenediamine and meeting or exceeding the following minimum requirements:
1. Flexure strength: 400 psi in accordance with ASTM D790.
  2. Tensile strength: 1,200 psi in accordance with ASTM D638.
  3. Bond strength: ASTM C293 and as follows:
    - a. Prepare concrete-beam test specimen in accordance with ASTM C192, using concrete mix design for 1-1/2 inch aggregate.
    - b. Break concrete beam in accordance with ASTM C78.
    - c. Bond broken beam using epoxy with bond-line thickness of 20 mils and cure for seven days at constant temperature of 65F.
    - d. After curing, rebreak beam in accordance with ASTM C78.
    - e. Attain specified values of flexure and tensile strength for repaired beam.
    - f. Cores taken for testing in accordance with ASTM C42.
- L. Protection-Board Adhesive: As recommended by the protection-board manufacturer.

## **2.02 WATERPROOFING SYSTEMS:**

- A. Fluid-Applied Membrane System:
1. Asphaltic primer.
  2. Membranes: One of the following:
    - a. Glass fabric.
    - b. Asphalt-saturated felt.
  3. Accessories:
    - a. Asphaltic mastic.
    - b. Asphalt cement.
    - c. Butyl-gum tape.
    - d. Boots.
    - e. Iron clamps and bolts: Hot-dip, galvanized, ASTM A123, Grade 100; ASTM A153 Class A.
- B. Rubberized-Asphalt Sheet Membrane System:
1. Asphaltic primer.

2. Rubberized-asphalt membrane.
3. Accessories:
  - a. Asphaltic mastic.

### **PART 3 - EXECUTION**

#### **3.01 PREPARATION:**

- A. Place membrane waterproofing after concrete has cured as specified in Section 03300 and surface is completely dry.
- B. Keep surfaces thoroughly dry, immediately before and during application of waterproofing.
- C. Should surface of the concrete become temporarily damp, dry surface.
- D. Remove laitance, dust, dirt, projections, oil, grease and other matter by brooming, scraping, air-hosing or combination of such methods. Surface to be approved prior to application of waterproofing material.
- E. Provide one-inch asphaltic mastic cants (fillets) in internal corners.
- F. Prepare preconstructed protection of courses where shown in accordance with recommendations of membrane manufacturer. Fill holes and grooves.
- G. Treat vertical surfaces with trowel coat of asphalt cement to fill pores and irregularities and level low areas to provide smooth surface for application of membrane waterproofing.

#### **3.02 GENERAL INSTALLATION REQUIREMENTS:**

- A. Tightly fit waterproofing to structure without voids or kinks. Upon completion, allow no cuts, holes, pockets, bulges, wrinkles, folds or creases in surfaces of finished waterproofing; if such defects are present, repair by patching as specified. If waterproofing is damaged, punctured or in any way pervious and cannot be effectively patched or repaired, remove and replace to extent necessary to ensure that structure is waterproof.
- B. Mop surfaces to be waterproofed in sections. Begin waterproofing at low point. Allow sufficient fabric for suitable overlap and anchorage at upper edge.
- C. If leaks occur in areas where backfilling has not been placed, cut-out waterproofing and protection and patch as necessary to ensure watertight barrier. Where membrane is inaccessible, stop leaks with epoxy injection.
- D. Cover horizontal surfaces of membrane waterproofing on which backfill is to be placed with portland-cement concrete of class and thickness shown and as specified in Section 03300.
- E. Protect penetrations in membrane, such as pipes, conduits, piles, struts, walers and other braces. Provide sleeves, clamping rings or other approved devices at penetrations and install with counterflashing where shown and mastic tape where needed to ensure watertight joint.
- F. Where shown in concrete floors and roof, fill electrical-bonding notches with asphalt cement finished flush with top of concrete.

### 3.03 FLUID APPLIED MEMBRANE SYSTEM:

- A. General:
1. Approximately 24 hours before first mopping is applied, cover concrete surfaces to be waterproofed with one coat of asphaltic primer at minimum rate of one gallon per 100 square feet. Work primer well into surfaces to achieve uniform coating.
  2. Completely cover concrete surfaces so that no concrete is left exposed. On fabric surfaces, apply mopping sufficiently heavy to conceal weave completely. For each mopping use not less than 4-1/2 gallons per 100 square feet of surface.
  3. Regulate the work so that installed membrane receives final asphalt mopping before end of day. Thoroughly seal laps.
  4. Before applying membrane on exterior of expansion and construction joints, lay strip of waterproof building paper twelve inches wide; extend six inches on each side of joint and secure to surface near edges using approved method.
  5. Do not permit one layer of membrane to touch another layer, or concrete surface; separate each by mopped coat of hot asphalt.
  6. At edges of membrane, insert membrane into reglets as shown and caulk with approved mixture of asphalt cement, or butyl-gum tape and necessary boots to prevent water intrusion between waterproofing and surface being waterproofed.
  7. Where pipes, sleeves for pipes, or drains, penetrate surfaces to be waterproofed, provide synthetic-membrane flashings and two additional plies of membrane extending at least one-foot beyond edge of flashing, set in place with hot moppings of asphalt. Where flashing sleeves are not shown, flash membrane onto pipe or conduit with hot moppings of asphalt and secure with galvanized-iron clamps and bolts or by other approved methods.
- B. Heating of Asphalt:
1. Heat asphalt to flow freely not exceeding 350F; stir frequently to avoid local overheating. Provide heating kettles of quality, number and capacity to service work adequately. Keep spare serviceable burners available at site for immediate replacement of malfunctioning burners. Keep kettleman in attendance during operation to ensure that maximum specified temperatures are not exceeded.
  2. Employ kettle operators experienced in operating and maintaining type of equipment being used. Provide large metal pans at least one-inch deep under kettle to prevent drippings or fuel leaks from falling on prepared concrete or membraned surfaces. Ensure that each kettle is continuously equipped with calibrated thermometer.
  3. Collect strippings from drums daily and remove from site. Set up kettles immediately adjacent to work in progress to reduce carrying distance of hot buckets.
  4. Lower hot asphalt with extreme care to avoid endangering workmen in trench or excavation.
- C. Two-Ply Work:
1. For first strip of membrane, use half-width; for second, use full-width, lapped full width of first strip.
  2. For each succeeding strip, use full-width and overlap so that entire area has two layers of membrane except at joints. Lap joints two inches minimum, producing three plies at such overlaps.
  3. Give entire surface final mopping of hot asphalt. When protective covering is shown, place covering on final mopping of asphalt while still hot.
- D. Three-Ply Work:
1. Proceed as for two-ply work, except use 1/3-width for first strip; for second strip use 2/3-width; and for the third and succeeding strips use full-width. Overlap strips at least two inches, resulting in surface being completely covered by three plies, with four plies at overlaps.

- E. More Than Three-Ply Work:
  - 1. Build in shingle fashion similar to three-ply work by adding as many plies as are shown. In joining membrane waterproofing to waterproofing in place, clean and heat in-place waterproofing before joining new waterproofing to that previously laid and overlap such joints one-foot minimum.
  - 2. At intersections of walls with horizontal surfaces, and at other locations, lap the greater number of plies of membrane over the other plies a minimum of one foot.
  - 3. Reinforce waterproofing at angles and expansion joints and at other locations where membrane may be subjected to unusual strain. Reinforce by means of two additional plies of saturated fabric and alternate moppings of asphalt. At angles between floor and wall provide reinforcing strips of sufficient width to extend six inches minimum on floor and four inches up wall. Extend strips at vertical corners five inches minimum on each side of corner.
  
- F. Patching:
  - 1. Where the Engineer permits patching of defective waterproofing, extend first patching ply 12 inches minimum beyond outermost edge of defective portion.
  - 2. Extend second and each succeeding ply of patch three inches minimum beyond preceding ply.
  - 3. For patch area use at least as many new plies as specified for original membrane.

#### **3.04 RUBBERIZED ASPHALT SHEET MEMBRANE SYSTEM:**

- A. Prime concrete surfaces as recommended by membrane manufacturer. Do not prime surfaces more than 36 hours prior to applying membrane. Allow primer to dry for one hour or until tack-free. Do not prime metal surfaces, but ensure that they are dry and free of grease, oil, dust, rust and other contaminants.
- B. Apply membrane to clean primed surfaces. Lay membrane from low points or drains toward high points in shingle fashion. Overlap each strip 2-1/2 inches minimum and roll down firmly and completely.
- C. Double-cover inside and outside corners with membrane by applying initial strip of minimum 12-inch width centered along axis of corner. Mortar inside corners; round outside corners.
- D. Double-cover construction and control joints with membrane. Apply double thickness of membrane over sealed expansion joints.
- E. Provide troweled bead of asphaltic mastic as recommended by membrane manufacturer to perimeter of membrane placed in each day's operation and to outside edges of membrane after the membrane is placed.
- F. At areas around drains, posts and other protrusions, install double layer of membrane and coat liberally with asphaltic mastic.
- G. Immediately before covering membrane, inspect carefully and patch holes, tears, misaligned or wrinkled seams and other discontinuities with membrane or mastic. Conduct 24-hour flood test with minimum two-inch head of water on horizontal areas. Repair leaks, using methods recommended by membrane manufacturer.
- H. Place specified protection material on membrane within five days after application. Apply material in accordance with manufacturer's written instructions, as shown and as specified.

#### **3.05 PROTECTION OF WATERPROOFED SURFACES:**

- A. Install protection courses as soon as practicable after waterproofing is placed. Do not place loads on exposed membrane waterproofing. Traffic on such exposed membrane waterproofing is prohibited.
- B. Provide temporary protection as required pending installation of permanent protection.
- C. Exercise care in placing protection courses against waterproofing so as not to break, tear, puncture or otherwise damage waterproofing.
- D. Provide protection of waterproofing surfaces as shown and as specified.
  - 1. Concrete: Place concrete protection courses in accordance with the applicable requirements of Section 03300 and as shown.
  - 2. Concrete blocks and common brick: Lay concrete blocks and common brick in portland-cement mortar, as shown and in accordance with the related work sections
  - 3. Concrete plank: Erect concrete plank with tight tongue-and-groove joints as shown.
  - 4. Insulation board:
    - a. Apply protection-board adhesive in accordance with the manufacturer's instructions.
    - b. Fit boards carefully and neatly around pipes and projections and cover up entire surface of waterproofing.
  - 5. Protection board: Affix protection board to membrane surface by butting and taping or lapping and taping in accordance with manufacturer's written instructions and as approved.
  - 6. Backfill: At depths of 10 feet or more from top of structure, excluding reliefs, place layer of sand 12 inches thick over membrane as approved.

### **3.06 REPAIR OF LEAKS:**

- A. Repair areas of concrete which leak, including cracks and other defective areas, and areas where membrane is inaccessible by using injected waterproofing or by repair methods that provide an impervious and watertight envelope around affected areas. Use epoxy-injection method.
  - 1. Epoxy injection:
    - a. Commence epoxy-injection work after embankment or other backfill and waterproofing membrane have been placed to full required height on structure and for minimum distance of thirty feet beyond extent of repair area.
    - b. Install injection work from interior side of repair areas by port-to-port method. Port spacing: Approximately 1-1/2 times thickness of receiving concrete section.
    - c. Preseal intermediate joints to prevent escape of epoxy and complete each repair area for its entire length before commencing work in another area.
    - d. Before proceeding, sweep space in vicinity of joint or crack receiving epoxy and leave in a generally clean condition. Remove dirt, laitance and other loose material from areas receiving epoxy by means of compressed-air jet.
    - e. At joints and cracks, complete in order floors, walls and ceilings. Proceed with work from port-to-port, beginning at one end of joint. Inject epoxy by means of small nozzle held tightly against port. Continue operation until material begins to exude from next port. Repeat operations from port-to-port until entire area has been treated in one continuous operation. Seal ports as necessary to prevent drips or runout.
    - f. Remove ports and finish surface of joints and cracks flush with adjacent concrete surfaces leaving no indentations or evidence of port fittings. Point joint surfaces and remove excess material from adjacent surfaces as necessary to leave joint smooth.

- g. Equip injection pumps with device to positively indicate failure to pump in proper proportions, as well as bypass valves and gauges compatible with pump.
- h. The Engineer may take cores at any location for inspection and testing. When it is determined that epoxy material has not penetrated to sufficient depth or is otherwise unsatisfactory, costs of coring and testing are the responsibility of the Contractor; where tests demonstrate that work is not substandard, costs of coring and testing will be paid by the Authority.
- i. When cores demonstrate that epoxy has penetrated less than 90 percent of crack volume within core, work will be considered defective. Repair defective work by refilling cracks at such locations to achieve at least 90-percent penetration.

**END OF SECTION**

## SECTION 07137

### TUNNEL WATERPROOFING (Two-Pass System)

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing a permanent waterproofing system and associated construction drainage between the initial and the final linings.
- B. Related Work Specified Elsewhere:
  - 1. Subway drainage: Section 02625.
  - 2. Earth tunneling: Section 02415.
  - 3. Precast concrete tunnel lining: Section 02425.
  - 4. Cast-in-place concrete: Section 03300.
  - 5. Miscellaneous metal: Section 05500.
- C. Definitions:
  - 1. Waterproofing: Geomembrane and geotextile installed around the entire circumference of the tunnel (invert and arch) between initial and final linings.
  - 2. Geotextile: Geofabric providing groundwater drainage channel and protection of the geomembrane from sharp object projections of the initial lining.
  - 3. Geomembrane: Synthetic membrane specifically formulated for waterproofing tunnel structure against groundwater pressure.
  - 4. Invert drain: Temporary invert drain pipe
  - 5. Water barrier: Water barriers installed around the entire circumference of tunnel where indicated.
  - 6. Geo-drain filter fabric: Installed at weep holes where indicated.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ASTM: A276, D257, D374, D638, D746, D751, D1777, D2136, D3776, D3787, D4491, D4533, D4632, D4716.
  - 3. NFPA: 701.
- B. Manufacturer's Qualifications:
  - 1. Select a manufacturer who is regularly engaged in the production of similar geomembranes, geotextiles and water barriers.
- C. Supervision and Training:
  - 1. Have manufacturer's representative present during first 10 working days of installation.
  - 2. Execute installation testing under direct supervision of an individual with recent, continuous and successful experience in the installation of tunnel membrane linings.
  - 3. Provide personnel involved in lining installation and testing with training prior to beginning lining installation.
- D. Membrane Protection:
  - 1. Provide method and material to detect damage to geomembrane from final lining reinforcement placement.

### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with additional requirements as specified for each:
  - 1. Material Samples:
    - a. Geomembrane: One square foot.
    - b. Double welded seam: One foot long.
    - c. Geotextile: One square foot.
    - d. Membrane attachment system: Two.
    - e. Water barrier: One foot long, welded to geomembrane.
    - f. Geo-drain filter fabric: One square foot.
  - 2. Manufacturer's Installation Recommendations:
    - a. Storage.
    - b. Handling.
    - c. Installation.
    - d. Seaming.
    - e. Attachment.
    - f. Testing.
    - g. Repair instructions.
    - h. Special instructions for corners and intersections.
    - i. Installation equipment.
    - j. Damage detection method.
  - 3. Manufacturer and Installer Qualifications:
    - a. Evidence of manufacturer and installation qualifications.
    - b. Resume of lining installation supervisors.
  - 4. Certification of compliance with the requirements of this specification.
  - 5. Shop drawings, including as a minimum the following:
    - a. Sheet layout of geomembrane detailing seams.
    - b. Details of seams, form bulkhead protection, attachment assembly for embedded lining items and other construction details.
    - c. Water barrier and geo-drain filter fabrics locations and details attachment.
  - 6. Working drawings including sequence of installation and details of invert drain support.

### 1.04 JOB CONDITIONS:

- A. Install waterproofing only after acceptance of initial lining.
- B. Replace or repair sections of the waterproofing membrane determined to be defective in accordance with geomembrane seam testing or visual inspection.

## PART 2 - PRODUCTS

### 1.01 2.01 MATERIALS:

- A. Geotextile:
  - 1. Non-woven, needle punched, 100 percent polypropylene geotextile of uniform thickness and surface texture.
  - 2. Minimum Physical Properties:

<u>Property</u>	<u>Testing Method</u>	<u>Minimum Specifications</u>
Thickness (mils)	ASTM D1777	285
Unit Weight (oz./sq. yd.)	ASTM D3776	22
Grab Strength (lbs.)	ASTM D4632	285/340
Elongation (percent)	ASTM D4632	85
Trapezoidal Tear (lbs.)	ASTM D4533	135/155
Burst Strength (psi)	ASTM D3787	400
In-Plane Flow Rate (gpm/ft. width)	ASTM D4716	0.04
pH Range	—	2 to 13

- B. Geomembrane:
1. General: Plasticized PVC (PVC-P) waterproofing membrane of uniform surface texture reinforced with woven reinforcing fabric of glass felt.
  2. Physical Properties:

<u>Property</u>	<u>Testing Method</u>	<u>Minimum Specifications</u>
Thickness (inch)	ASTM D751	
Invert		0.118
Arch		0.079
Ultimate Tensile Strength (lbs./sq. in.)	ASTM D638	2000
Ultimate Elongation (percentage)	ASTM D638	
glass-felt-reinforced membrane		200
woven-fabric-reinforced membrane		25
Flammability	NFPA 701	Self Extinguishing
Dielectric Strength (volts/mil.)	ASTM D257	440 to 462
pH Range	—	2 to 13

<u>Property</u>	<u>Testing Method</u>	<u>Minimum Specifications</u>
Low Temperature Bend	ASTM D2136	Pass at minus 40F
Woven Reinforcing Fabric (oz./sq. yd.)	—	13 for woven-fabric-reinforced membrane

- C. Invert Drain:
  1. PVC pipe: Section 02625.
  2. Support: Manufactured of PVC compatible materials.
- D. Attachments: Manufactured of PVC compatible materials, with recess for metal washers and nail.
- E. Water Barriers:
  1. Base seal type water barrier with 6 rib minimum configuration, 1-1/2 inches minimum height, minimum 16 inches wide, manufactured from polyvinyl-chloride plastic compound, compatible with geomembrane.

2. Physical Properties:

<u>Property</u>	<u>Testing Method</u>	<u>Minimum Specifications</u>
Thickness (inch)	ASTM D374	0.125
Ultimate Tensile Strength (lbs./sq. in.)	ASTM D638	2000
Ultimate Elongation (percent)	ASTM D638	300
Low Temperature Impact	ASTM D746	Pass at minus 20F

- F. Geo-Drain Filter Fabric:
  1. BML Enterprises' B-Drain 60 or AKZO Industrial Systems Co.'s Enkadrain Type 9120 or approved equal.
  2. Physical Properties:

<u>Property</u>	<u>Testing Method</u>	<u>Minimum Specifications</u>
Tensile Strength (lbs.)	ASTM D4632	100
Weight (oz./sq.yd.)	ASTM D3776	4.0
Water Flow Rate (gpm/sq. yd.)	ASTM D4491	160

- G. Sponge Rubber: Neoprene, closed cell, minimum 1/4-inch thick, as approved by PVC membrane waterproofing manufacturer.
- H. Neoprene Adhesive: As approved by PVC membrane waterproofing manufacturer.
- I. Batten Plates: Stainless steel, ASTM A276.
- J. Expansion Anchor Bolts: Section 05500, hot-dip galvanized.
- K. Nonshrink Grout: Section 03300.

## **PART 3 - EXECUTION**

### **3.01 INITIAL LINING PREPARATION:**

- A. Repair damaged or spalled areas having a depth of greater than one inch.
- B. Patch or plug recesses left from temporary supports of greater than 1-1/2 inches in diameter or least dimension, installed in initial lining for construction purposes.
- C. Where surface offsets between initial liners exceeds 2-1/2 inches, place cement mortar or bush hammer to provide for a smooth transition from one lining to the next.
- D. Remove sharp points and protrusions.

### **3.02 INVERT DRAIN:** Install as shown.

### **3.03 DRAINAGE FABRIC AND SYNTHETIC MEMBRANE:**

- A. Installation sequence:
  - 1. Installation of geotextile with attachment assembly.
  - 2. Welding of geomembrane of attachments.
  - 3. Welding of seams.
  - 4. Testing.
  - 5. Installation of water barrier and filter fabric.
  - 6. Testing.
- B. Attachment of geotextile membrane:
  - 1. Place attachment assemblies to achieve snug fit of geotextile membrane.
  - 2. Provide minimum of two attachments for 10 square feet of waterproofing in the arch and one attachment per 10 square feet in the invert.
  - 3. Provide additional attachments if required to provide support and fit to initial lining.
- C. Provide sufficient scaffolding to allow inspection of installation.
- D. Overlap materials minimum of three inches to form seams
- E. Use radial seams in typical cross-sections unless otherwise approved.
- F. Provide double seams unless single seams are approved.
- G. Provide second layer of geomembrane welded over single seams. Second layer to completely cover single seams.
- H. Where reinforcement is shown, use approved method to detect damage to geomembrane.
- I. Provide attachment for reinforcement without penetration of the geomembrane.
- J. Ensure flush contact between reinforcement spacers and geomembrane.
- K. Provide minimum 1-1/2 inch clearance between items embedded in final lining and geomembrane, except grout pipes.
- L. After the initial cast-in-place liner has cured, cap the drain pipe.
- M. Provide attachment of water barriers at final cast-in-place liner construction joints at locations shown.

- N. Provide attachment of geo-drain filter fabric at weep hole locations.

**3.04 GEOMEMBRANE SEAM TESTING:**

- A. General:
  - 1. Perform tests in presence of Engineer
  - 2. Perform tests as installation progresses. Before installation continues, repair and retest seams that fail tests.
  - 3. Maintain written record for test results, repairs, and retesting.
- B. Double Seams:
  - 1. Test by applying internal air pressure between seams.
  - 2. Test at 30 psi for 10 minutes.
  - 3. Reject seam if pressure falls below 27 psi.
- C. Single Seams (repairs and circular tunnel-structure interface only):
  - 1. Perform visual inspection while running a rounded screwdriver or similar tool along the joint after the weld has cooled.
- D. Water Barrier Welds: Spark test weld for capability of maintaining dielectric integrity at 2,500 volts minimum.
  - 1. Directly behind each single weld between water barrier and membrane, insert one 18 gauge bare copper wire for testing.
  - 2. Test the full length of the water barrier weld unless directed otherwise by the Engineer.
  - 3. Document the welds tested and the number of defects repaired. Provide documentation to the Engineer.
- E. Replace or repair sections of the membrane determined to be defective at no additional cost to the Authority.

**END OF SECTION**

## SECTION 07138

### TUNNEL WATERPROOFING (NATM SYSTEM)

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies furnishing and installing the permanent waterproofing system for the NATM tunnels installed between the shotcrete and the cast-in-place concrete linings.
- B. Related Work Specified Elsewhere:
  - 1. Subway drainage system: Section 02625.
  - 2. Earth tunneling: Section 02416.
  - 3. NATM excavation: Section 02417.
  - 4. NATM shotcrete lining: Section 02426.
  - 5. Cast-in-place concrete: Section 03300.
  - 6. NATM concrete lining: Section 02427.
- C. Definitions:
  - 1. Tunnel waterproofing: Layered system of geomembrane and geotextile installed around the entire circumference of the tunnel between shotcrete and cast-in-place concrete linings to prevent intrusion of groundwater into the interior of the finished structure.
  - 2. Geotextile: Fabric providing protection of the synthetic membrane from sharp projections of the shotcrete surface to which the membrane is applied.
  - 3. Geomembrane: Synthetic waterproofing membrane specifically formulated for sealing underground structures against intruding groundwater and forming an electrical insulative barrier.
  - 4. Water barrier: Base seal waterstop welded to membrane.
  - 5. Sectioning: Water barriers arranged to seal off individual membrane sections.
  - 6. Weepholes: Pipes typically installed near water barrier intersections and invert to drain water in case of leakage. These pipes are also used for repair in case of leakage by remedial grouting.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ASTM: D257, D374, D638, D1593, D1777, D1785, D3776, D3787, D4533, D4632.
  - 3. NFPA: 701.
- B. Manufacturer's Qualifications:
  - 1. Select manufacturers who are regularly engaged in the production of similar materials for underground structures.
  - 2. Supply and install only products specifically designed and manufactured for this type of work.
- C. Supervision and Training:
  - 1. Execute installation and testing under direct supervision of an individual with recent, continuous and successful experience in the installation of waterproofing systems for underground structures using membrane materials as specified.
  - 2. Provide trained personnel for installation and testing operations. Ensure that the installer has a minimum of five years experience in the installation of flexible

membranes in underground waterproofing installations. Have installer demonstrate proficiency of each welder in the field for respective approval by the Engineer.

- D. Demonstration Section: Before proceeding with waterproofing installation, completely seal a minimum 30-foot-long demonstration section using materials and methods to be used in the work in accordance with specified requirements.

### **1.03 SUBMITTALS:**

- A. Submit the following for approval in accordance with the General Requirements and with additional requirements as specified for each:
1. Shop Drawings: Include as a minimum:
    - a. Sequence of waterproofing installation relative to construction sequence.
    - b. Details of attachment assembly, connections to waterproofing of adjacent structures, break-out structures, waterproofing at penetrations.
    - c. Layout of sectioning by water barriers including detailed location of weep holes.
    - d. Type and method of membrane protection at termination of work.
    - e. Sheet layout of membrane detailing locations and types of seams.
    - f. Manufacturer's Installation Procedures for:
      - 1) Storage.
      - 2) Handling.
      - 3) Seaming.
      - 4) Attachment.
      - 5) Smooth surfaces.
      - 6) Testing.
      - 7) Installation equipment.
      - 8) Detection of physical damage.
      - 9) Methods of local repair.
      - 10) Special instructions for corners and intersections/interfaces.
      - 11) Sequencing of waterproofing installation relative to formwork and concrete placement.
      - 12) Methods and materials used for prevention and detection of damage to the membrane by the above and any other construction equipment and materials.
  2. Samples:
    - a. Geotextile: One square foot.
    - b. Geomembrane: One square foot including double welded seam one foot long.
    - c. Attachment assembly: Three pieces.
    - d. Protective fabric: One square foot.
    - e. Water barrier: One foot length welded to membrane.
  3. Certifications:
    - a. Certification of compliance with the requirements of this specification.
    - b. Resume of waterproofing installation supervisor.

### **1.04 DELIVERY, STORAGE AND HANDLING:**

- A. Deliver materials and products in labeled packages. Store and handle in compliance with manufacturer's instructions, recommendations and material safety data sheets. Place material on a smooth surface free of rocks or other protrusions which may damage the material. Protect from damage from sunlight, weather, excessive temperatures and construction operations. Remove damaged materials from the site and dispose of in accordance with applicable regulations.

- B. Store flammable materials in a cool, dry area distant from sparks and open flames.

**1.05 JOB CONDITIONS:**

- A. Install waterproofing only after surfaces to which geomembrane and geotextile will be applied have been accepted by the waterproofing installer and the Engineer.
- B. Provide sufficient access to allow for thorough inspection.
- C. Repair sections of the waterproofing determined to be defective by testing or which have been damaged during or after installation at no additional cost to the Authority.
- D. Prior to waterproofing installation, prove the absence of continuing and significant deflection or increase of stress.
- E. Drain off water that may be trapped between waterproofing and shotcrete by means of perforated drain pipes or drain mattings.

**1.06 WARRANTY:**

Provide a warranty for the watertightness of the structure for two years beyond the final work completion date.

**PART 2 - PRODUCTS**

**2.01 MATERIALS:**

- A. Geotextile: Non-woven polypropylene geotextile of uniform thickness and surface texture with the following minimum physical properties and testing methods:

<u>Property</u>	<u>Testing Method</u>	<u>Minimum Specifications</u>
Thickness (mils)	ASTM D1777	285
Unit Weight (oz./sq. yd.)	ASTM D3776	22
Grab Strength (lbs.)	ASTM D4632	285
Elongation (percent)	ASTM D4632	85
Trapezoidal Tear (lbs.)	ASTM D4533	35
Burst Strength (psi)	ASTM D3787	400
Chemical Resistance	—	pH value 2 to 13

- B. Geomembrane: Polyvinyl chloride (PVC) waterproofing membrane of uniform thickness and surface texture. PVC membrane non-reinforced with the following minimum physical properties under respective testing methods:

<u>Property</u>	<u>Testing Method</u>	<u>Minimum Specifications</u>
Thickness (inch)	ASTM D374	0.079
Ultimate Tensile Strength (lbs./sq. in.)	ASTM D638	2,200
Ultimate Elongation (percentage)	ASTM D638	230
Low Temperature Impact	ASTM D1593	Pass at minus 20C
Chemical Resistance	—	pH value 2 to 13
Flammability	NFPA 701	Self Extinguishing
Dielectric Strength (volts/mil.)	ASTM D257	440 to 465
Dielectric Constant		
60 Hertz	—	3.4 to 3.5
10 <sup>6</sup> Hertz	—	3.3 to 3.4
Power Factor		
60 Hertz	—	0.006 to 0.007
10 <sup>6</sup> Hertz	—	0.030 to 0.040

- C. Attachments: Membrane attachment disk manufactured of membrane-compatible materials with minimum three-inch diameter with one steel washer embedded in disk. Attachment of discs with minimum 1-1/4 inch nails.
- D. Water Barriers: Continuous strip weldable to membrane with six embedment ribs of the following minimum dimensions: 15-inch minimum width, 1-1/2 inch minimum height. Intersections of water barriers pre-fabricated at workshop on site or by manufacturer.
- E. Protective Concrete: Section 03300, minimum class 2,500 psi, thickness as shown.
- F. Weepholes: Three-inch polyvinyl chloride (PVC) pipe schedule 40, ASTM D1785, length as shown.
- G. Invert Drain:
  - 1. PVC pipe: Section 02625.
  - 2. Support: Manufactured of PVC-compatible materials.

### **PART 3 – EXECUTION**

#### **3.01 PREPARATION OF SURFACE:**

- A. Cut off and patch projecting portions of dowels flush with the face of the shotcrete surface and remove temporary supports and hangers installed in shotcrete lining for construction purposes.
- B. Ensure that embedded elements of the shotcrete lining are covered by at least one inch of shotcrete prior to installing geotextile and sealing membrane.
- C. General Smoothness Criteria: Earth Tunneling, Section 02416.

- D. Apply leveling shotcrete to areas that do not conform with the above requirements. Apply shotcrete in accordance with Section 02426.
- E. Remove loose soil and debris.
- F. Repair damaged or spalled surfaces, voids and cracks having depths greater than one inch with shotcrete, quick setting grout, mortar or equal.
- G. Apply four-inch shotcrete layer at support of excavation walls to which geomembrane and geotextile will be applied at transitions to cut-and-cover structures as shown.
- H. Ensure that surfaces are free of oils, grease and gasolines.

### **3.02 GEOTEXTILE AND GEOMEMBRANE:**

- A. General Installation Sequence:
  - 1. Install geotextile with attachments assembly.
  - 2. Weld geomembrane to attachment assemblies.
  - 3. Weld seams.
  - 4. Test seams.
- B. Installation Area:
  - 1. Place geotextile and geomembrane so as to cover the whole waterproofing area as shown.
  - 2. Use radial seams in typical tunnel cross sections unless otherwise directed.
  - 3. Use longitudinal seams at lap between invert and arch section.
- C. Attachment:
  - 1. Place attachment assemblies in surface depressions to achieve tight fit of geotextile.
  - 2. Provide minimum of four attachments per 10 square feet of waterproofing area.
  - 3. Provide additional attachment where necessary to achieve secure support and snug fit to shotcrete lining.
- D. Geomembrane:
  - 1. Provide double hot-wedge welded seams unless otherwise approved.
  - 2. Single Seams: Where single seams are required and approved, weld second layer of geomembrane to completely cover single seams unless otherwise approved.
  - 3. Prior to placement of concrete, re-inspect membrane for possible damages or other detrimental effects to membrane, such as build-up of water behind the membrane, and perform remedial work as required.
- E. Water Barriers and Weepholes:
  - 1. Install weepholes as shown prior to concrete lining placement.
  - 2. As approved, arrange exact location of weepholes. Following concreting, contact grouting and repair grouting, clean weepholes and grout pipes in roof by approved methods and ensure that pipes are in operating conditions.
  - 3. Document at a minimum the following and submit to the Engineer in form of a table:
    - a. Location of weepholes.
    - b. Location of water barriers and size of selections.
    - c. Date of pipe installation.
    - d. Names and signatures of installer and supervisor of sectioning and weepholes.
    - e. Date of concreting and contact grouting.
    - f. Names of workers and supervisors for respective work.

**3.03 INVERT DRAIN:**

- A. Install as shown.

**3.04 CONCRETE REINFORCEMENT AND OTHER EMBEDDED ITEMS:**

- A. Where reinforcement is placed, use approved methods to detect damage of geomembrane due to installation of reinforcement.
- B. Provide minimum of two inches of clearance between embedded items and geomembrane.
- C. Ensure flush contact between reinforcement spacers and geomembrane.

**3.05 TESTING OF GEOMEMBRANE SEAMS:**

- A. General:
  - 1. Perform tests in the presence of the Engineer.
  - 2. Perform tests as installation progresses. Repair and retest seams that failed before continuing installation.
  - 3. Maintain written records of test results, repairs and retesting.
- B. Double Seams: Perform test by applying internal air pressure between seams as follows:
  - 1. Test Pressure: 30 psi.
  - 2. Performance Requirements: Air pressure loss less than 10 percent after 10 minutes.
- C. Single Seams:
  - 1. Including heat welding to water barriers or special fittings
  - 2. Check welds for continuity by either of the following visual inspections:
    - a. Run a rounded screwdriver along the joint after the weld has cooled.
    - b. Blow stream of air under high pressure against the weld and observe opening of the weld. Re-weld and test any discontinuity.
- D. Replace or repair sections of the membrane determined to be defective at no additional cost to the Authority.

**3.06 LEAK REMEDIATION:**

- A. Monitor structure interior by regular inspection for water leakage until the final work completion date. Beyond this date the structure to be inspected by the Authority.
- B. If water leakage exceeds minimum allowable limits as specified in the watertightness criteria in Section 03300, undertake remedial measures consisting of:
  - 1. Grouting through weepholes using suitable grouts, eg. Silangels, Dynagrout or equal within the area of sectioning.
  - 2. Prior to beginning grouting work, submit grouting plan procedure and sample of grouting materials for approval.
  - 3. Establish injection pressure by means of on-site demonstration. Do not exceed structural capacity of the structure.
- C. Do not penetrate or puncture membrane, except for permanent purposes using proven watertightness techniques as approved.

**END OF SECTION**

## SECTION 07165

### METALLIC WATERPROOFING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing metallic waterproofing.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ASTM: C33, C144, C150.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Include detailed mixing, application and curing procedures from the metallic-waterproofing compound manufacturer.
  - 2. Certification:
    - a. Certification that materials furnished meet specified requirements and are compatible with each other.

##### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver materials to the jobsite in their original unopened containers clearly labeled with manufacturer's name, brand designation, reference specification number, type and class, as applicable.
- B. Store materials in approved dry area and protect from contact with soil and from exposure to the elements. Keep materials dry.
- C. Handle materials so as to prevent breakage of containers and damage to products.

##### 1.05 JOB CONDITIONS:

- A. Environmental Requirements:
  - 1. Application of metallic waterproofing when ambient temperature is below 50F is prohibited.
  - 2. Do not apply metallic waterproofing until surfaces to be treated are enclosed or protected from excessive temperature changes.
  - 3. Keep water level below surface being treated until completion of curing treatment.

#### PART 2 - PRODUCTS

##### 2.01 MATERIALS:

- A. Portland Cement: ASTM C150, Type I.
- B. Sand Aggregate: ASTM C144 for brush coat; ASTM C33 for protective coat.

- C. Water: Potable.
- D. Metallic Waterproofing Compound: Pulverized iron consisting of not less than 85 percent by weight of metallic aggregate with iron-oxide content not exceeding five percent by weight of iron, and chemical oxidizing agent within minimum of three percent and maximum of five percent by weight of compound.
  1. Compound free of oil, paraffin, bitumen and other foreign substances.
  2. Gradation requirements for iron particles:

Sieve Size	Percent Passing By Weight
20	100
30	95 to 100
40	90 to 100
60	65 to 100
100	45 to 70
200	10 to 25

**PART 3 - EXECUTION**

**3.01 PREPARATION:**

- A. Wire brush surfaces to receive metallic-waterproofing treatment down to firm unspalled surfaces; ensure that surfaces are clean and free from loose materials, debris and deleterious substances such as oil and grease.
- B. Strip and clean construction joints, grooved recesses and intersections of vertical and horizontal surfaces; remove loose material.
- C. Install anchorage items prior to application of waterproofing. Except for anchorage items, obtain approval for completed work prior to attachment of utilities to waterproofed surfaces.

**3.02 TEST AREA:**

- A. Prepare 100-square foot specimen of typical waterproofing application using specified methods and materials.
- B. Location of test area as directed. Waterproofing will be visually and physically examined for bond and loose materials by the Engineer.
- C. Failure of waterproofing to bond or appearance of excessive loose materials constitute grounds for rejection of proposed waterproofing materials and method of application. If test area is rejected, remove applied finish leaving base clean and acceptable for new application.
- D. If necessitated by rejection of original test area, provide additional test areas. Do not proceed with waterproofing work until test area has been approved. Leave in place and open to observation as criteria for waterproofing work specified in this section.

**3.03 APPLICATION:**

- A. Pack grooved recesses and intersections of vertical and horizontal surfaces with waterproofing mortar mixed in proportions of one-part portland cement to two parts sand aggregate, with 25 pounds of waterproofing compound added for each sack of cement. Do not use mortar that has been wet-mixed longer than 45 minutes.
- B. Pack mortar into grooves and finish flush with adjacent surfaces. Finish internal angles to a 1/2-inch cove. Brush-coat construction joints with metallic-waterproofing mortar prior to placement of adjoining concrete.
- C. Saturate surfaces, except cut-back or undercut walls, with water and apply a minimum total amount of 30 pounds for three brush-coats of metallic-waterproofing compound per 100 square feet of surface, mixed and applied in accordance with approved procedure.
- D. Saturate cut-back or undercut walls, with water and apply bond coat of metallic-waterproofing compound and water. Fill walls flush and smooth with portland-cement mortar and metallic-waterproofing compound in proportion of ten pounds of compound to each sack of cement. Fill and patch in layers not exceeding 3/4-inch thickness, work into voids, compact and finish flush with adjacent surfaces.
- E. Accomplish waterproofing work so that surface is uniformly oxidized.
- F. After waterproofing vertical surfaces, apply minimum 3/8-inch thick protective coating consisting of one-part portland cement to two and one-half parts sand aggregate, directly over metallic-waterproofing treatment. Float protective coating to smooth level surface.
- G. Moist-cure metallic waterproofing for seven days minimum in accordance with Section 03300.

**3.04 PROTECTING AND CLEANING:**

- A. Protect finish work during application of waterproofing. Repair or replace damaged finish work as directed.
- B. Remove spots and spattering of waterproofing from finish work and leave entire work area in a condition acceptable to the Engineer.
- C. Remove all waterproofing rubbish from premises and leave spaces in broom-clean condition.

**END OF SECTION**

## SECTION 07170

### BENTONITE WATERPROOFING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing bentonite composite sheet membrane waterproofing and waterstop, including accessories and related items.
- B. Related Work Specified Elsewhere:
  - 1. Cast-In-Place Structural Concrete: Section 03300.
  - 2. Cast-In-Place Architectural Concrete: Section 03331.
  - 3. Seals and Sealants: Section 07900.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Samples:
    - a. Three of each type of the following materials used in the work:
      - 1) Composite sheet membrane waterproofing: 12 inches square.
      - 2) Tapes: Two feet long.
      - 3) Fasteners: Sets of 12.
      - 4) Termination bar: Two feet long.
      - 5) Mastic: One pint container.
      - 6) Waterstop material: Two feet long.
      - 7) Granular bentonite: One pound container
      - 8) Polyethylene sheets: 12 inches square.
      - 9) Primer: One pint container.
      - 10) Protection board: 12 inches long.
  - 2. Manufacturer's Certification: Submit written certification, signed by the manufacturer or authorized representative, per the following requirements:
    - a. Prior to the submittal of shop drawings, certify that the waterproofing materials are compatible with the groundwater and soil characteristics. Perform required groundwater and soil testing to confirm compatibility of materials at no additional cost to the Authority. A written report of acceptability or required modifications to the bentonite mix to suit the subsurface conditions is to be submitted by the manufacturer.
    - b. Certify that the submitted shop drawings and installation instructions correctly describe the waterproofing system to be installed.
    - c. Certify that the materials furnished are compatible with each other.
    - d. Prior to installation, certify that the substrate is in an acceptable condition for membrane installation.
    - e. At completion of the installation, certify that the materials used in the work were in accordance with these Specifications, and that they were installed in accordance with the material manufacturer's installation instructions and recommendations.
  - 3. Complete catalogue cuts for each bentonite material used in the work, including manufacturer's installation instructions and data sheets indicating tensile strength, elongation, puncture resistance, resistance to hydrostatic head, pliability, permability and water migration.
  - 4. Manufacturer's Field Report: Submit copies of project inspection reports confirming proper installation of waterproofing system.

5. Shop Drawings: Submit shop drawings, certified as reviewed and approved by the manufacturer, showing waterstop and waterproofing membrane details at penetrations in the membrane (for pipes, conduits, etc.), corners of structures, ends of the membrane, joints in the structure, and interfaces with adjacent structures. Indicate joint or termination detail conditions, and conditions of interface with other materials. Indicate the sequence of installation of the materials.

### **1.03 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
  1. Comply with codes and regulations of jurisdictional authorities.
  2. AASHTO: M171.
  3. ASTM: C272, D146, D226, D412, D449, D543, D638, D751, D781, D1621, D1668, E96, E154.
- B. Qualifications of Applicator:
  1. Furnish evidence from manufacturer that the waterproofing applicator is a qualified applicator of the material to be applied.
- C. Manufacturer
  1. Obtain primary waterproofing materials of each type required from a single manufacturer. Provide secondary materials only as recommended by manufacturer of primary materials.
  2. Arrange for waterproofing system manufacturer to inspect and approve the waterstop and waterproofing membrane installation and to provide job service at no additional cost to the Authority.
  3. Make arrangements with the manufacturer to provide on-site consultation and inspection services to ensure the correct installation of the waterstop and waterproofing membrane at no additional cost to the Authority. Have the manufacturer monitor the waterstop and membrane installation on a full time basis during initial installation period, and at least once a week thereafter, until completion of the waterproofing work.
  4. Have the manufacturer's representative present at the time any phase of the work is started. Apply waterstop and waterproofing membrane only over substrate previously approved by the manufacturer's representative and the Engineer.
  5. Have the manufacturer's representative make periodic visits to the site as work proceeds as necessary for consultation and for expediting the work in the most practical manner.
- D. Preinstallation Conference:
  1. Prior to installation of waterproofing and associated work, meet at project site with waterproofing installer and installers of each component of associated work, including manufacturer's representatives and inspection personnel, to coordinate related requirements with waterproofing work. Review material selections and procedures to be followed in performing work. Perform a sample installation of each of the waterproofing materials. Notify Engineer at least 48 hours before conducting meeting.

### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Deliver products to the job site in their original unopened containers clearly labeled with manufacturer's name, brand designation, type and class, as applicable.
- B. Store products in approved dry area and protect from contact with soil and from exposure to elements. Keep products dry.

- C. Handle products so as to prevent breakage of containers and damage to products.

**1.05 JOB CONDITIONS:**

- A. Environmental Requirements:
  1. Application of waterproofing to surfaces on which ice or frost is visible is prohibited. Keep substrate free of ponded water.
  2. Install and proceed with waterproofing and associated work only when existing and forecasted weather conditions will permit work performance in accordance with manufacturer's recommendations and warranty requirements for specific project requirements.

**1.06 WARRANTY:**

- A. In addition to warranty requirements of the General Provisions, furnish a four-year warranty for a total of five years against defective materials and workmanship.

**PART 2 – PRODUCTS**

**2.01 MATERIALS:**

- A. Polyethylene Sheet: AASHTO M171, clear, eight mils thick, reinforced.
- B. Bentonite Composite Waterproofing Membrane:
  1. Membrane: Multiple component sheet membrane composed of high density polyethylene (HDPE) laminated to bentonite that is coated with a protective layer of spun polypropylene or protected with high-strength woven geotextile. The membrane is to exhibit the following properties:

<u>Property</u>	<u>Test Method</u>	<u>Result</u>
Weight of Sodium Montmorillonite (Bentonite)		one pound per square foot minimum
Thickness of HDPE	—	20 mils
Total thickness of membrane	—	180 mils plus or minus 10 mils
Tensile strength	ASTM D412	4,000 psi
Ultimate elongation	ASTM D638, Type 4	700 percent
Puncture resistance	ASTM E154	160 pounds
Resistance to hydrostatic head; 150 feet of water	ASTM D751 Method A	Zero leakage
Pliability; 180 degree bend over one-inch mandrel at minus 25F; 10,000 cycles	ASTM D146	No cracks
Permeance	Membrane applied	$2.7 \times 10^{-13}$ cm/sec

to porous stone and placed in permeameter. Pressure increased to equivalent of 150 foot water head.

Chemical resistance                      ASTM D543                      No damage

C. Joint Tape:

1. Self-adhering, four-inch wide, minimum 60-mils thick, multi-purpose rubberized asphalt membrane, laminated to a polyethylene film reinforcing. Use for permanently sealing the seams. Compatible with the membrane system used.

<u>Property</u>	<u>Test Method</u>	<u>Result</u>
Tensile strength	ASTM D412C	250 psi
Elongation	ASTM D412C	350 percent
WVT at 80F	ASTM E96B	0.1 maximum gr/sq.ft./hr./in. Hg
Peel adhesion	—	Joint tape is applied over the seams of membrane. Wipe membrane clean and free from dust or moisture.
Pliability	ASTM E96b	Passes at minus 25F
Membrane	ASTM E154	40 pound minimum
Film	ASTM D781	250 inches per ounce
Burial (16 weeks)		unaffected
Hydrostatic head	—	150 feet minimum

D. Termination Bar:

1. Aluminum alloy bar, factory pre-punched, designed for use as termination bar, edge protector or caulk bar for membranes and systems specified.

E. Primer for Tapes and Waterstops:

1. Bonding agent for use as primer at concrete, masonry, metal and wood surfaces and as recommended by manufacturer.

F. Water Barrier Tape:

1. Tape consisting of a layer of bentonite, approximately 3/16-inch thick by one-inch, three-inches and six-inches wide, sandwiched between an open woven mesh and a spun bond polypropylene fabric, with one side coated with pressure sensitive adhesive and release paper.

G. Mastic:

1. Thick compound of expandable mastic containing not less than 55 percent high swelling, Wyoming-type sodium montmorillonite (bentonite) for use at voids, honeycombs, penetrations, tie-backs, cants and similar conditions.

- H. Granular Bentonite:
  - 1. High quality, Wyoming-type, sodium montmorillonite (bentonite), similar to material used in membrane specified above, for use in forming coves and for filling voids during installation of waterproofing systems. Granular, high-swelling Wyoming-type bentonite weighing 60 pounds per cubic foot minimum, and capable of expanding a minimum of 10 times its apparent dry volume when added to water.
  - 2. Granule size: 90 percent minimum passing Size 20 mesh with less than five percent passing Size 200 mesh.
- I. Bentonite Composition Waterstop:
  - 1. Multiple composite waterstop cube, one-inch wide by 3/4-inch high, of laminated sodium montmorillonite (bentonite) reinforced with two layers of polyester netting and non-woven polypropylene, with one side coated with pressure sensitive adhesive and release paper, or a bentonite and butyl rubber based waterstop.
- J. Fasteners:
  - 1. Case hardened nails with enlarged head or caps to hold membrane.
  - 2. Head or cap to be one-inch in diameter, minimum.
  - 3. Fluted shank of appropriate length to fasten waterproofing membrane or joint seal.
- K. Asphalt: ASTM D449, Type A.
- L. Fibrous-Glass Membrane: ASTM D1668, Type I or III.
- M. Asphalt-Saturated Felt: ASTM D226, Type I.
- N. Protection Course Material:
  - 1. Mud slab and concrete protection course: Section 03300, Class 3500.
  - 2. Protection Board:
    - a. Semi-flexible board, five-ply or more, composed of asphaltic core sealed under heat and pressure between two liners of asphalt-saturated kraft paper or felt, bonded to independent waterproofing during the manufacturing process. Thickness as recommended by manufacturer.
    - b. Extruded, rigid polystyrene-foam board, one-inch thick. Compressive strength 25-psi minimum, ASTM D1621; water absorption 0.1 percent, ASTM C272.
- O. Protection Board Adhesive: As recommended by the protection board manufacturer.

## **PART 3 – EXECUTION**

### **3.01 INSPECTION:**

- A. General: Inspect surfaces to receive waterproofing membrane system. Ensure that voids greater than 3/8-inch are filled with grout or with mastic, and that sharp projections are removed.
- B. Do not install membrane or system in standing water. Have accidental water accumulation pumped out and proper drainage ensured. Restore the bentonite waterproofing system if damage occurs. Comply with temperature limitations for each product.
- C. Vacuum or broom clean surfaces to receive tape, adhesive products or primers. Ensure that such surfaces are free of dust, dirt, snow, ice and other contaminants not compatible with applied products.

### 3.02 PREPARATION:

- A. Layout: Layout project to determine anticipated conditions prior to start of work. Note termination and penetration conditions and determine preferred methods for creating waterproof envelope.
- B. Voids: Fill voids greater than 3/8-inch with mastic and remove sharp projections in substrate.
- C. Coves: Form coves, one-inch to two-inches, with granular bentonite at intersections of walls and footings. Form coves with mastic at vertical inside corners, under ledges and at penetrations.
- D. Priming: Prime surfaces immediately prior to application of tapes and waterstops with specified primer. Prime surfaces, including concrete, masonry, metal and wood, to properly prepare areas to receive waterstop, taped applications and terminations.

### 3.03 INSTALLATIONS:

- A. General: Conform to manufacturer's installation instructions and the following: If the waterproofing membrane is damaged during installation, overlap the damaged area with another piece of waterproofing membrane, providing the minimum overlap around the damaged area per the manufacturer's recommendations. Fasten the overlap piece of membrane and seal along its edges per the manufacturer's recommendations.
- B. Below Slab-On Grade:
  - 1. Ensure that mud slab surfaces are level and prepared as specified above. Apply polyethylene slip sheet, minimum eight mils thick, with seams lapped minimum six inches prior to installing membrane.
  - 2. Place membrane over prepared surfaces in such a manner as to ensure minimum handling. Fit material closely and seal around inlets, outlets and other projections. Follow installation procedures as recommended by membrane manufacturer.
  - 3. Install membrane with HDPE side up with edges overlapped a minimum of six inches. Staple joints every eight inches on center and wipe joint surfaces clean and free of dirt, dust, moisture and other foreign material. Apply joint tape to joint areas and press together immediately. Compress membrane and joint sealant tape with roller using 10 psi nominal pressure. Remove wrinkles, holidays and fishmouths. Carefully inspect seams and reseal voids. Install only as much membrane as can be covered in one day.
  - 4. Protect membrane from damage caused by rebar chairs with sharp edges and construction operations by placing three-inch concrete protection course, or per manufacturer's recommendation.
  - 5. Pour granular bentonite, adhere water barrier tape or bentonite composite waterstop, and trowel mastic around penetrations as directed by the manufacturer. Place custom fitted collar of membrane as directed by the manufacturer.
  - 6. Extend the waterproofing membrane 12 inches up or beyond the perimeter slab form. Use this excess material to overlap with wall waterproofing membrane.
  - 7. Inspect and replace damaged waterproofing material before placing concrete.
- C. Backfilled Walls:
  - 1. General: Place membrane, with the HDPE side facing installer, over prepared surfaces, vertically and horizontally as applicable for conditions, to ensure minimum handling of products. Fit materials closely and seal around inlets, outlets and other

- penetrations and projections. Comply with installation procedures as recommended by membrane manufacturer.
2. Field Joints: Install membrane shingle fashion to prevent intrusion of water. Overlap a minimum of six inches typically, depending on installation conditions.
    - a. Vertical Seam Application: Nail at 24 inches to 48 inches on center as recommended by manufacturer for conditions indicated. Tape seams with joint tape.
    - b. Horizontal Seam Applications: Nail at 18 inches on center, maximum. Tape seams with joint tape as specified above.
  3. Penetrations: Prior to pouring the wall concrete, wrap water barrier tape or bentonite composite waterstop around the pipe or sleeve within the wall area as recommended by the manufacturer. Cut membrane to fit snugly at penetration. Form cove around penetrations with specified mastic. Provide site fabricated collar made from waterproofing membrane to fit tightly around penetration and press firmly to embed fully in mastic. Fasten collar and tape in place.
  4. Termination: Terminate membrane applications as shown and as follows:
    - a. Install membrane into reglet as shown and fasten termination bar at top of membrane. Position to properly apply elastometric sealant, specified in Section 07900, Seals and Sealants. Space fasteners as eight inches on center. Confirm suitability of substrate to accept fasteners.
    - b. Protect membrane from damage by placing protection board against the membrane prior to backfilling operations in accordance with manufacturer's recommendations.
- D. Underground Roof Slabs:
1. General: Place membrane over prepared surfaces in such a manner as to ensure minimum handling. Fit closely and seal around inlets, outlets and other penetrations and projections. Follow installation procedures as recommended by membrane manufacturer.
  2. Install membrane with bentonite side down, facing roof slab, in shingle fashion. Start installation at lowest point.
  3. Field Joints: Provide lapped and sealed joints in field using joint tape. Form lapped joints by lapping edges a nominal six inches, unless larger overlap is recommended by membrane manufacturer. Wipe contact surfaces of pieces clean and free of dust, dirt, moisture and other foreign materials. Apply joint tape to joint area and press together immediately. Compress membrane and joint tape with roller using 10 psi nominal pressure. Remove wrinkles, holidays and fishmouths. Carefully inspect seams and reseal voids.
  4. Penetrations: Prior to pouring the roof concrete, wrap water barrier tape or bentonite composite waterstop around the pipe or sleeve within the slab area as recommended by the manufacturer. Install membrane around penetrations. Liberally apply mastic or granular bentonite around penetration. Install site fabricated collar, made from waterproofing membrane, fit tightly around penetration and tape in place.
  5. Transitions and Terminations: Comply with manufacturer's instructions for conditions, applications, transitions and terminations.
  6. Protect membrane from damage by placing three inch concrete protection course.
- E. Lagging and Shoring Applications:
1. General: Place membrane over prepared surfaces in such a manner as to ensure minimum handling. Fit closely and seal around inlets, outlets and other projections. Cover openings larger than one inch with minimum 1/4-inch thick plywood, or fill with grout. Follow installation procedures as recommended by membrane manufacturer.
  2. Membrane Installation: Install membrane as directed by manufacturer, with bentonite surface facing installer. When installed, prior to placement of concrete against the bentonite face, secure membrane and accessories to prevent

displacement or damage. Start installation at low point and install shingle fashion to prevent intrusion of water with minimum 12 inches overlap. Install nails only at seams as described above under Backfilled Walls. Apply mastic over the nail heads and staples. Close fishmouths, blousing and holidays with staple hammer at four inches on center.

3. Penetrations: Trowel apply mastic at penetrations and other locations to provide a complete and proper waterproofing envelope. Furnish and install site fabricated collar made from waterproofing membrane to fit tightly around penetration and press firmly to embed fully in mastic. Fasten collar in place. Wrap water barrier tape or bentonite composite waterstop around pipe or sleeve within the wall area prior to pouring the concrete, as recommended by the manufacturer.
  - a. At special conditions, including but not limited to soldier piles and beams, construction joints, pipe penetrations and other conditions, based on manufacturer's printed product data, apply water barrier tape.
4. Transitions and Terminations: Comply with the manufacturer's specific instructions for special conditions, applications, transitions and terminations.
5. After membrane installation, drape polyethylene sheets with seams lapped a minimum of six inches over membrane and fasten securely. Immediately before or concurrently with placement of concrete, remove sheets, exposing membrane.

F. Joints:

1. Waterproof contraction and construction joints at exterior walls and slabs using PVC waterstop, composite bentonite or bentonite composite water barrier tape as shown.
2. Trowel smooth the joint surfaces where bentonite composite waterstop is to be installed. If the surface becomes roughened during the preparation of a bonded joint per Section 03300, install mastic prior to installing the bentonite composite waterstop.
3. Install primer and nail bentonite composite waterstop in place at 12 inches on center as recommended by the manufacturer.
4. Do not install bentonite composite waterstop in wet conditions except as recommended by the manufacturer.

**3.04 PROTECTION OF WATERPROOFED SURFACES:**

- A. Install protection course as soon as practicable after waterproofing membrane is placed. Do not place loads on exposed waterproofing membrane. Traffic on exposed waterproofing membrane is prohibited.
- B. Provide temporary protection as required pending installation of permanent protection.
- C. Exercise care in placing protection course against waterproofing membrane so as not to break, tear, puncture or otherwise damage waterproofing membrane.
- D. Protect waterproofing surfaces as shown and with the following:
  1. Concrete: Place concrete protection course and mud slab in accordance with the applicable requirements of Section 03300 and as shown.
    - a. Protection Board: Affix protection board to membrane surface by butting and taping, or lapping and taping, in accordance with manufacturer's written instructions and as approved.

**3.05 REPAIR OF LEAKS:**

- A. Repair leak areas by means of a bentonite slurry, epoxy injection or both methods to provide impervious and watertight envelope around affected areas.

- B. Pump bentonite slurry toward outside of structure through drilled holes, at a pressure not exceeding 50 psi, to create waterproof layer.
- C. Submit repair schedule and methods for approval before proceeding with work.

**END OF SECTION**

**SECTION 07180**  
**TRAFFIC COATINGS**

**PART 1 - GENERAL**

**1.01 DESCRIPTION:**

- A. This Section includes traffic coatings for the following applications:
  - 1. Vehicular traffic.
- B. Related Sections include the following:
  - 1. Structural Precast Concrete - Section 03331

**1.02 SUBMITTALS**

- A. Product Data: For each product indicated.
- B. Shop Drawings: Show extent of each traffic coating. Include details for treating substrate joints and cracks, flashings, deck penetrations, and other termination conditions. Include layout of traffic striping and markings.
- C. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors, textures, and patterns available for each type of product indicated.
- D. Samples for Verification: For each type of traffic coating required, prepared on rigid backing and of same thickness and material indicated for the Work.
  - 1. Provide stepped samples on backing large enough to illustrate build-up of traffic coatings.
- E. Material Certificates: Signed by manufacturer certifying that traffic coatings comply with requirements, based on comprehensive testing of current product formulations within the last three years.
- F. Maintenance Data: To include in maintenance manuals specified in Division 1. Identify substrates and types of traffic coatings applied. Include recommendations for periodic inspections, cleaning, care, maintenance, and repair of traffic coatings.

**1.03 QUALITY ASSURANCE**

- A. Installer (Applicator) Qualifications: An experienced applicator who has specialized in installing work similar in material, design, and extent to that indicated for this Project and who is acceptable to manufacturer.
- B. Source Limitations: As follows:
  - 1. Use traffic coatings of a single manufacturer.
  - 2. Obtain primary traffic coating materials, including primers, from traffic coating manufacturer. Obtain secondary materials including aggregates, sheet flashings, joint sealants, and substrate repair materials of type and from source recommended by traffic coating manufacturer.
- C. Fire-Test-Response Characteristics: For traffic coatings as follows:
  - 1. Fire-response testing was performed by UL, ITS, or another independent testing and inspecting agency that is acceptable to authorities having jurisdiction and that performs testing and follow-up services.

2. Provide materials identical to those of traffic coatings tested according to ASTM E 108 for deck type and slopes indicated and that comply with requirements for roof-covering Class indicated.
- D. Mockups: The Engineer will select one representative surface for each traffic coating and each substrate to receive traffic coatings. Apply each coating to at least 200 sq. ft. 20 sq. m of each substrate to demonstrate surface preparation, joint and crack treatment, thickness, texture, color, and standard of workmanship.
1. Remove and reapply mockups until they are approved by The Engineer.
  2. Keep approved mockups undisturbed during construction as a standard for judging completed traffic coatings. Undamaged mockups may be incorporated into the Work.

#### **1.04 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver materials in original packages and containers with seals unbroken and bearing manufacturer's labels showing the following information:
1. Manufacturer's brand name.
  2. Type of material.
  3. Directions for storage.
  4. Date of manufacture and shelf life.
  5. Lot or batch number.
  6. Mixing and application instructions.
  7. Color.
- B. Store materials in a clean, dry location protected from exposure to direct sunlight. In storage areas, maintain environmental conditions within range recommended in writing by manufacturer.

#### **1.05 PROJECT CONDITIONS**

- A. Environmental Limitations: Apply traffic coatings within the range of ambient and substrate temperatures recommended in writing by manufacturer. Do not apply traffic coatings to damp or wet substrates, when temperatures are below 40 deg F 5 deg C, when relative humidity exceeds 85 percent, or when temperatures are less than 5 deg F 3 deg C above dew point.
1. Do not apply traffic coatings in snow, rain, fog, or mist, or when such weather conditions are imminent during the application and curing period. Apply only when frost-free conditions occur throughout the depth of the substrate.

#### **1.06 WARRANTY**

- A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.
- B. Special Warranty: Written warranty, signed by traffic coating manufacturer agreeing to repair or replace traffic coatings that do not comply with requirements or that deteriorate during the specified warranty period. Warranty does not include deterioration or failure of traffic coating due to unusual weather phenomena, failure of prepared and treated substrate, formation of new substrate cracks exceeding 1/16 inch 1.6 mm in width, fire, vandalism, or abuse by snowplow, maintenance equipment, and truck traffic.
1. Deterioration of traffic coatings includes, but is not limited to, the following:
    - a. Adhesive or cohesive failures.
    - b. Abrasion or tearing failures.

- c. Surface crazing or spalling.
  - d. Intrusion of water, oils, gasoline, grease, salt, deicer chemicals, or acids into deck substrate.
- C. Warranty Period: Five years from date of Substantial Completion.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS**

- A. Physical Requirements: Provide traffic coatings complying with ASTM C 957.
- B. Material Compatibility: Provide primers; base, intermediate, and top coats; and miscellaneous materials that are compatible with one another and with substrate under conditions of service and application, as demonstrated by the manufacturer based on testing and field experience.

### **2.02 TRAFFIC COATING**

- A. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Dura-Deck 800V ; Pecora Corporation.
- B. Primer: Manufacturer's standard factory-formulated primer recommended for substrate and conditions indicated.
- C. Preparatory and Base Coats: Single- or multicomponent aromatic liquid urethane elastomer.
- D. Intermediate Coat: Single- or multicomponent aromatic liquid urethane elastomer.
- E. Top Coat: Single- or multicomponent aromatic liquid urethane elastomer.
  - 1. Color: As selected by The Engineer from manufacturer's full range.
- F. Component Coat Thicknesses: As recommended by manufacturer for substrate and service conditions indicated.
- G. Aggregate: Uniformly graded washed silica sand of particle sizes, shape, and minimum hardness recommended in writing by traffic coating manufacturer.
  - 1. Spreading Rate: As recommended by manufacturer for substrate and service conditions indicated.
    - a. Top Coat: As required to achieve slip-resistant finish.
- H. Fire-Test-Response Characteristics: Class A roof covering per ASTM E 108.

### **2.03 MISCELLANEOUS MATERIALS**

- A. Sheet Flashing: Sheet material recommended by manufacturer.
- B. Adhesive: Manufacturer's recommended contact adhesive.
- C. Reinforcing Strip: Manufacturer's recommended fiberglass mesh.
- D. Traffic Paint: Alkyd-resin ready mixed, complying with AASHTO M 248.

## **PART 3 - EXECUTION**

### **3.01 EXAMINATION**

- A. Examine substrates, with Applicator present, for compliance with requirements and for other conditions affecting performance of traffic coatings.
  - 1. For the record, prepare written report, endorsed by Applicator, listing conditions detrimental to performance.
  - 2. Verify compatibility with and suitability of substrates.
  - 3. Begin coating application only after minimum concrete curing and drying period recommended by traffic coating manufacturer has passed, after unsatisfactory conditions have been corrected, and after surfaces are dry.
  - 4. Verify that substrates are visibly dry and free of moisture. Test for moisture by method recommended in writing by manufacturer.
  - 5. Application of coating indicates acceptance of surfaces and conditions.

### **3.02 PREPARATION**

- A. Clean and prepare substrates according to manufacturer's written recommendations to produce clean, dust-free, dry substrate for traffic coating application.
- B. Mask adjoining surfaces not receiving traffic coatings, deck drains, and other deck substrate penetrations to prevent spillage, leaking, and migration of coatings.
- C. Concrete Substrates: Mechanically abrade concrete surfaces to a uniform profile according to ASTM D 4259. Do not acid etch.
  - 1. Remove grease, oil, paints, and other penetrating contaminants from concrete.
  - 2. Remove concrete fins, ridges, and other projections.
  - 3. Remove laitance, glaze, efflorescence, curing compounds, concrete hardeners, form-release agents, and other incompatible materials that might affect coating adhesion.
  - 4. Remove remaining loose material to provide a sound surface, and clean surfaces according to ASTM D 4258.

### **3.03 TERMINATIONS AND PENETRATIONS**

- A. Prepare vertical and horizontal surfaces at terminations and penetrations through traffic coatings and at expansion joints, drains, and sleeves according to ASTM C 1127 and manufacturer's written recommendations.
- B. Provide sealant cants at penetrations and at reinforced and nonreinforced deck-to-wall butt joints.
- C. Terminate edges of deck-to-deck expansion joints with preparatory base-coat strip.
- D. Install sheet flashings at deck-to-wall expansion and dynamic joints, and bond to deck and wall substrates according to manufacturer's written recommendations.

### **3.04 JOINT AND CRACK TREATMENT**

- A. Prepare, treat, rout, and fill joints and cracks in substrates according to ASTM C 1127 and traffic coating manufacturer's written recommendations. Before coating surfaces, remove dust and dirt from joints and cracks according to ASTM D 4258.
  - 1. Comply with recommendations in ASTM C 1193 for joint-sealant installation.

### **3.05 TRAFFIC COATING APPLICATION**

- A. Apply traffic coating material according to ASTM C 1127 and manufacturer's written recommendations.
  - 1. Start traffic coating application in presence of manufacturer's technical representative.
  - 2. Verify that wet film thickness of each component coat complies with requirements every 100 sq. ft/9 sq. m.
  - 3. Apply traffic coatings to prepared wall terminations and vertical surfaces to height indicated and omit aggregate on vertical surfaces.
  
- B. Apply traffic paint for striping and other markings with mechanical equipment to produce uniform straight edges. Apply at manufacturer's recommended rates for a 15-mil/0.38-mm minimum wet film thickness.

**END OF SECTION**

## SECTION 07210

### BUILDING INSULATION

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing building insulation.
- B. Related Work Specified Elsewhere:
  - 1. Wood preservation treatment: Section 06075.
  - 2. Built-Up Roofing: Section 07515.
  - 3. Flashing and Sheet Metal: Section 07600.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Include manufacturer's material, handling, adhesive-mixing and application instructions for each type of product used in the work.
    - b. Woodnailers, cant strips.
    - c. Each tapered and flat roof insulation system.
      - 1) Show location and spacing of wood nailers and cants that are required for securing insulation and for back nailing of roofing felts. Show a complete description for the procedures for the installation of each phase of the system indicating the type of materials thicknesses, identity codes, sequence of laying insulation, special methods for cutting and fitting of insulation, and special precautions. The drawings shall be based on installation of the insulation in conjunction with the roofing system specified in Section 07515.
  - 2. Samples:
    - a. Three of each type of the following materials used in the work:
      - 1) Insulation: 12- inch square units; pint container for loose fill.
      - 2) Adhesive: Pint containers.
      - 3) Fasteners: Six of each type.
      - 4) Asphalt: Pint containers.
      - 5) Vapor Barrier: 12 inches square.
      - 6) Cant strip: 12 inches long.
  - 3. Certification:
    - a. Submit certification from manufacturer of insulation verifying that insulation applicator is approved by manufacturer, and has successfully performed at least three satisfactory insulation installations using methods and materials similar to those specified.
    - b. Certification that materials furnished meet specified requirements and are compatible with each other.
  - 4. Test Reports:
    - a. Submit flame spread and smoke developed ratings in accordance with ASTM E84.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:

1. Comply with codes and regulations of the jurisdictional authorities.
2. ASTM: C516, C518, C549, C552, C665, C728, C1289, D41, D226, D312, D2626, D4586, E84.
3. FM: A/S4470, P7825.
4. FS: HH-I-1972/3.

#### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Deliver products to jobsite in their original unopened containers or wrappings clearly labeled with manufacturer's name and brand designation, referenced specification number, type, class and rating as applicable.
- B. Store products in approved dry area and protect from contact with soil, exposure to the elements and temperatures lower than 40F or higher than 150F. Keep products dry; store rolled goods standing on end.
- C. Handle products so as to prevent breakage of containers and damage to products.

#### **1.05 JOB CONDITIONS:**

- A. Environmental Requirements:
  1. Application of roof insulation when ambient temperature is lower than 40F or when ice, frost or dampness are visible on the roof decks is prohibited.
  2. Maintain temperature of 55F minimum in structure for 48 hours prior to, during and 48 hours after application of wall insulation.
- B. Allowable Roof Loads:
  1. During insulation application do not use equipment of weight which exceeds allowable roof load.
- C. Coordinate insulation work with related roofing work.

### **PART 2 - PRODUCTS**

#### **2.01 ROOF INSULATION MATERIALS:**

- A. General: Use roof insulation materials acceptable to the roofing manufacturer. See related roofing specifications in other sections.
- B. Insulation Board: One of the following materials for which installed thickness will produce overall average thermal resistance of R19.5, including decrease in thermal resistance value due to aging; and which is labeled and classified as a roof deck construction material by UL for use in Fire-Classified metal roof deck assemblies (TGKX), or by FM for use in Class-1 metal-roof-deck construction.
  1. Composite polyisocyanurate (including polyurethane) board, ASTM C1289, Type III, factory faced with perlite insulation board on one side and asphalt-saturated felt on the other.
  2. Perlite board, ASTM C728, Type 1; except with 35-psi compression resistance at five percent consolidation, and with integral factory-treatment designed to improve bond with built-up roofing membranes.
- C. Tapered Insulation Board: Where roof slope through the use of tapered insulation is required, use approved insulation board as specified above, but factory fabricated so as to provide smooth drainage inclines (1/8-inch, 1/4-inch and 1/2-inch per 12 inches), as shown.
- D. Asphalt Primer: ASTM D41.

- E. Steep Asphalt: ASTM D312, Type III, or IV.
- F. Asphalt-Saturated Felt: ASTM D226, Type I.
- G. Asphalt Base Sheet: ASTM D2626.
- H. Asphalt Cement (Asbestos-Free): ASTM D4586.
- I. Asphalt for Glaze Coats: ASTM D312.
- J. Adhesive: Manufacturer's standard.
- K. Wood Nailers and Edges: Preservation treated per Section 06075.
- L. Cant Strips and Tapered Edge Strips: Pre-fabricated from urethane or mineral aggregate board.
- M. Nails and Tin Caps for Vapor Barriers: 11-gauge, annular-thread, 3/8-inch head, galvanized roofing nails and flat-disc galvanized-tin caps, 1-3/8 inch minimum diameter or galvanized combination nails and caps with one-inch heads.
- N. Insulation Nails: Types standard with insulation manufacturer.
- O. Clips and Fasteners: Types standard with metal-roof deck manufacturer; stainless steel or zinc coated, 18-gauge minimum.

## **2.02 WALL INSULATION MATERIALS:**

- A. Batt Insulation:
  1. Fibrous flexible blankets faced with a reinforced foil-kraft facing vapor retarder.
  2. Complies with ASTM C665, type III, Class B, Category 1.
  3. Fire hazard classification rating of 25/50 or less, per ASTM E84.
  4. Vapor Barrier Facing: Perms maximum, 0.1 when tested in accordance with ASTM C518.
  5. Thermal Resistance Minimum: R value of II except where indicated otherwise on the drawings. Thickness as indicated on drawings.
- B. Loose-Fill Insulation:
  1. Perlite: ASTM C549, Type IV (water-repellant and dust-control treated).
  2. Vermiculite: ASTM C516, Type II (water-repellant treated), Premium Grade..

## **2.03 PERIMETER AND CAVITY WALL INSULATION:**

- A. Rigid Board types of cellular glass or polystyrene insulation with 15 psi compressive strength.
  1. Cellular glass (Foamglass): ASTM C552. Minimum R value: 5.0 per inch of thickness
  2. Polystyrene: ASTM C578, Minimum R value: 4.35 per inch of thickness with density of 1.0 lbs. Per cubic foot.
- B. Adhesive and Fastenings: As recommended by the manufacturer.
- C. Insulation inserts for concrete masonry units cores.

## **PART 3 - EXECUTION**

### 3.01 PREPARATION:

- A. Prepare surfaces smooth, dry, clean, and free of projections, oil, grease, wax, rough mortar, debris and other substances that might prevent proper application of insulation.
- B. Allow decks and wall surfaces to dry thoroughly before application of insulation. Test for dampness per manufacturer's recommendations.
- C. Cut mortar joints flush with masonry walls. Remove fins and projections left after removal of concrete forms.
- D. Back plaster walls with cement mortar, if necessary to obtain smooth surfaces.

### 3.02 APPLICATION OF ROOF INSULATION:

- A. General Requirements for Application:
  - 1. Apply insulation in direct contact with roof deck or over vapor barrier, as shown. Keep roof-insulation materials dry before, during and after application. Place perlite side of composite insulation face up.
  - 2. Apply insulation to deck so that continuous longitudinal joints are parallel to short dimension of roof; stagger cross joints by starting alternate courses with half-size insulation boards. Keep insulation 1/2-inch clear of vertical surfaces.
  - 3. When using multiple layers of insulation, stagger the joints of each succeeding layer in both directions with respect to layer below. Embed succeeding layers firmly in solid mopping of steep asphalt.
  - 4. Mop sufficient area to provide complete embedment of one board at a time.
  - 5. Except for strip-mopping on metal decks, use 25 pounds minimum of asphalt per 100 square feet of roof deck for mopping each layer of insulation in place.
  - 6. Provide treated-wood nailers at edges of roofs and at intersections with vertical surfaces. Provide additional treated-wood nailers at necessary intervals for nailing insulation on non-nailable decks or for nailing roofing felt.
  - 7. Do not heat steep asphalt above 450F. Do not heat asphalt used for glaze coats above 400F. Apply steep asphalt at no less than 350F. Apply glaze coat at no less than 325F.
- B. Application on Concrete Decks:
  - 1. Completely cover concrete decks with asphalt primer at minimum rate of one gallon per 100 square feet of roof surface.
  - 2. Vapor barrier:
    - a. Provide vapor barrier consisting of two plies of asphalt-saturated felt with each ply lapped not less than 19 inches and mopped-in with steep asphalt. Vapor barrier, consisting of one layer of asphalt base sheets and weighing not less than 35 pounds minimum per 100 square feet, may be provided in lieu of two felt plies. Lap base sheets not less than four inches at sides and ends; solidly mop-in with steep asphalt.
    - b. Mop-in vapor barriers at rate of 25 pounds minimum of steep asphalt per 100 square feet. Ensure that vapor barriers are free of wrinkles and buckles. Press air bubbles out to obtain proper adhesion between surfaces.
    - c. At walls, edges and vertical projections, extend vapor barrier six inches to form lap to be wrapped around edge of insulation.
  - 3. Apply insulation as specified under general requirements for application.
  - 4. If roof slope exceeds one inch per foot, provide wood nailers for nailing insulation to roof deck. Use six nails minimum per eight square feet of insulation.
- C. Application on Steel Decks:

1. Apply insulation so that joints occur on solid bearing surfaces only rather than over open ribs. Apply insulation of the indicated thickness and as required to achieve the roof slopes indicated.
  2. Before insulation is installed, uniformly strip-coat high sections of steel deck with asphalt primer using 1/2-gallon minimum per 100 square feet of roof surface. Allow primer to dry.
  3. Strip-mop high sections of deck using not less than 12 pounds of steep asphalt per 100 square feet of roof surface. Do not permit asphalt to flow into ribs or flutes of decking.
  4. Place insulation while asphalt is still hot and fluid. When multiple layers of insulation are used, mop-in second layer and succeeding layers as specified under general requirements for application.
  5. Fastening of insulation on steel decks:
    - a. If roof slope exceeds one inch per foot, supplement asphalt moppings with mechanical fasteners. Where mechanical fastening is required, provide approved steel-deck, manufacturer's standard, nonpiercing, double-prong steel clips designed to fit into ribs of decking.
    - b. Provide fastener of length necessary to accommodate thickness of insulation and with holding power 120 pounds minimum per fastener.
    - c. Provide clips at the rate of 25 clips minimum per 100 square feet.
- D. Cant Strips and Tapered Edge Strips:
1. Cant strips:
    - a. Where shown or specified, provide 45-degree cant strips at intersections of roof with vertical surfaces extending above roof. Place cant strips on insulation and fit flush against vertical surfaces.
    - b. Where possible, nail cant strips to adjoining surfaces. For installation against non-nailable materials, place cant strips in heavy mopping of steep asphalt or set in asphalt cement.
    - c. Do not install projections, such as vent pipes and braces, through cant strips or within 10 inches from cant strips.
  2. Tapered edge strips:
    - a. Where shown or specified, provide tapered edge strips in right angle formed by junction of roof and wood nailing strips that extend above roof level. Fit strips flush against vertical surfaces of wood nailing strips.
    - b. Where possible, nail edge strips to adjoining surfaces. Where installed against non-nailable materials, apply strips in heavy mopping of steep asphalt or set in asphalt cement.
- E. Protection:
1. Cover each day's application of insulation, which cannot be roofed over, with at least one glaze coat of hot bitumen.
  2. Protect open ends of each day's work with temporary water cut-offs; remove cut-offs when work is resumed.
  3. Protect open spaces between insulation and parapets or other walls and spaces at curbs, scuttles, expansion joints and similar locations until permanent roofing and flashing is applied. Storing, walking, wheeling or trucking directly on insulation or on roofed surfaces is prohibited; provide smooth, clean board or plank walkways, runways and platforms as necessary.
  4. Limit storage loads on platforms and wheeling loads to 40 psf uniformly distributed. Limit size and weight of mechanical equipment used for insulation work so that deflection of roof deck under its use does not exceed 1/240 of deck span.

### **3.03 APPLICATION OF MASONRY-CELL WALL INSULATION:**

- A. Follow manufacturer's recommended installation practices.
- B. Pour loose-fill insulation into cells of concrete masonry units as masonry work progresses. Use approved procedures to ensure complete filling of cells.
- C. Minimize free fall impact and dust formation.

**3.04 APPLICATION OF BATT INSULATION:**

- A. The vapor barrier facing shall face toward the warm-in-winter side of the space.
- B. Lay batts on top of soffit tightly butted together.
- C. Attach wall mounted batts with, mechanical fasteners as required for permanent installation.

**3.05 APPLICATION OF PERIMETER CAVITY WALL INSULATION:**

- A. Secure vertical insulation with mechanical fasteners sufficient to permanently retain all insulation in place during subsequent construction operations.
- B. Fitted with tight butt joints with openings for penetrations nearly cut for tight fit.
- C. Placed just prior to subsequent construction operations to prevent damage of insulation left exposed. Coordinate with masonry work. Prevent damage during placement of fill and compaction or concrete against insulation.
- D. Place insulation in concrete masonry unit cores at plant prior to job site delivery.

**3.06 CLEAN-UP:**

- A. Clean up rubbish and debris caused by this work and remove from site.
- B. Remove drippings of asphalt and adhesives in exposed places on brick, concrete, steel, metal or other surfaces.

**END OF SECTION**

## SECTION 07411

### SHEET METAL ROOFING SYSTEMS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies preformed, prefinished standing seam and flat seam metal roofing, metal fascia panels, flashing, and accessories.
- B. Related Work Specified Elsewhere:
  - 1. Metal Decking: Section 05310.
  - 2. Flashing and Sheet Metal: Section 07600.
  - 3. Roof Accessories: 07730.
  - 4. Seals and Sealants: 07900.

##### 1.02 PERFORMANCE REQUIREMENTS:

- A. Install sheet metal roofing capable of withstanding normal thermal movement, wind loading, structural movement, thermally induced movement, and exposure to weather without failure or infiltration of water into the building interior or through the canopy structure.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements for approval and with the additional requirements as specified for each:
  - 1. Product Data: For each product indicated.
    - a. Submit product data indicating the metal roofing systems meet the specified requirements and indicating compliance with minimum specified ASTM and U.L. requirements.
  - 2. Shop Drawings: Show details for forming, joining, and securing metal roofing, and for pattern of seams. Show expansion-joint details and waterproof connections to adjoining work and at obstructions and penetrations. Include details of construction relative to materials, dimensions of individual components, profiles, and finishes.
    - a. Submit calculations with registered engineer seal, verifying roof panel and attachment method resists wind pressures imposed on it pursuant to applicable building codes.
  - 3. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for metal roofing with color-coated finishes.
  - 4. Samples for Verification: 12-inch- square specimens of metal roofing material with specified finishes applied. Where finishes involve normal color and texture variations, include Sample sets of 2 or more units showing the full range of variations expected.
  - 5. Certifications.

#### 1.04 QUALITY ASSURANCE:

- A. Installer Qualifications: Engage an experienced installer who has completed sheet metal roofing similar in material, design, forming method, and extent to that indicated for this Project and with a record of successful in-service performance.
- B. Select a Manufacturer specializing in Architectural Sheet Metal Products with five (5) years minimum experience.
- C. Codes, regulations, Reference Standards and Specifications:
  - 1. ASTM A653, A666, A775, B209, B370, C920, D 226, D523, D926, D4214, D1970E 699-99, E 1646 E 1680-95, E1592-98
  - 2. SMACNA - Architectural Sheet Metal Manual.
  - 3. CDA - Copper Development Association Handbook.
  - 4. AAMA 1402.
- D. General: Provide manufactured sheet metal roofing assemblies complying with performance requirements indicated and capable of withstanding structural movement, thermally induced movement, and exposure to weather without failure or infiltration of water into the building interior.
  - 1. Air Infiltration: Provide manufactured roof panel assemblies with permanent resistance to air leakage through assembly of not more than 0.09 cfm/sq. ft. of fixed roof area when tested according to ASTM E 1680 at a static-air-pressure difference of 4.0 lbf/sq. ft.
  - 2. Water Penetration: Provide manufactured roof panel assemblies with no water penetration as defined in the test method when tested according to ASTM E 1646 at a minimum differential pressure of 20 percent of inward acting, wind-load design pressure of not less than 6.24 lb/sq. ft. and not more than 12.0 lb/sq. ft.
  - 3. Wind-Uplift Resistance: Provide roof panel assemblies that meet requirements of UL 580 for Class 90 wind-uplift resistance. Design Load: 90 m.p.h., basic wind load velocity.
  - 4. Structural Performance: Provide manufactured roof panel assemblies capable of safely supporting design loads indicated under in-service conditions with vertical deflection no greater than the following, based on testing manufacturer's standard units according to ASTM E 1592 by a qualified independent testing and inspecting agency.
    - a. Maximum Deflection: 1/140 of the span.
    - b. Design Load: 30 p.s.f.
- E. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in the jurisdiction where the Project is located and who is experienced in providing engineering services of the kind indicated.
- F. Field Measurements: Verify location of structural members and openings in substrates by field measurements before fabrication and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.
  - 1. Established Dimensions: Where field measurements cannot be made without delaying the Work, either establish opening dimensions and proceed with fabricating roof panels without field measurements or allow for trimming panel units. Coordinate roof construction to ensure actual locations of structural members and to ensure opening dimensions correspond to established dimensions.

### **1.05 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Deliver metal coils, panels, and other roofing materials so they will not be damaged or deformed. Package roofing materials for protection against transportation damage.
- B. Handling: Exercise care in unloading, storing, and erecting roofing materials to prevent bending, warping, twisting, and surface damage.
- C. Stack materials on platforms or pallets, covered with tarpaulins or other suitable weathertight and ventilated covering. Store metal roof coils and panels to ensure dryness. Do not store coils or panels in contact with other materials that might cause staining, denting, or other surface damage.

### **1.06 WARRANTY:**

- A. General Warranty: Special warranties specified in this Section shall not deprive the Authority of other rights the Authority may have under other provisions of the General Provisions and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.
- B. Special Finish Warranty: Submit a written warranty executed by the manufacturer covering failure of the factory-applied exterior finish on metal roofing within the specified warranty period and agreeing to repair finish or replace sheet metal roofing that evidences finish deterioration. Deterioration of finish includes, but is not limited to, color fade, chalking, cracking, peeling, and loss of film integrity.
  - 1. Finish Warranty Period: Nineteen (19) year guarantee in addition to the warranty provisions of the General Provisions for at total of 20 years from date of Substantial Completion.
- C. Special Weathertight Warranty: Submit a written warranty executed by the manufacturer agreeing to repair or replace sheet metal roofing that fails to remain weathertight within the specified warranty period.
  - 1. Weathertight Warranty Period: One year guarantee in addition to the warranty provisions of the General Provisions for at total of 2 years from date of Substantial Completion.

## **PART 2 - PRODUCTS**

### **2.01 ROOFING SHEET METALS:**

- A. Metallic-Coated Steel Sheet Prepainted with Coil Coating: Steel sheet metallic coated by the hot-dip process and prepainted by the coil-coating process to comply with ASTM A 755ASTM A 755M and the following requirements:
  - 1. Galvanized Steel Sheet: ASTM A 653, G90 (ASTM A 653M, Z275); structural quality.
  - 2. Finish: Apply the following organic coating in a thickness of not less than 0.0336 inch, unless otherwise indicated. Furnish appropriate air-drying spray finish in matching color for touchup.
    - a. Durability: Provide coating field tested under normal range of weather conditions for minimum of 20 years without significant peel, blister, flake, chip, crack, or check in finish; without chalking in excess of a chalk rating

of 8 according to ASTM D 4214; and without fading in excess of 5 Hunter units.

- 1) Fluoropolymer 2-Coat Coating System: Manufacturer's standard 2-coat, thermocured system composed of specially formulated inhibitive primer and fluoropolymer color topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight with a total minimum dry film thickness of 0.9 mil and 30 percent reflective gloss when tested according to ASTM D 523.
  - b. Color: As selected by Architect from manufacturer's full range of colors.
- B. Aluminum Sheets: ASTM B 209 (ASTM B 209M) for Alclad alloy 3003 or 3004 with temper as required to suit forming operations and finish indicated.
1. Surface: Smooth, flat, mill finish.
  2. High-Performance Organic Coating Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations relative to applying and designating finishes. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturer's written instructions.
    - a. Fluoropolymer 3-Coat Coating System: Manufacturer's standard 3-coat, thermocured system composed of specially formulated inhibitive primer, fluoropolymer color coat, and clear fluoropolymer topcoat, with both color coat and clear topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight; complying with AAMA 1402.
      - 1) Color and Gloss: As selected from manufacturer's full range of choices for color and gloss.
- C. Copper Sheet: ASTM B 370, cold-rolled copper sheet, H00 temper, unless otherwise indicated.
1. Weight (Thickness): 16 oz./sq. ft., unless otherwise indicated.
- D. Stainless-Steel Sheet: ASTM A 666, Type 304, dead soft, fully annealed.
1. Finish: 2D (dull).
- E. Terne-Coated Stainless-Steel Sheet: ASTM A 666, Type 304, dead-soft, fully annealed stainless-steel sheet, coated on both sides with terne alloy (80 percent lead, 20 percent tin) to produce a nominal total coating weight of 1.45 oz./sq. ft.
1. Thickness and Weight: 0.018 inch plus coating, weighing approximately 0.82 lb/sq. ft. including coating, unless otherwise indicated.
  2. In lieu of spot tests to determine coating weight, manufacturer may submit nondestructive radiographic test results and certification showing that terne-coating weight of sheets furnished for Project complies with requirements.

## **2.02 UNDERLAYMENT MATERIALS:**

- A. Self-Adhering, Polymer-Modified, Bituminous Sheet Underlayment: ASTM D 1970, minimum 40 mils thick. Provide primer when recommended by underlayment manufacturer.
- B. Building Paper: Minimum 5 lb/100 sq. ft., rosin sizing.
- C. Felts: ASTM D 226, Type II (No. 30), asphalt-saturated organic felts.

### **2.03 MISCELLANEOUS MATERIALS:**

- A. General: Provide materials and types of fasteners, solder, welding rods, protective coatings, separators, sealants, and accessory items as required for a complete roofing system and as recommended by sheet metal manufacturer and fabricator for metal roofing work, unless otherwise indicated.
- B. Expansion-Joint Sealant in accordance with Section 07900: For hooked-type expansion joints, which must be free to move, provide nonsetting, nonhardening, nonmigrating, heavy-bodied polyisobutylene sealant.
- C. Terne Base Coating: Red iron-oxide/linseed oil paint, with iron oxide as 40 percent minimum of pigment and linseed oil as 50 percent minimum of vehicle.
- D. Metal Accessories in accordance with Section 07600: Provide components matching sheet metal roofing in finish and material that are required for a complete roofing system, including the following:
  - 1. Clips, flashings, and ridge closure strips.
  - 2. Trim, copings, fascia.
- E. Sealing Tape: Pressure-sensitive, 100 percent solids, polyisobutylene compound sealing tape with release paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape.
- F. Elastomeric Joint Sealant: ASTM C 920, of base polymer, type, grade, class, and use classifications required to produce joints in roofing that will remain weathertight and as recommended by the roofing manufacturer for installation indicated and in accordance with Section 07900
- G. Bituminous Coating: Cold-applied asphalt mastic, SSPC-Paint 12, compounded for 15-mil dry film thickness per coat, unless otherwise indicated. Provide inert-type noncorrosive compound free of asbestos fibers, sulfur components, and other deleterious impurities.
- H. Snow Guards: Section 07730.

### **2.04 FABRICATION:**

- A. General: Fabricate sheet metal roofing to comply with details shown, with metal roofing manufacturer's written instructions, and with recommendations of SMACNA's "Architectural Sheet Metal Manual" that apply to the design, dimensions, metal, and other characteristics of installation indicated. For copper roofing, comply with details shown and with recommendations of CDA's Copper Design Handbook.
- B. Fabricate sheet metal to allow for expansion in running work sufficient to prevent leakage, damage, and deterioration of the Work. Form exposed sheet metal work to fit substrates without excessive oil canning, buckling, and tool marks, true to line and levels indicated, and with exposed edges folded back to form hems.
- C. Expansion Provisions: Where lapped or bayonet-type expansion provisions in the Work cannot be used, or would not be sufficiently waterproof and weatherproof, form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with sealant (concealed within joints).
- D. Sealant Joints: Where movable, nonexpansion-type joints are indicated or required to produce weathertight seams, form metal to provide for proper installation of elastomeric sealant, in compliance with SMACNA standards.

- E. Separations: Separate metal from noncompatible metal or corrosive substrates by coating concealed surfaces at locations of contact with bituminous coating or other permanent separation as recommended by manufacturer or fabricator.
- F. Lap-Seam Roof Panels: Manufacturer's standard factory-formed, lap-seam roof panel assembly designed for mechanical attachment of panels to roof purlins using exposed fasteners and sealants.
- G. Standing-Seam Roof Panels: Manufacturer's standard factory-formed, standing-seam roof panel assembly designed for concealed mechanical attachment of panels to roof purlins or deck.
  - 1. Standing-seam roof assemblies vary among manufacturers. Revise paragraph below to reflect assembly desired.
  - 2. Clips: Provide minimum 0.0625-inch- thick, stainless-steel panel clips designed to meet negative-load requirements.
  - 3. Cleats: Mechanically seamed cleats formed from minimum 0.0250-inch- thick, stainless-steel or nylon-coated aluminum sheets.

## **PART 3 - EXECUTION**

### **3.01 EXAMINATION:**

- A. Examine substrates and conditions, with Installer present, for compliance with requirements indicated for conditions affecting performance of sheet metal roofing. Do not proceed with installation until unsatisfactory conditions have been corrected

### **3.02 PREPARATION:**

- A. Coordinate metal roofing with rain drainage work, flashing, trim, and construction of decking as specified in Section 05310, parapets, walls, and other adjoining work to provide a leakproof, secure, and noncorrosive installation.
- B. Promptly remove protective film, if any, from exposed surfaces of metal roofing. Strip with care to avoid damage to finish.

### **3.03 INSTALLATION, GENERAL:**

- A. Install roofing to comply with sheet metal roofing manufacturer's written instructions, unless otherwise indicated.
- B. Separate dissimilar metals by painting each metal surface in area of contact with a bituminous coating, by applying rubberized-asphalt underlayment to each metal surface, or by other permanent separation as recommended by manufacturers of dissimilar metals.
- C. Install felt underlayment and building paper slip sheet on substrate under metal roofing, unless otherwise recommended by sheet metal manufacturer. Use adhesive for temporary anchorage, where possible, to minimize use of mechanical fasteners under metal roofing. Apply from eave to ridge in shingle fashion and lap joints 2 inches minimum.
- D. Underlayment is limited to placing building paper only directly under terne metal.

- E. Coat back side of metal roofing with bituminous coating where it will contact wood, ferrous metal, or cementitious construction.
- F. Paint back side of terne roofing with terne base coating, 1.0-mil dry film thickness, where slope of roofing is 3 inches per foot (1:4) or less.
- G. Form and fabricate sheets, seams, strips, cleats, valleys, ridges, edge treatments, integral flashings, and other components of metal roofing to profiles, patterns, and drainage arrangements shown and as required for leakproof construction. Provide for thermal expansion and contraction of the Work. Seal joints as shown and as required for leakproof construction. Shop fabricate materials to greatest extent possible.
- H. Sealant-Type Joints: Where sealant-filled joints are used, embed hooked flanges of joint members not less than 1 inch into sealant. Form joints to completely conceal sealant. When ambient temperature is moderate, between 40 and 70 deg F, at time of installation, set joint members for 50 percent movement either way. Adjust setting proportionately for installation at higher ambient temperatures. Do not install sealant-type joints at temperatures below 40 deg F. Comply with requirements of Section 07900: Joint Sealants for handling and installing sealants.
- I. Fabricate and install work with lines and corners of exposed units true and accurate. Form exposed faces flat and free of buckles, excessive waves, and avoidable tool marks, considering temper and reflectivity of metal. Provide uniform, neat seams with minimum exposure of solder, welds, and sealant. Fold back sheet metal to form a hem on concealed side of exposed edges, unless otherwise indicated.
- J. Conceal fasteners and expansion provisions where possible in exposed work and locate to minimize possibility of leakage. Cover and seal fasteners and anchors as required for a tight installation.
- K. Stainless-Steel Roofing: Tin edges of uncoated sheets to be soldered, for a width of 1-1/2 inches, using solder recommended for stainless steel and acid flux. Promptly remove every trace of acid flux residue from metal after tinning. Comply with manufacturer's recommended methods for cleaning and neutralization. Clean exposed surfaces of stainless steel of every substance that is visible or that might cause corrosion of metal.
- L. Tin uncoated copper surfaces at edges of sheets to be soldered, for a width of 1-1/2 inches, using solder recommended for copper work. Where surfaces to be soldered are lead coated, do not tin edges, but wire brush lead coating before soldering.
- M. Rivet joints in uncoated aluminum where necessary for strength. Clean exposed surfaces of every substance that is visible or that might cause corrosion of metal or deterioration of finish.
- N. Install metal accessories in accordance with Section 07600.
- O. Install snow guards in accordance with Section 07730.

### **3.04 CLEANING:**

- A. Clean exposed metal surfaces of substances that interfere with uniform oxidation and weathering.

**3.05 PROTECTION:**

- A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure metal roofing is without damage or deterioration at the time of Substantial Completion.

**END OF SECTION**

## SECTION 07515

### BUILT-UP ROOFING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing built-up roofing.
- B. Related Work Specified Elsewhere:
  - 1. Thermal insulation, nailers and cants: Section 07210.
  - 2. Metal counter flashing and other sheet metal: Section 07600.
  - 3. Roof accessories: Section 07730.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ASTM: D41, D312, D1668, D1863, D2178, , D4586.
  - 3. National Roofing Contractor's Association (NRCA):The NCRA Roofing and Waterproofing Manual.
- B. Single Source: Provide products as produced or recommended by the roofing system manufacturer.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Include the following:
      - 1) Manufacturer's material, handling, and application instructions.
      - 2) Step-by-step application procedure proposed.
      - 3) Show perimeter details, tapered insulation layout (as applicable), penetration details, drainage details and other typical and special conditions.
      - 4) Staging plan showing access points, waste disposal, storage areas, etc.
  - 2. Certification:
    - a. Submit certification from manufacturer of roofing, that roofing applicator is approved by manufacturer and has successfully performed at least three satisfactory roofing installations using materials and methods similar to those specified.
    - b. Certification that materials furnished meet specified requirements and are compatible with each other and with adjacent materials under Related Work Specified Elsewhere.

##### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver products to jobsite in their original unopened containers clearly labeled with manufacturer's name and brand designation, referenced specification number, type, class and rating as applicable.
- B. Store products in approved dry area with roll goods standing on ends and protect from contact with soil and from exposure to the elements. Keep products dry.

- C. Handle products so as to prevent breakage of containers and damage to products.
- D. Do not exceed designed live load of roof deck when stockpiling materials in areas of work.

**1.05 JOB CONDITIONS:**

- A. Environmental Requirements:
  - 1. Application of roofing when precipitation is occurring or when ice, frost or dampness is visible on roof decks is prohibited.
  - 2. Application of roofing when ambient temperature is lower than 40F is prohibited, unless otherwise approved.
  - 3. Maintain rolls of felt at 60F minimum 24 hours minimum prior to installation.

**1.06 WARRANTY:**

- A. One year in addition to the requirements of the General Provisions for a total of two years.

**PART 2 - PRODUCTS**

**2.01 MATERIALS:**

- A. General:
  - 1. Insofar as practicable, furnish products produced or recommended by a single roofing system manufacturer, including roofing system products specified in other sections.
- B. Thermal Insulation, Nailers and Cants: Section 07210.
- C. Asphalt Primer: ASTM D41.
- D. Asphalt: ASTM D312.
  - 1. Type I, 135F-151F softening point for level to 1/4-inch slope (*use not permitted*)
  - 2. Type II, 158F-176F softening point for 1/4-inch to one-inch slope.
  - 3. Type III, 185F-205F softening point for one-inch to three-inch slope.
  - 4. Type IV, 210F-225F softening point for three-inch to six-inch slope.
- E. Asphalt Cement(Asbestos-Free): ASTM D4586.
- F. Asphalt-Saturated and Coated Organic Felt Base Sheet: ASTM D2626 (*use not permitted*).
- G. Asphalt-Saturated Organic Roofing Felt: ASTM D226, Type I, perforated (*use not permitted*).
- H. Asphalt Glass Felt: ASTM D2178, Type IV or Type VI.
- I. Base Flashing Cap Sheet: Roofing system manufacturer's standard asphalt impregnated and coated composite sheet, glass fiber or polyester reinforced, with or without surface granules.
- J. Aggregate for Surfacing: ASTM D1863, light-colored crushed stone, slag or gravel, opaque to ultraviolet radiation.
- K. Walkway Surface: Homogenous core of asphalt, plasticizers and inert fillers bonded by heat and pressure between two saturated and coated inorganic sheets, with the walking surface

finished with gray ceramic granules. Supply in 36-inch wide by 72-inch long sheets, 1/2-inch thick minimum.

- L. Nails: 11-gauge, annular-thread, galvanized roofing nails with 3/8-inch diameter head or combination nail with head one-inch square minimum.
- M. Tin Caps: Flat discs of galvanized sheet steel 28-gauge minimum and 1-3/8 inches minimum diameter.
- N. Combination Nails: Square-head cap 11-gauge, hot-dip galvanized, annular thread with one-inch diameter cap.
- O. Glass-Fiber Fabric: Woven glass cloth, treated with asphalt, ASTM D1668, Type I.
- P. Metal Counter Flashing and Other Sheet Metal: Section 07600.
- Q. Roof Accessories: Section 07730.

### **PART 3 - EXECUTION**

#### **3.01 EXAMINATION AND PREPARATION OF SURFACES:**

- A. Clean substrates of dust, debris and other substances detrimental to roofing installation according to roofing system manufacturer's written instructions. Remove sharp projections.
- B. Examine substrates, areas, and conditions under which roofing will be applied, with installer present, for compliance with requirements.
- C. Verify proper secure placement of roof openings, penetrations, insulation, roof accessories and roof drains.
- D. Verify that substrates are smooth, dry, clean and free of projections or debris that might damage roofing materials.
- E. Do not proceed with installation until unsatisfactory conditions have been corrected.

#### **3.02 INSTALLATION:**

- A. General: Perform installation in accordance with the NCRA Roofing and Waterproofing Manual unless specified or shown differently.
  - 1. Apply roofing perpendicular to roof slope progressively and continuously. Provide starter sheets to maintain specified number of felt plies throughout roof. Extend roofing plies to tops of cant strips.
  - 2. Protect edges of each day's application of felt, except for coated base sheet, with glaze coat of hot Type-III asphalt. Apply glaze coat at minimum rate of 15 pounds of asphalt per 100 square feet of roof surface.
  - 3. Do not store materials on applied roofing. Provide sufficient crew to complete roofing work on area begun before end of each day's work.
  - 4. Roll felt into bitumen not more than three feet behind mop; broom thoroughly with roofer's smoothing brushes to ensure thorough bonding of sheets to eliminate air pockets, wrinkling and buckling. Felt may be machine applied if approved. Do not lay plies dry and turn back laps for mopping between plies.
  - 5. Heat Types-II, III and IV asphalts 450F maximum; do not keep heated overnight.

6. Apply asphalt at no less than 350F. Use thermometers to check temperature of asphalt during heating and application. Keep kettle operator in attendance during entire operation to ensure that maximum specified temperatures are not exceeded.
7. Provide smooth, clear, board or plank runways and platforms near supports for traffic over partially or completely finished roofing.
8. Follow commercial practice and recommendations of manufacturer and supplier for handling and use of materials, except as otherwise specified.

B. Materials Schedule:

1. Each of the following for each 100 square feet of roof area:

Materials	Specification Amount
Base sheet	1 ply
Felt	3 plies
Asphalt - on deck	25 pounds
Asphalt - between plies	60 pounds
Asphalt - top pouring	60 pounds
Aggregate: One of the following: Slag Gravel or crushed stone	300 pounds 400 pounds

2. Base flashing is additional to the quantities above.

C. Application:

1. For direct application to concrete decks, coat decks uniformly with asphalt primer using not less than one gallon per square of roof area and allow to dry thoroughly.
2. Apply hot Type-III or Type IV asphalt uniformly in a solid mopping over primer or insulation at minimum rate of 25 pounds of asphalt per 100 square feet. On roofs of precast units, apply felt strips four inches or more in width centered over joints of precast units in cold-applied asphalt cement before solid mopping. Apply base sheet in hot asphalt with ends and edges lapped four inches over preceding sheet and sealed with hot asphalt.
3. Apply hot asphalt uniformly to base sheet at minimum rate of 20 pounds per 100 square feet. Apply three felt plies in hot asphalt, shingle fashion, each sheet in each ply lapping 24-3/4 inches over preceding ply. Lap ends of sheets six inches minimum and stagger laps in adjacent courses 12 inches minimum. Mop hot asphalt full lap-width of each ply so that felt never touches felt. Apply not less than 20 pounds of asphalt per 100 square feet between successive plies.
4. On roof slopes greater than one inch per foot, nail each ply of felt on slopes as specified. Correct fishmouths, breaks, blisters and other defects before flood-coating roofing.
5. Flood coat: After felt flashing applications, repairs and corrective actions have been completed and approved, coat entire surface uniformly with hot asphalt, poured from dipper, at minimum rate of 60 pounds per 100 square feet.
6. Aggregate surfacing: Immediately embed gravel, crushed stone or slag into hot asphalt.
7. Double surfacing: Provide double surfacing of aggregate in addition to normal requirement under each board of walkway-surface material as follows:
  - a. Apply not less than 80 pounds of hot asphalt poured from dipper per 100 square feet of roof area.

- b. Embed immediately into hot asphalt 200 pounds minimum of slag or 300 pounds minimum of gravel or crushed stone.
- D. Nailing On Roof Slopes Greater Than One Inch Per Foot:
  - 1. Nail each ply of felt. Run felt perpendicular to roof slope and nail to embedded nailers parallel to slope.
  - 2. Nail felt to each nailer with two nails spaced approximately two and eight inches from upper edge of felt.
- E. Base Flashing: Follow NRCA Roofing and Waterproofing Manual details and roofing system manufacturer's details.
  - 1. Provide flashing in angles formed where roof decks abut walls, curbs, ventilators, pipes and other vertical surfaces and wherever necessary to make work watertight.
  - 2. Prime walls and curbs; allow to dry before flashing is applied.
  - 3. Apply base flashing in two layers: first of asphalt glass felt and topped with base flashing cap sheet cut in strips 12 feet long maximum with reinforced fabric side toward wall.
  - 4. Extend flashing felt onto roof over membrane six to eight inches from toe of cant. Nail felt 1-1/2 inches from top edge of felt with roofing nails and tin caps at 10-inch maximum spacing.
  - 5. Seal top of flashing with strip of glass fiber fabric embedded in 1/8-inch thick asphalt cement, extending from one-inch above top of felt to one-inch below nail heads.
  - 6. Lap ends of felt three inches minimum, staggered in each ply, and seal watertight with asphalt cement. Apply six-inch wide strip of asphalt-saturated felt with asphalt cement to seal lower edge of flashing installation.
  - 7. Cement felt to underlying surfaces and to each other with asphalt cement applied not less than 1/16-inch thick or 35 pounds per 100 square feet for each coating.
- F. Stripping-In:
  - 1. Strip-in roof-accessory aprons, pipe sleeves and metal flashings as follows:
    - a. Prime surfaces and allow to dry. Strip-in with two layers of asphalt-saturated felt cemented with asphalt cement.
    - b. Extend felt three and six inches, respectively, beyond edge of apron, flange or flashing.
  - 2. Gravel stops, fascias and scuppers:
    - a. Strip-in with two layers of asphalt-saturated felt, one 10-inch strip and one 12-inch strip.
    - b. Solidly mop strips with hot bitumen.
- G. Roof-Drain Flashing Application:
  - 1. Strip-in roof drain with two layers of asphalt-saturated felt, one 10 inches wide and one 12 inches wide, set in asphalt cement or hot bitumen.
  - 2. Heavily coat flashing ring of drain with asphalt cement before installing felt flashing. Clamp roofing felt and felt flashing securely in drain clamping ring.
  - 3. Apply trowel coat of asphalt cement width of trowel on top of felt around clamping ring before flood coat and application of aggregate. Embed aggregate into asphalt cement.
- H. Metal Fascias and Flashings:
  - 1. Where metal fascias or other metal flashing extend into built-up roofing, extend felt plies under metal with first two plies turned over succeeding plies and back 12 inches.
  - 2. After metal flashing is placed, apply two plies of asphalt-saturated felt flashing, set in pitch-base asphalt cement, over that part of metal extending onto roof.

- I. Approval of Flashing: Obtain approval of complete flashing and connections of roofing with other work before applying final coating and surfacing materials.
- J. Traffic Surfaces: Apply walkway-surface material in hot asphalt over double-aggregate surfacing in individual boards with 10-inch separation between each board. Extend separation through top surfacing to provide drain through walkways at level of original surfacing.

### **3.03 FIELD QUALITY CONTROL:**

- A. Tests:
  - 1. The Engineer may cut six-inch by 24-inch test specimens from roof; one specimen for each 5,000 square feet, but not less than one specimen for each roof level or area. In the event of test cuts, immediately restore roof to its original state, using same number of plies and moppings, shingled-out not less than 26 inches on sides of cut.
  - 2. Should examination and test of specimens disclose lack of specified material or nonconformity to specified requirements, the Engineer may order removal of roofing and replacement as specified, order that additional materials be applied uniformly over entire surface at least to the amount of deficiency disclosed in test specimens or order other corrections to be made.
- B. Prevention of Roof-Drain System Clogging:
  - 1. Prevent asphalt and other roofing materials from entering and clogging roof drains and conductors.
  - 2. Repair or replace clogged or damaged components as directed.
  - 3. Remove roof-drain plugs when no work is taking place or during precipitation.
- C. Correct deficiencies in or remove built-up roofing that does not comply with requirements. Repair substrates, reinstall roofing and repair flashings to a condition free of damage and deterioration.
- D. Prevent asphalt and other roofing materials from spilling or migrating onto surfaces of other construction. Clean spillage using cleaning agents and procedures recommended by manufacturer of affected construction.

### **3.04 CLEAN-UP:**

- A. Clean up rubbish and debris caused by this work and remove from the site.
- B. Promptly remove drippings of pitch and asphalt in exposed places on brick, concrete, steel, copper and other surfaces to prevent irreparable damage to exposed finish surfaces.

**END OF SECTION**

## SECTION 07553

### SELF-ADHERING MODIFIED BITUMINOUS MEMBRANE ROOFING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION

- A. This Section includes the following:
  - 1. Protected, self-adhering roofing membrane, two ply.
  - 2. Insulation.
  - 3. Aggregate ballast.
  - 4. Roof pavers.
  
- B. Related Sections include the following:
  - 1. Rough Carpentry: Section 06100.
  - 2. Flashing and Sheet Metal: Section 07600
  - 3. Roof Specialties: Section 07730
  - 4. Piping Systems: Section 15205

##### 1.02 PERFORMANCE REQUIREMENTS

- A. Install self-adhering modified bituminous membrane roofing and flashing system with compatible components that will not permit passage of liquid and will withstand wind loads, flotation loads, thermally induced movement, and exposure to weather without failure.

##### 1.03 SUBMITTALS

- A. Product Data: For each type of roofing material indicated.
  
- B. Shop Drawings: Show locations and extent of roofing. Include plans, sections, details, and attachments to other Work, for substrate joints and cracks, flashing sheets, roof penetrations, inside and outside corners, vertical intersections, roof slope, expansion joints, and membrane terminations.
  - 1. Show locations, extent, and details of roof pavers.
  
- C. Samples for Verification: For each of the following products:
  - 1. 12-by-12-inch300-by-300-mm square of flashing sheet.
  - 2. 12-by-12-inch300-by-300-mm square of board insulation.
  - 3. 10 lb4.5 kg of aggregate ballast in gradation indicated.
  - 4. Roof paver, full sized, in each color and texture required.
  
- D. Installer Certificates:: Signed by manufacturers certifying that installers comply with requirements.
  
- E. Qualification Data: For Installer.
  
- F. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for current formulation of self-adhering modified bituminous membrane roofing.
  
- G. Research/Evaluation Reports: For self-adhering modified bituminous membrane roofing.
  
- H. Maintenance Data: For roofing system to include in maintenance manuals.
  
- I. Warranties: Draft of special warranty specified in this Section.

- J. Inspection Report for Information: Copy of roofing system manufacturer's inspection report of completed roofing membrane.

#### **1.04 QUALITY ASSURANCE**

- A. Installer Qualifications: An employer of workers trained and approved by manufacturer.
- B. Source Limitations: Obtain roofing membrane materials through one source from a single manufacturer.
- C. Fire-Test-Response Characteristics: Provide self-adhering modified bituminous membrane roofing with the fire-test-response characteristics indicated, as determined by testing identical products per test method indicated below by UL or another testing and inspecting agency acceptable to authorities having jurisdiction. Identify materials with appropriate markings of applicable testing and inspecting agency.
  - 1. Exterior Fire-Test Exposure: Class A; complying with ASTM E 108, for application and slopes indicated.
- D. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Management and Coordination."

#### **1.05 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver materials to Project site in original containers with seals unbroken, labeled with manufacturer's name, product brand name and type, date of manufacture, and directions for storing and mixing with other components.
  - 1. Handle and store roofing materials and place equipment in a manner to avoid significant or permanent damage to deck or structural supporting members.
- B. Protect roofing insulation materials from damage and from deterioration by sunlight, moisture, soiling, and other sources. Store in a dry location.

#### **1.06 PROJECT CONDITIONS**

- A. Environmental Limitations: Apply roofing within the range of ambient and substrate temperatures recommended by roofing system manufacturer. Do not apply roofing to a damp or wet substrate.
  - 1. Do not apply roofing in snow, rain, fog, or mist.

#### **1.07 WARRANTY**

- A. Special Roofing Membrane Manufacturer's Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace roofing that does not remain watertight and base flashing that does not remain watertight or that splits, tears, or separates at seams or from substrate within specified warranty period.
  - 1. Warranty also includes board insulation and roof pavers.
  - 2. Warranty does not include failure of roofing membrane due to formation of new joints and cracks in roof deck in excess of 1/16 inch 1.6 mm wide.
  - 3. Warranty Period: 15 years from date of Substantial Completion.

### **PART 2 - PRODUCTS**

#### **2.01 MANUFACTURERS**

- A. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

## 2.02 ROOFING MEMBRANE

- A. Self-Adhering Modified Bituminous Roofing Membrane: 50-mil-1.3-mm- thick, minimum, sheet consisting of 46 mils1.2 mm, minimum, of rubberized asphalt laminated to a 4-mil-0.10-mm- thick, cross-laminated, high-density polyethylene film; with release liner on adhesive side.
  - 1. Physical Properties: As follows, measured per standard test methods referenced:
    - a. Tensile Strength (Membrane): 250 psi1.7 MPa minimum; ASTM D 412, Die C, modified.
    - b. Ultimate Elongation: 250 percent minimum; ASTM D 412, Die C, modified.
    - c. Pliability: Pass at minus 25 deg Fminus 32 deg C; ASTM D 146.
    - d. Crack Cycling: Unaffected after 100 cycles of 1/8-inch3-mm movement; ASTM C 836.
    - e. Puncture Resistance: 40 lbf180 N minimum; ASTM E 154.
    - f. Water Absorption: 0.15 percent weight-gain maximum after 48-hour immersion at 70 deg F21 deg C; ASTM D 570.
  - 2. Underlayment Membrane: Self-leveling, two-component, elastomeric, cold fluid-applied modified urethane.

## 2.03 AUXILIARY MATERIALS

- A. General: Furnish auxiliary materials recommended by roofing system manufacturer for intended use and compatible with roofing.
  - 1. Furnish liquid-type auxiliary materials that meet VOC limits of authorities having jurisdiction.
- B. Concealed Flashing Membrane: Self-adhering, rubberized-asphalt composite sheet of same material, construction, and thickness as roofing membrane.
- C. Metal Counterflashing: Metal counterflashing is specified in Division 7 Section "Sheet Metal Flashing and Trim."
- D. Liquid Membrane: Trowel grade, two-component, elastomeric, cold fluid-applied urethane.
- E. Mastic and Sealant: Liquid mastic and sealant recommended by manufacturer.
- F. Metal Termination Bars: Manufacturer's standard predrilled stainless-steel or aluminum termination bars, approximately 1 by 1/8 inch25 by 3 mm thick; with anchors.
- G. Fabric Mat: Woven or nonwoven polypropylene, polyolefin, or polyester fabric mat; water permeable and resistant to UV-light degradation; of type and weight recommended by insulation manufacturer for application.

## 2.04 INSULATION

- A. Board Insulation: ASTM C 578; extruded polystyrene, of type, minimum density, and minimum compressive strength indicated below; fabricated with rabbeted edges and with one side having ribbed drainage channels:
  - 1. Type VI, 1.8 lb/cu. ft.29 kg/cu. m and 40 psi276 kPa. Retain paragraph and selected subparagraph below if mortar-faced, extruded-polystyrene roofing insulation is required.
- B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Board Insulation:
    - a. Diversifoam Products.

- b. Dow Chemical Company (The).
- c. Owens Corning.
- d. Tenneco Building Products.

## 2.05 AGGREGATE BALLAST

- A. Aggregate Ballast: Washed, crushed stone or smooth stone that will withstand weather exposure without significant deterioration and will not contribute to membrane degradation. Provide one of the following sizes in accordance with applicable wind load design:
  - 1. Size: ASTM D 448, Size 5, ranging in size from 1/2 to 1 inch13 to 25 mm.
  - 2. Size: ASTM D 448, Size 4, ranging in size from 3/4 to 1-1/2 inches19 to 38 mm.
  - 3. Size: ASTM D 448, Size 2, ranging in size from 1-1/2 to 2-1/2 inches38 to 63 mm.

## 2.06 ROOF PAVERS

- A. Roof Pavers: Heavyweight, hydraulically pressed, concrete units, with top edges beveled **3/16 inch5 mm**, factory cast for use as roof pavers; absorption not greater than 5 percent, ASTM C 140; no breakage and maximum 1 percent mass loss when tested for freeze-thaw resistance, ASTM C 67; and as follows:
  - 1. Size: 24 by 24 inches600 by 600 mm. Manufacture pavers to dimensional tolerances of plus or minus 1/16 inch1.6 mm in length, height, and thickness
  - 2. Weight: In accordance with wind load design.
  - 3. Colors and Textures: As selected by The Engineer from manufacturer's full range.
  - 4. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - 5. Hanover Architectural Products, Inc.
    - 6. Rapid Building Systems.
    - 7. Roofblok, Ltd.
    - 8. Sunny Brook Pressed Concrete Co.
    - 9. Wausau Tile, Inc.; Terra-Paving Div.
    - 10. Westile Roofing Products.

## PART 3 - EXECUTION

### 3.01 EXAMINATION

- A. Examine substrates, areas, and conditions under which roofing will be applied, with Installer present, for compliance with requirements and other conditions affecting performance.
  - 1. Proceed with installation only after minimum concrete drying period recommended by roofing system manufacturer has passed.
  - 2. Verify that concrete substrate is visibly dry and free of moisture. Test for capillary moisture by plastic sheet method according to ASTM D 4263.
  - 3. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.02 PREPARATION

- A. Clean and prepare substrate according to manufacturer's written recommendations. Provide clean, dust-free, and dry substrate for roofing application.
- B. Mask off adjoining surfaces not receiving roofing to prevent spillage from affecting other construction.
- C. Protect roof drains and other deck penetrations to prevent spillage and migration of roofing fluids.

- D. Remove grease, oil, form-release agents, paints, curing compounds, and other penetrating contaminants or film-forming coatings from concrete.
- E. Remove fins, ridges, mortar, and other projections and fill honeycomb, aggregate pockets, holes, and other voids.
- F. Prepare, fill, and treat joints and cracks in substrate. Remove dust and dirt from joints and cracks according to ASTM D 4258.
  - 1. Install roofing membrane strip and center over treated construction and contraction joints and cracks exceeding a width of 1/16 inch1.6 mm.
- G. Prepare, treat, and seal vertical and horizontal surfaces at terminations and penetrations through roofing and at drains and protrusions.

### **3.03 ROOFING MEMBRANE INSTALLATION**

- A. Install roofing membrane according to roofing membrane manufacturer's written instructions.
- B. Install fluid-applied underlayment membrane to substrate over area to receive roofing membrane and base flashing. Spread over roof deck to form a uniform, seamless membrane, average 60 mils1.5 mm thick, but not less than 40 mils1 mm thick. Allow to cure for at least 24 hours before subjecting to foot traffic.
  - 1. Install fluid-applied underlayment membrane to extend beyond height of concealed flashing membrane.
- C. Install liquid-membrane beads at roof-deck-supported wall junctions. Install transition membrane strips centered over inside and outside corners and at roof terminations.
  - 1. Install bead of liquid membrane on horizontal inside corners.
- D. Install self-adhering modified bituminous membrane roofing.
- E. Two-Ply Application: Apply and firmly adhere membrane over underlayment membrane. Accurately align sheets and maintain uniform side laps of not less than 50 percent of sheet width to provide minimum coverage of 2 thicknesses of membrane. Maintain uniform 6-inch-150-mm- wide end laps. Overlap and roll seams and stagger end laps. Seal T-joints at end laps of top ply.
- F. Apply membrane from low point to high point of roof deck to ensure that side laps shed water.
- G. Repair tears, voids, and lapped seams in roofing not complying with requirements. Slit and flatten fishmouths and blisters. Patch with roofing membrane extending 6 inches150 mm beyond repaired areas in all directions.
- H. Correct deficiencies in or remove roofing membrane that does not comply with requirements, repair substrates, reapply roofing membrane, and repair flashing sheets.

### **3.04 FLASHING INSTALLATION**

- A. Install concealed flashing membrane at terminations, at roof edges, and at penetrations through roofing membrane, according to roofing membrane manufacturer's written instructions.
- B. Install concealed flashing membrane and extend up walls or parapets a minimum of 8 inches200 mm above insulation.

- C. Install termination bars and mechanically fasten to top of concealed flashing membrane at terminations and perimeter of roofing.
- D. Seal junction of roofing membrane and concealed flashing membrane with mastic or sealant fillets.

### 3.05 INSULATION INSTALLATION

- A. Loosely lay board insulation units over roofing membrane, with long joints of insulation in continuous straight lines and with end joints staggered between rows. Abut edges and ends between units.
- B. Install one or more layers of insulation to achieve required thickness over roofing membrane. Cut and fit to within 3/4 inch 19 mm of projections and penetrations.
- C. Install fabric mat over insulation, overlapping edges and ends at least 12 inches 300 mm. Do not lap ends of fabric sheets within 72 inches 1800 mm of roof perimeter. Extend fabric 2 to 3 inches 50 to 75 mm above ballast at perimeter and penetrations. Apply additional layer of fabric around penetrations to prevent aggregate from getting between penetration and insulation. Do not cover drains or restrict water flow to drains.

### 3.06 BALLAST INSTALLATION

- A. Apply ballast uniformly over fabric mat at rate required by insulation manufacturer, but not less than the following, carefully spreading aggregate to minimize possibility of damage to membrane. Apply ballast as insulation is installed, leaving roofing membrane insulated and ballasted at end of workday. Provide one of the following in accordance with wind load design:
  1. Ballast: 15 lb/sq. ft. 75 kg/sq. m, Size 5 aggregate within 48 inches 1200 mm of roof perimeter and 24 inches 600 mm of roof penetrations; 10 lb/sq. ft. 50 kg/sq. m, Size 5 aggregate elsewhere.
    - a. Install one row of roof pavers in lieu of aggregate ballast to roof perimeter and penetrations.
  2. Ballast: 15 lb/sq. ft. 75 kg/sq. m, Size 4 aggregate within 48 inches 1200 mm of roof perimeter and 24 inches 600 mm of roof penetrations; 12 lb/sq. ft. 60 kg/sq. m, Size 4 aggregate elsewhere.
  3. Ballast: 12 lb/sq. ft. 60 kg/sq. m, Size 4 aggregate to field of roof; lay 2 rows of roof pavers at roof perimeters and penetrations according to insulation manufacturer's written instructions.
  4. Ballast: 15 lb/sq. ft. 75 kg/sq. m, Size 2 aggregate within 48 inches 1200 mm of roof perimeter and 24 inches 600 mm of roof penetrations; 13 lb/sq. ft. 65 kg/sq. m, Size 2 aggregate to field of roof; lay 3 rows of roof pavers to corners of roof according to insulation manufacturer's written instructions. Mechanically fasten securement strapping to first row of corner edge roof pavers.
  5. Ballast: 13 lb/sq. ft. 65 kg/sq. m, Size 2 aggregate to field of roof; lay 3 rows of concrete pavers at roof perimeter, corners, and penetrations according to insulation manufacturer's written instructions. Mechanically fasten securement strapping to first row of perimeter and corner edge roof pavers.
  6. Ballast: 15 lb/sq. ft. 75 kg/sq. m, Size 2 aggregate within 24 inches 600 mm of roof penetrations; 13 lb/sq. ft. 65 kg/sq. m, Size 2 aggregate to field of roof; lay 4 rows of roof pavers along roof perimeter and at corners according to insulation manufacturer's written instructions. Mechanically fasten securement strapping to first two rows of perimeter and corner edge roof pavers.
  7. Walkway Pavers: Lay roof-paver walkways using roof pavers of size indicated or, if not indicated, of manufacturer's standard size.

### 3.07 ROOF-PAVER INSTALLATION

- A. Lay roof-paver ballast according to insulation manufacturer's written instructions.
  - 1. Install roof pavers on pedestals set according to pedestal manufacturer's written instructions.

### **3.08 FIELD QUALITY CONTROL**

- A. Engage a qualified testing agency to observe flood tests and to determine and report leaks.
- B. Flood Testing: Flood test each roof deck area for leaks, according to recommendations in ASTM D 5957, after completing roofing and flashing, but before overlying construction is placed. Install temporary containment assemblies, plug or dam drains, and flood with potable water.
  - 1. Flood to an average depth of 2-1/2 inches65 mm with a minimum depth of 1 inch25 mm and not exceeding a depth of 4 inches100 mm. Maintain 2 inches50 mm of clearance from top of base flashing. Water depth not to exceed load capacity of roof deck.
  - 2. Flood each area for 24 hours.
  - 3. After flood testing, repair leaks, repeat flood tests, and make further repairs until roofing and flashing installation is watertight.
- C. Final Roof Inspection: Arrange for roofing system manufacturer's technical personnel to inspect roofing installation on completion of roofing membrane and flashing.
  - 1. Notify The Engineer 48 hours in advance of date and time of inspection.
- D. Correct deficiencies in or remove roofing that does not comply with requirements, repair substrates, reapply roofing, and repair flashing.
  - 1. After flood tests, repair leaks and make further repairs until roofing installation is watertight.
- E. Additional testing, at Contractor's expense, will be performed to determine compliance of corrected Work with requirements.

### **3.08 PROTECTING AND CLEANING**

- A. Protect roofing according to manufacturer's written recommendations to prevent damage and wear during application and remainder of construction period.
- B. Protect installed insulation from damage due to UV-light exposure, physical abuse, and other causes. Provide temporary coverings where insulation will be subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.
- C. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

**END OF SECTION**

## SECTION 07600

### FLASHING AND SHEET METAL

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing miscellaneous-waterproofing sheet metal including metal flashings, copings, exposed trim, fasciae, gravel stops, reglets, scuppers, gutters and downspouts, conductor heads, splash pans, drip edges, roof and roof-to-wall expansion joint covers, shower pans, overhead piping safety pans, metal accessories, gutter screens, strainers, red-rosin paper, solder, and related nailing strips and miscellaneous wood supports.
- B. Related Work Specified Elsewhere:
  - 1. Brick Masonry: Section 04215.
  - 2. Concrete Unit Masonry: Section 04220
  - 3. Rough Carpentry: Section 06100.
  - 4. Seals and Sealants: Section 07900.
  - 5. Roof Accessories: Section 07730.
  - 6. Sheetmetal Roofing Systems: Section 07411.
  - 7. Built-up Roofing: Section 07515.

##### 1.02 PERFORMANCE REQUIREMENTS:

- A. General: Install sheet metal flashing and trim to withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failing.
- B. Fabricate and install flashings at roof edges to comply with recommendations of FM Loss Prevention Data Sheet 1-49 for the following wind zone:
  - 1. Wind Zone 3: Wind pressures of 46 to 104 psf.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Product Data including manufacturer's material and finish data, installation instructions, and general recommendations for each specified flashing material and fabricated product.
  - 2. Shop Drawings:
    - a. Show both shop-fabricated and site-fabricated work, indicating where each item is fabricated. Include complete details of joints, supports and fasteners, in accordance with SMACNA Architectural Sheet Metal Manual standard details where applicable.
    - b. Show dimensions and locations of wood nailing strips, miscellaneous wood supports and details of installation.
    - c. Fabricated Masonry Flashing: Detail corner units, end-dam units, and other special applications.
  - 3. Samples: Three of each type of the following materials used in the work:
    - a. Stainless steel: 12 inches square.
    - b. Lead-coated copper: 12 inches square.
    - c. Bituminous paint: Pint containers.
    - d. Aluminum coping: 12-inch by 12-inch corner section.
    - e. Stainless steel coping: 12-inch by 12-inch corner section.

- f. Reglets: 12-inch strips.
- g. Expansion-joint cover: 12-inch strips.
- h. Downspout and gutter: 12-inch length with anchor strap.
- i. Copper-Laminated Flashing: 12 inches square.
- j. Coil-coated galvanized steel: 12 inches square.
- k. Copper: 12 inches square.
- l. Metal accessories.

B. Certification.

#### **1.04 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. SMACNA: Architectural Sheet Metal Manual.
  - 3. FS: QQ-L-201, UU-B-790.
  - 4. AAMA: 606.1.
  - 5. NRCA: Roofing and Waterproofing Manual.
  - 6. ASTM: A167, A755, B32, B101, B209, B221, B370.
  - 7. UL: 580 for Class 90 wind-uplift resistance.
  - 8. FM: Loss Prevention Data Sheet 1-49.
  - 9. Copper Development Association: Copper in Architecture Handbook.
- B. Installer Qualifications: Engage an experienced Installer who has completed sheet metal flashing and trim work similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.
- C. Coordinate Work of this Section with interfacing and adjoining Work for proper sequencing of each installation. Ensure best possible weather resistance, durability of Work, and protection of materials and finishes.

#### **1.05 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Deliver products to jobsite in original unopened containers clearly marked with manufacturer's name and brand designation, reference specification number, type and class as applicable.
- B. Store products in approved dry area and protect from contact with soil and exposure to the elements. Keep products dry.
- C. Handle products so as to prevent breakage of containers and damage to products.

### **PART 2 - PRODUCTS**

#### **2.01 MATERIALS:**

- A. Stainless Steel:
  - 1. Through-wall flashing (mechanically keyed) sheets: ASTM A167, Type 304, soft annealed, minimum thickness 0.012 inch.
  - 2. Fascia, exposed trims, reglets, roof drain flashings, base flashings, counterflashings, flashing receivers, valley flashings, drip edges, eave flashings, equipment support flashings, roof penetration flashings, roof expansion joint covers, scuppers: ASTM A167, Type 304, hard tempered, minimum thickness 0.0187 inch, unless otherwise shown or indicated.

3. Copings, gravel stops, and roof-to-wall expansion joint covers: ASTM A167, Type 304, hard tempered, minimum thickness 0.025 inch, unless otherwise shown or indicated.
    - a. Backing or stiffeners required to prevent oil-canning and waviness.
    - b. Finish: No. 2D.
- B. Copper Sheet and Strips: ASTM B370; temper H00, cold-rolled except where temper O60 is required for forming:
1. Shower pans: Not less than 16-ounces/square foot, unless otherwise shown.
  2. Concealed copper-laminated flashing:
    - a. Manufacturer's standard laminated flashing consisting of 7-oz./sq. ft. sheet copper bonded with asphalt between 2 layers of glass-fiber cloth. Use only where flashing is fully concealed in masonry.
- C. Lead-Coated Copper:
1. ASTM B101, cold-rolled copper sheet with temper O60 (soft) for flashing, temper H00 or H01 for other uses as appropriate, sheet weight and lead coating weight as specified below:
    - a. Gutters with girth up to 20 inches, downspouts, conductor heads, reglets, base flashings, counterflashings, flashing receivers, valley flashings, drip edges, eave flashings, equipment support flashings, roof drain flashings, roof penetration flashings, roof expansion joint covers, roof-to-wall expansion joint covers, and splash pans: Copper sheet weighing not less than 16 ounces/square foot.
    - b. Scuppers: Copper sheet weighing not less than 20 ounces/square foot.
    - c. Gutters with girth larger than 20 inches and overhead piping safety pans: Copper sheet weighing not less than 24 ounces/square foot.
    - d. Both sides of copper sheet coated with lead weighing not less than 12 nor more than 15 pounds/100 square feet, unless otherwise indicated.
- D. Coil-Coated Galvanized Steel Sheet:
1. Zinc-coated, commercial quality steel sheet with thickness as specified below conforming to ASTM A755, G90 coating designation, coil coated with high-performance fluoropolymer coating of not less than 1 mil thick (0.2 mil primer and 0.8 mil fluoropolymer) each side, unless otherwise specified.
  2. Counter flashings and flashings receivers: Minimum thickness of steel sheet 0.0217 inch, unless otherwise shown or indicated.
  3. Fasciae, trims, drip edges, eave flashings, base flashings, valley flashings, and equipment support flashings: Minimum thickness of steel sheet 0.0276 inch, unless otherwise shown or indicated.
    - a. Backing or stiffeners for fasciae and trims required to prevent oil-canning and waviness.
- E. Aluminum:
1. Extruded anodized fasciae, exposed trims, copings and gravel stops: ASTM B221, Alloy 6063-T52, minimum thickness 0.125 inch.
  2. Alloy sheet anodized scuppers, roof expansion joint covers, and roof-to-wall expansion joint covers: ASTM B209, Alloy 5005-H14, minimum thickness 0.050 inch.
  3. Alloy sheet anodized drip edges, eave flashings, base flashings, counterflashings, and flashing receivers: ASTM B209, Alloy 5005-H14, minimum thickness 0.040 inch.
  4. Finish: Class I color anodized finish with anodic layer thicker than 0.7 mil, dark bronze color, per AAMA 606.1, Guide Specifications and Inspection Methods for Integral Color Anodic Finishes for Architectural Aluminum.

- F. Lead:
  - 1. Flashing for plumbing vents:
    - a. Sheet lead, FS QQ-L-201, minimum 2-1/2 pounds per square foot.
  
- G. Miscellaneous Items:
  - 1. Red-rosin paper:
    - a. FS UU-B-790, Type I, Style 1b, 5 lb/sq., sized building paper.
  - 2. Vinyl tape: As recommended by the metal product manufacturer as a dissimilar metal separator.
  - 3. Wood blocking: Section 06100.
  - 4. Bituminous Paint: As recommended by the manufacturer as a dissimilar metal separator.
  - 5. Solder: ASTM B32, with flux-core; of the following solder alloys. Use another alloy if it is demonstrated to the Engineer that better results, including visual as applicable, can be achieved on the particular metals being joined.
    - a. For stainless steel: Tin/silver solder, Alloy Grade Sn96, with acid flux of type recommended by stainless steel manufacturer.
    - b. For copper: 50-50 tin/lead solder, Alloy Grade Sn50, with rosin flux. For lead-coated copper: 60-40 tin/lead solder, Alloy Grade Sn60, with rosin flux.
  - 6. Sealant:
    - a. Elastomeric: Section 07900.
    - b. Epoxy Seam Sealer: Two-part, non-corrosive, aluminum seam-cementing compound as recommended by aluminum manufacturer for exterior and interior non-moving joints including riveted joints.
    - c. Mastic Sealant: Polyisobutylene, nonhardening, nonskinning, nondrying, nonmigrating sealant.
  - 7. Metal Accessories and Fasteners: Provide sheet metal clips, straps, anchoring devices, and similar accessory units as required for installation of Work, matching, matching finish of exposed heads, or compatible with material being installed as approved; noncorrosive; size and thickness required for performance per approved samples.
  - 8. Gutter Screen: 1/4-inch non-corrosive hardware cloth installed in sheet metal frames.
  - 9. Adhesives: Type recommended by flashing sheetmetal manufacturer for waterproof and weather-resistant seaming and adhesive application of flashing sheetmetal.
  - 10. Roofing Cement: ASTM D4586, Type I, asbestos free, asphalt based.
  - 11. Asphalt Mastic for under flashing receivers and counterflashing and paint on lap seams and base flashing: SSPC-Paint 12, solvent-type mastic, nominally free of sulfur and containing no asbestos fibers, compounded for 15-mil dry-film thickness per coat.

## **2.02 FABRICATION, GENERAL:**

- A. Sheet Metal Fabrication Standard: Fabricate sheet metal flashing and trim to comply with recommendations of SMACNA's "Architectural Sheet Metal Manual" that apply to the design, dimensions, metal, and other characteristics of the item indicated.
- B. Comply with details shown to fabricate sheet metal flashing and trim that fit substrates and result in waterproof and weather-resistant performance once installed. Verify shapes and dimensions of surfaces to be covered before fabricating sheet metal.
- C. Form exposed sheet metal Work that is without excessive oil canning, buckling, and tool marks and that is true to line and levels indicated, with exposed edges folded back to form hems.

- D. Expansion Provisions: Space movement joints at maximum of 10 feet with no joints allowed within 24 inches of corner or intersection. Where lapped or bayonet-type expansion provisions in the Work cannot be used or would not be sufficiently weatherproof and waterproof, form expansion joints or intermeshing hooked flanges, not less than one-inch deep, filled with mastic sealant (concealed within the joints).
- E. Fabricate nonmoving joints with flat-lock seams. For tin edges to be seamed, form seams and solder. For aluminum to be seamed, form seams and seal with epoxy seam sealer and rivet joints for additional strength as approved.
- F. Sealed joints: Form movable joints in metal to accommodate elastomeric sealant to comply with SMACNA standards.
- G. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces of sheet metal exposed to public view.
- H. Fabricate cleats and attachment devices from same material as sheet metal component being anchored or from compatible, noncorrosive metal recommended by sheet metal manufacturer.
  - 1. Size: As recommended by SMACNA manual or sheet metal manufacturer for application but never less than thickness of metal being secured.

### **2.03 SHEETMETAL FABRICATIONS:**

- A. Downspout: Plain, rectangular, lead-coated copper in accordance with SMACNA Architectural Sheet Metal Manual standards, unless otherwise shown.
- B. Gutters: Lead-coated copper in accordance with SMACNA standards.
- C. Gutter Screen: Fabricate screen and frame of approved material
- D. Reglets:
  - 1. Stainless steel or lead-coated copper, matching flashing material, closed-slot, friction-type.
- E. Roof and Wall-to-Roof Expansion Joint Covers:
  - 1. Combination of neoprene and lead-coated copper or stainless steel, with the following additional requirements:
    - a. Cover with neoprene bonded to metal edgings by means of neoprene-based adhesive comprising primer and vulcanizing cement to produce high-strength bond.
    - b. For neoprene part of cover, cured neoprene sheet, tensile strength 1,500-psi minimum, elongation 250-percent minimum, bonded to metal with peel-pull value of 25 pounds per inch minimum at right angles; thickness and width as shown.
    - c. Edgings of metal cover, four inches wide, perforated with holes four inches on centers minimum.
- F. Coping and Gravel Stops:
  - 1. Extruded aluminum or stainless steel, assemblies tested for wind-uplift resistance in accordance with UL 580 for Class 90-uplift resistance, or greater as required by jurisdictional authority, with testing performed by testing agency acceptable to the Engineer.

- a. Size: 10-foot long sections, with factory-fabricated corners and intersections, formed with no visible fasteners.
  - b. Movement joint design: Incorporate a waterproof seal using an internal weep system and rubber or vinyl seals into the non-welded joints.
  - c. Fasteners and clips: As standard with the manufacturer for required wind-uplift resistance. Where exposed, finish to match the metal finish.
- G. Flashing for Plumbing Vents:
- 1. Lead, sized to extend at least four inches horizontally on roof around pipe, over pipe, and one-inch inside pipe.
- H. Strainer:
- 1. Stainless-steel ,12-gauge wires spaced not greater than 1/2-inch apart, as shown and as approved.
- I. Miscellaneous-waterproofing sheetmetal flashings, fasciae, trims, drip edges, scuppers, conductor heads, shower pans, splash pans, and overhead piping safety pans:
- 1. Fabricated from material as previously specified, sized as shown and as approved.

### **PART 3 - EXECUTION**

#### **3.01 PREPARATION:**

- A. Clean dirt, debris, grease, oil and other foreign substances from surfaces that are to receive metalwork. Coordinate with work of other Sections: 04215, 04220, 07411, and 07730.

#### **3.02 INSTALLATION:**

- A. Coordinate flashing and sheet metal with the work of other trades. Shop-fabricate the work whenever possible. Provide for expansion and contraction of sheet metal.
- B. Install the work of this Section in accordance with the NRCA Roofing and Waterproofing Manual, performance requirements, manufacturers' instructions and SMACNA's Architectural Sheet Metal Manual. Anchor units securely in place by methods indicated and conceal fasteners where possible. Set units true to line and level with exposed edges folded back to form hems. Install exposed sheetmetal without excessive oil canning, buckling and tool marks. Verify shapes and dimensions of surfaces to be covered prior to fabrication and trim to fit substrates. Install work with laps, joints and seams that will be permanently watertight and weatherproof. Provide for thermal expansion of metal units. Space movement joints at a maximum of 10 feet with no joints allowed within 24 inches of corner or intersection. Where lapped or bayonet-type expansion provisions cannot be used or would not be sufficiently weatherproof and waterproof, form expansion joints of intermeshing hooked flanges not less than one-inch deep and fill with mastic sealant concealed within joints. Form nonexpansion joints in metal to accommodate elastomeric sealant to comply with SMACNA standards. Fill joint with sealant and form metal to completely conceal sealant. Use joint adhesive for non-moving joints specified not to be soldered. Fabricate non-moving seams in sheetmetal with flat-lock seams, except fabricate non-moving seams in aluminum with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints as approved for additional strength.. Tin edges to be seamed, form seams and solder.
- C. Perform cutting, drilling and other operations in connection with sheet metal work to accommodate work of other trades. Provide accessories as recommended by SMACNA Architectural Sheet Metal Manual.

- D. Where sheet metal abuts or interfaces with adjacent materials, join as shown on approved shop drawings. Isolate dissimilar metals by use of compatible coatings or other approved methods. Apply red-rosin paper backing for sheet metal applied to any surface to permit movement caused by expansion or to prevent galvanic action.
- E. Soldering:
1. Clean surfaces to be soldered to remove oils and foreign matter. Brush liberal amount of flux on seams, solder immediately, neutralize acid and clean.
  2. Solder slowly, thoroughly heating seam and completely sweating solder through full width of seam. Use ample solder for full width along seams.
  3. Do not solder aluminum and coil-coated galvanized steel sheet. Pre-tinning is not required for lead and lead-coated copper. Do not use torches for soldering, heat surfaces to receive solder and flow solder into joint. Fill joint completely. Completely remove flux and spatter from exposed surfaces.
- F. Seams:
1. Flat lock: 3/4-inch wide, minimum.
  2. Solder lap: One-inch wide, minimum
  3. Unsoldered plain lap: Three-inches wide, minimum.
  4. Seams: Corresponding to direction of flow.
- G. Form flashings from material shown or specified made up from sheets eight to 10 feet long with locked and soldered seams into units of not more than 16 feet. Join units together with three-inch wide loose-locked seams filled with sealant before units are joined. Runs of flashing shorter than 16 feet will not require loose-seam joints. Miter corners and join by locked and soldered joints.
- H. Install expansion-joint covers as indicated and in accordance with manufacturer's recommendations. Splice ends of adjoining lengths of covers with neoprene tabs applied to both faces with approved adhesive. Provide prefabricated corners, intersections and crossovers.
- I. Form cap flashing at parapet walls and other vertical surfaces to extend into metal reglets built into structure and prefilled with sealant. Lap built-up roof flashings and form metal to provide spring action against roof flashings. Prior to installation, coat flashing portions to be concealed with bituminous paint.
- J. Where cants do not occur at intersections of roof decks and vertical surfaces of walls and other construction, provide flashings. Extend base flashings up vertical surfaces eight inches unless otherwise shown, behind metal cap flashing and out onto roof or horizontal surface not less than eight inches. Coat back sides of base flashing with bituminous paint and set into angle formed by roof and vertical surfaces after three plies of roofing-felt reinforcement have been laid. Nail flange with nails spaced three inches on centers and 3/4-inch from edge into wooden nailer provided in roof slab. Secure metal flashing at roof edges according to FM Loss Prevention Data Sheet 1-49 for specified wind zone.
- K. Reglets: Form reglets to reproduce detail and design shown. Form sharp, even and true profiles, bends and intersections. Lock or lap joints and solder or reinforce joints as shown on approved shop drawings or specified. Install reglets to receive counterflashings: Furnish reglets for installation under Division 3 concrete and under Division 4 masonry.
- L. Coping: Install coping in accordance with manufacturer's recommendations. Locate fasteners and clips as follows:
1. At joints and at five-foot maximum intervals.
  2. Center butt joints over anchor clips.
  3. Secure in place allowing for thermal expansion and establishing watertight joint.

- M. Counterflashings: Coordinate installation of counterflashings with installation of assemblies to be protected by counterflashing. Install counterflashings in reglets or receivers. Secure in a waterproof manner by means of snap-in installation and sealant, lead wedges and sealant, interlocking folded seam, or blind rivets and sealant. Lap counterflashing joints a minimum of 2 inches and bed with sealant.
- N. Roof-Drainage System: Install drainage items fabricated from sheet metal, with straps, adhesives, and anchors recommended by SMACNA's Manual or the item manufacturer, to drain roof in the most efficient manner. Coordinate roof-drain flashing installation with roof-drainage system installation. Coordinate flashing and sheet metal items for steep-sloped roofs with roofing installation. Install strainer at top of downspout.
- O. Equipment Support Flashing: Coordinate equipment support flashing installation with roofing and equipment installation. Weld or seal flashing to equipment support member.
- P. Roof-Penetration Flashing: Coordinate roof-penetration flashing installation with roofing and installation of items penetrating roof. Install flashing as follows:
  - 1. Turn flashing down inside vent piping, being careful not to block vent piping with flashing.
  - 2. Seal and clamp flashing to pipes penetrating roof, other than lead flashing on vent piping.
- Q. Install continuous gutter screens on gutters with noncorrosive fasteners, arranged as hinged units to swing open for cleaning gutters.
- R. Overhead-Piping Safety Pan: Suspend pans from pipe and install drain line to plumbing waste or drain line.
- S. Splash Pans: Install where downspouts discharge on low-sloped roofs, unless otherwise shown. Set in roof cement or sealant compatible with roofing material.
- T. Install sealant in accordance with Section 07900.
- U. Install wood blocking in accordance with Section 06100.

**3.03 CLEAN-UP:**

- A. Clean up rubbish and debris caused by this work and remove from site.
- B. Promptly remove drippings and stains of materials from exposed surfaces.
- C. Provide final protection and maintain conditions that ensure sheet metal flashing and trim Work during construction is without damage or deterioration other than natural weathering at the time of Substantial Completion.

**END OF SECTION**

## SECTION 07730

### ROOF ACCESSORIES

#### PART1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing roof hatches, equipment supports, roof vents, snow guards and miscellaneous roof accessories.
- B. Related Work Specified Elsewhere:
  - 1. Rough Carpentry: Section 06100.
  - 2. Seals and Sealants: Section 07900.
  - 3. Roof Anchors: Section 11010

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Product Data: For each type of product indicated. Include construction details, materials, dimensions of individual components and profiles, and finishes.
  - 2. Shop Drawings: Show fabrication and installation details. Indicate dimensions, weights, loadings, required clearances, method of field assembly, and components. Include plans, elevations, sections, details, and attachments to other Work.
  - 3. Coordination Drawings: Roof plans drawn to scale and coordinating penetrations and roof-mounted items. Show the following:
    - a. Size and location of roof accessories specified in this Section.
    - b. Method of attaching roof accessories to roof or building structure.
    - c. Other roof-mounted items including mechanical and electrical equipment, ductwork, piping, and conduit.
  - 4. Samples for Verification: For each type of exposed finish required, prepared on Samples in manufacturer's standard sizes, and of same thickness and material indicated for the Work. If finishes involve normal color or shade variations, include sample sets showing the full range of variations expected. Provide a mock-up of custom-fabricated items
  - 5. Certification.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. NRCA: Roofing and Waterproofing Manual.
  - 3. SMACNA: Architectural Sheet Metal Manual.
  - 4. ASTM: A653, A729, A780, B209, B221, C920, C1036, D256, D4586, E527.
  - 5. UL 793, 972.
  - 6. SSPC - Paint 12
  - 7. NFPA: 204M.
  - 8. NAAMM.

##### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver products to jobsite in original unopened containers clearly labeled with manufacturer's name and brand designation, type, class and rating as applicable.
- B. Store products in approved dry area and protect from contact with soil and from exposure to the elements.
- C. Handle products to prevent breakage of containers and damage to products.

#### PART 2 - PRODUCTS

## 2.01 MATERIALS, GENERAL:

- A. Aluminum Sheet: ASTM B 209 for alclad alloy 3005H25 or alloy and temper required to suit forming operations, with mill finish, unless otherwise indicated
- B. Extruded Aluminum: ASTM B 221 alloy 6063-T52 or alloy and temper required to suit structural and finish requirements, with mill finish, unless otherwise indicated
- C. Galvanized Steel Sheet: ASTM A 653 with G90 coating designation; commercial quality, unless otherwise indicated.
  - 1. Structural Quality: Grade 40, where indicated or as required for strength.
- D. Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792 with Class AZ-50 coating, structural quality, Grade 40, or as required for strength.
- E. Plastic Sheet: Unless additional thickness is required for light transmittances, provide glazing plastic sheet thickness required for 40-lbf/sq. ft. external and 20-lbf/sq. ft. internal loading pressures as recommended by the manufacturer for the size and shape indicated.
  - 1. Polycarbonate: Thermoformable, monolithic polycarbonate sheets manufactured by the extrusion process, burglar-resistance rated per UL 972 with average impact strength of 16 ft-lbf/in. of width when tested according to ASTM D 256, Method A (Izod)
- F. Insulation: Manufacturer's standard rigid or semirigid glass-fiber board of thickness indicated.
- G. Wood Nailers: Not less than 1-1/2 inches thick complying with Section 06100.
- H. Fasteners: Same metal as metals being fastened, or nonmagnetic stainless steel or other noncorrosive metal as recommended by manufacturer. Match finish of exposed fasteners with finish of material being fastened.
  - 1. Where removing exterior exposed fasteners affords access to building, provide nonremovable fastener heads.
- I. Gaskets: Manufacturer's standard tubular or fingered design of neoprene, EPDM, or PVC; or flat design of foam rubber, sponge neoprene, or cork.
- J. Bituminous Coating: SSPC-Paint 12, solvent-type bituminous mastic, nominally free of sulfur and containing no asbestos fibers, compounded for 15-mil dry film thickness per coating.
- K. Mastic Sealant: Polyisobutylene; nonhardening, nonskinning, nondrying, nonmigrating sealant.
- L. Elastomeric Sealant: Generic type recommended by unit manufacturer that is compatible with joint surfaces; ASTM C 920, Type S, Grade NS, Class 25, and Uses NT, G, A, and, as applicable to joint substrates indicated, O and in accordance with Section 07900.
- M. Roofing Cement: ASTM D 4586, nonasbestos, fibrated asphalt cement designed for trowel application or other adhesive compatible with roofing system.

## 2.02 ROOF CURBS AND EQUIPMENT SUPPORTS:

- A. General: Provide roof curbs capable of supporting superimposed live and dead loads, including equipment loads and other construction to be supported on roof curbs. Coordinate dimensions with rough-in information or Shop Drawings of equipment to be supported.
- B. Fabrication: Unless otherwise indicated or required for strength, fabricate units from minimum 0.0747-inch thick, structural-quality, hot-dip galvanized or aluminum-zinc alloy-coated steel sheet; factory primed and prepared for painting with welded or sealed mechanical corner joints.

### 2.03 ROOF HATCHES:

- A. General: Fabricate units to withstand 40-lbf/sq. ft. external and 20-lbf/sq. ft. internal loading pressure. Frame with minimum 9-inch- high, integral-curb, double-wall construction with 1-1/2-inch insulation, formed cants and cap flashing (roofing counterflashing), with welded or sealed mechanical corner joints. Provide double-wall cover (lid) construction with 1- inch-thick insulation core. Provide gasketing and equip with corrosion-resistant or hot-dip galvanized hardware including pintle hinges, hold-open devices, interior padlock hasps, and both interior and exterior latch handles.
- B. Type: Single-leaf personnel access.
  - 1. For Ladder Access: 30 by 36 inches.
  - 2. For Ship's Ladder Access: 30 by 54 inches.
    - a. For Stair Access: 30 by 102 inches.
- C. Type: Double leaf for equipment access.
  - 1. Size: 72 by 96 inches.
- D. Material and Finish: Galvanized steel, baked enamel.
- E. Sloping Roofs: Where slope or roof deck exceeds 1/4 inch per foot (1:48), fabricate hatch curbs with height tapered to match slope to level tops of units.

### 2.04 SMOKE VENTS:

- A. General: Automatically operated roof vents for heat and smoke constructed to operate (open) without power source that could be interrupted during a fire. Custom fabricate units only to extent necessary to comply with indicated dimensions and other special requirements.
- B. Live Load and Uplift: Unless otherwise indicated, fabricate to withstand a minimum 10-lbf/sq. ft. external live load and 30-lbf/sq. ft. uplift.
- C. Regulatory Requirements: Comply with provisions of the following:
  - 1. UL 793, for construction and performance of automatically operated roof vents for heat and smoke
  - 2. NFPA 204M, for heat-and-smoke vent design constraints, operation, size, and location.\
- D. Framing: Fabricate from the following materials, with manufacturer's standard welded or sealed mechanical corner joints, including cap flashing (roofing counterflashing):
  - 1. Material: Formed sheet or extruded aluminum or galvanized steel, at Contractor's option
    - a. Finish: Baked enamel.
    - b. Finish: High-performance organic coating.
  - 2. Unit Support: Double-wall curb construction with 1-inch insulation, of height indicated or, if not indicated, for mounting with height minimum 9 inches above roof membrane.
    - a. Provide formed cants and base profile coordinated with roof type and insulation thickness.
  - 3. Sloping Roofs: Where slope of roof deck exceeds 1/4 inch per foot(1:48), fabricate curbs with height tapered to match slope to level tops of units.
- E. Dome-Type Units: Manufacturer's standard gravity-opened, shrink-back and drop-out, acrylic or PVC sheet, dome unit for 165 deg F activation. Provide glazing system for easy replacement of activated domes and for drainage of condensation to exterior.
  - 1. Inner Double-Dome Color: Bronze.

### 2.05 SNOWGUARDS:

- A. L-shaped stop-type, metal or plastic.
- B. Provide in accordance with approved mock-up sample.

## **2.06 FINISHES, GENERAL:**

- A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- C. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

## **2.07 ALUMINUM FINISHES:**

- A. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
- B. Conversion-Coated and Factory-Primed Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; Organic Coating: as specified below).
  - 1. Organic Coating: Air-dried primer of not less than 2.0-mil/0.5-mm dry film thickness.
- C. Baked-Enamel Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; Organic Coating: as specified below). Apply baked enamel complying with paint manufacturer's specifications for cleaning, conversion coating, and painting. Below references AAMA standard for pigmented organic coating on extrusions. Color as selected by the Authority's representative.
- D. High-Performance Organic Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; Organic Coating: as specified below). Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
  - 1. Fluoropolymer Two-Coat System: Manufacturer's standard two-coat, thermocured system consisting of specially formulated inhibitive primer and fluoropolymer color topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight. Color as selected by the Authority's representative.

## **2.08 GALVANIZED STEEL SHEET FINISHES:**

- A. Surface Preparation: Clean surfaces with nonpetroleum solvent so surfaces are free of oil and other contaminants. After cleaning, apply a conversion coating suited to the organic coating to be applied over it. Clean welds, mechanical connections, and abraded areas, and apply galvanizing repair paint specified below to comply with ASTM A 780.
  - 1. Galvanizing Repair Paint: High-zinc-dust-content paint for regalvanizing welds in steel, complying with SSPC-Paint 20.
- B. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-enamel finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil for topcoat. Comply with paint manufacturer's written instructions for applying and baking to achieve a minimum dry film thickness of 2 mils.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. General: Comply with manufacturer's written instructions. Coordinate installation of roof accessories with installation of roof deck, roof insulation, flashing, roofing membranes, penetrations, equipment, and other construction involving roof accessories to ensure that each element of the Work performs properly and that combined elements are waterproof and weather tight. Anchor roof accessories securely to supporting structural substrates so they are capable of withstanding lateral and thermal stresses, and inward and outward loading pressures
- B. Install roof accessory items according to construction details of NRCA's "Roofing and Waterproofing Manual," unless otherwise indicated,
- C. Separation: Separate metal from incompatible metal or corrosive substrates, including wood, by coating concealed surfaces, at locations of contact, with bituminous coating or providing other permanent separation.
- D. Flange Seals: Unless otherwise indicated, set flanges of accessory units in a thick bed of roofing cement to form a seal.
- E. Cap Flashing: Where required as component of accessory, install cap flashing to provide waterproof overlap with roofing or roof flashing (as counterflashing). Seal overlap with thick bead of mastic sealant.
- F. Operational Units: Test-operate units with operable components. Clean and lubricate joints and hardware. Adjust for proper operation.
- G. Heat-and-Smoke Vents: Locate, install, and test according to NFPA 204M.
- H. Install wood nailers in accordance with Section 06100.
- I. Install sealants in accordance with Section 07900.
- J. Adhere snow guards to sheetmetal roofing by approved silicone sealant as specified in Section 07900. Locate and space snow guards in accordance with manufacturer's recommendations. Where snow guards are located on standing seams, provide approved mechanical fastenings.

### **3.02 CLEANING AND PROTECTION:**

- A. Clean exposed surfaces according to manufacturer's written instructions. Touch up damaged metal coatings.

**END OF SECTION**

## SECTION 07815

### SPRAYED FIREPROOFING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section includes providing sprayed fireproofing for application to structural steel.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings:
    - a. Product data, installation instructions, and recommendations for each sprayed fireproofing product and auxiliary material, demonstrating compliance with requirements. Include written data verifying that applied thicknesses meet specified hourly fire-resistance ratings.
    - b. Structural framing plans indicating the following:
      - 1) Surface preparation requirements required prior to fireproofing application.
      - 2) Extent of sprayed fireproofing for each different construction and fire-resistance rating including the following:
        - a) Applicable fire-resistive design designations of inspecting and testing agency acceptable to authorities having jurisdiction.
        - b) Minimum thicknesses needed to achieve required fire-resistance ratings of structural components and assemblies.
      - 3) Treatment of fireproofing after application.
  2. Samples: Three of each type of the following:
    - a. Sprayed fireproofing sample 12 inches square by 3/8 inch thick.
    - b. Metal lath, anchorage devices, and accessories.
    - c. In-place samples of each type of fireproofing sprayed on structural-steel elements where directed and in thickness required for specified hourly fire-resistance ratings for testing by the Engineer.
  3. Quality Assurance Submittals:
    - a. Qualification Data: For firms and persons specified in the Quality Assurance article to demonstrate their capabilities and experience.
    - b. Code Approval: Submit research or evaluation reports of the model code organization acceptable to authorities having jurisdiction showing that sprayed fireproofing products comply with the building code.
    - c. Manufacturer's certification that the sprayed fireproofing system and each product used are compatible with adhesives, primers and other surface coatings on substrates indicated.
  4. Certification:

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications.
1. Comply with codes and regulations of the jurisdictional authorities.
  2. UL: Fire Resistance Directory, Building Materials Directory.
  3. ASTM: E84, E119, E605, E736, E759, E760, E761, E859, E937, G21.

4. AWCI: Technical Manual 12-A.
- B. Fire-Test-Response Characteristics: Provide sprayed fireproofing products identical to those used in assemblies tested for the following fire-test-response characteristics by UL or another testing and inspecting agency acceptable to authorities having jurisdiction. Identify packages containing fireproofing with appropriate classification markings of applicable testing and inspecting agency.
  1. Fire-Resistance Ratings: As indicated by reference to fire-resistive designs listed in UL Fire Resistance Directory, or in the comparable publication of another testing and inspecting agency acceptable to authorities having jurisdiction, for fire-resistive assemblies where sprayed fireproofing serves as direct-applied protection, tested in accordance with ASTM E119.
  2. Surface-Burning Characteristics: As indicated for each sprayed fireproofing product required, tested in accordance with ASTM E84.
- C. Manufacturer Qualifications: Obtain sprayed-on fireproofing system materials from a single manufacturer who evaluates and licenses installers to ensure products are properly installed.
- D. Installer Qualifications: Employ an experienced installer licensed by the sprayed fireproofing manufacturer as having the necessary skill, training, experience and staff to install manufacturer's products as specified and in accordance with manufacturer's recommendations.
- E. Certify that each product in the sprayed fireproofing system is compatible with adhesives, primers, and other surface coatings on substrates.
- F. Provide fireproofing products containing no asbestos.

#### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Deliver products to jobsite in original unopened containers clearly labeled with manufacturer's name and brand designation, referenced specification number, type, class and ratings as applicable.
- B. Store products in an approved dry area. Protect from contact with soil and from exposure to the elements. Keep products dry.
- C. Handle products to prevent breakage of containers and damage to products.
- D. Use materials with limited shelf life within period indicated. Discard materials whose shelf life has expired.

#### **1.05 JOB CONDITIONS:**

- A. Environmental Requirements:
  1. Application of sprayed fireproofing when temperature of substrate material or ambient temperature is lower than 40F is prohibited. Maintain temperature above 40F until fire proofing is cured and dried.
  2. Additional environmental requirements in accordance with manufacturer's recommendations.
  3. Provide ventilation in area to receive sprayed fireproofing, introducing fresh air and exhausting air continuously for 24 hours after application to maintain nontoxic, unpolluted, safe working area.

- B. Coordination: Coordinate installation work to minimize need for other trades to cut into applied fireproofing.
  - 1. Perform application only when substrate construction and penetrating work is complete.
  - 2. Ensure that attachments to steel for work of other trades are complete before application of fireproofing.
  - 3. Immediately patch cut-away fireproofing to comply with requirements for original work.
  - 4. Install fireproofing prior to installation of ductwork, piping, conduits, suspended equipment and other obstructions.

## **PART 2 - PRODUCTS**

### **2.01 SPRAYED CEMENTITIOUS FIREPROOFING:**

- A. General: Factory-mixed, dry formulation listed in the UL Building Materials Directory or by another testing and inspecting agency acceptable to authorities having jurisdiction, consisting of portland cement, additives and mineral aggregates mixed with water at project site to form a slurry for pumping and dispersal by compressed air.
- B. Physical Properties: Minimum values, unless otherwise indicated or higher values required to attain designated fire-resistance ratings, measured per standard test methods referenced with each property listed below:
  - 1. Dry Density: 15 pcf for average and individual densities regardless of density indicated in referenced fire-resistive design, or greater if required to attain fire-resistance ratings indicated, as determined per ASTM E605 or Appendix A, Alternate Method for Density Determination, of AWC Technical Manual 12-A.
  - 2. Bond Strength: 300 psf as determined in accordance with ASTM E736.
  - 3. Compressive Strength: 1400 psf as determined in accordance with ASTM E761.
  - 4. Surface-Burning Characteristics: Provide materials with the following maximum surface-burning characteristics as determined in accordance with ASTM E84.
    - a. Flame spread: 10.
    - b. Smoke developed: 0.
  - 5. Corrosion Resistance: No evidence of corrosion as determined in accordance with ASTM E937.
  - 6. Deflection: No cracking, spalling, delamination or the like as determined in accordance with ASTM E759.
  - 7. Effect of Impact on Bonding: No cracking, spalling, delamination or the like as determined in accordance with ASTM E760.
  - 8. Air Erosion: Maximum weight loss of 0.0025 gram per sq. ft. in 24 hours as determined per ASTM E859.
  - 9. Fungal Resistance: No observed growth on specimens in accordance with ASTM G21.
  - 10. Thickness: Provide minimum average thickness required for fire-resistive design indicated according to the following criteria, but not less than 3/8 inch, as determined per ASTM E605.
    - a. Where the referenced fire-resistive design lists a thickness of one inch or greater, the minimum allowable individual sprayed-on fireproofing thickness is the design thickness minus 1/4 inch.
    - b. Where the referenced fire-resistive design lists a thickness of less than one inch but more than 3/8 inch, the minimum allowable individual sprayed-on fireproofing thickness is the greater of 3/8 inch or 75 percent of the design thickness.

## **2.02 AUXILIARY FIREPROOFING MATERIALS**

- A. General: Provide auxiliary fireproofing materials that are acceptable to primary material manufacturer, are compatible with sprayed fireproofing products and substrates and are approved by UL or another testing and inspecting agency acceptable to authorities having jurisdiction for use in the fire-resistive designs indicated.
- B. Substrate Primers: Unless fireproofing manufacturer recommends against priming, provide primer that complies with one or more of the following requirements:
  - 1. Bond strength complies with requirements specified in UL Fire Resistance Directory for coating materials based on a series of bond tests in accordance with ASTM E736.
  - 2. Primer is identical to those used in assemblies tested for the fire-test-response characteristics of sprayed-on fireproofing, in accordance with ASTM E119, by UL or another testing and inspecting agency acceptable to authorities having jurisdiction.
- C. Adhesive for Bonding Fireproofing: Product approved by manufacturer of sprayed-on fireproofing.
- D. Metal Lath, Anchorage Devices and Accessories: Use only stainless steel, zinc alloy or hot-dip galvanized types as recommended by manufacturer for applications indicated.
- E. Topcoats: Type as recommended by manufacturer for applications indicated.

## **PART 3 - EXECUTION**

### **3.01 EXAMINATION:**

- A. Examine substrates with installer present to determine that they are in satisfactory condition to receive sprayed-on fireproofing. A substrate is in satisfactory condition if it complies with the following:
  - 1. Substrate is free of oil, grease, rolling compounds, incompatible primers, loose mill scale, dirt, or other foreign substances capable of impairing bond of fireproofing with substrate under conditions of normal use or fire exposure.
  - 2. Objects penetrating fireproofing, including clips, hangers, support sleeves, and similar items, are securely attached to substrate.
  - 3. Substrate is not obstructed by ducts, piping, equipment, and other suspended construction that will interfere with applying the fireproofing.
- B. Conduct tests according to sprayed fireproofing manufacturer's recommendations to verify that substrates are free of oil, rolling compounds, and other substances capable of interfering with bond where there is any doubt as to their presence.
- C. Do not proceed with installation of fireproofing until unsatisfactory conditions have been corrected.

### **3.02 PREPARATION:**

- A. Clean substrates of substances that could impair bond of fireproofing, including oil, grease, rolling compounds, incompatible primers, and loose mill scale.
- B. Prime substrates unless fireproofing manufacturer recommends against priming or unless compatible shop primer acceptable to fireproofing manufacturer has been applied and is in satisfactory condition to receive fireproofing.

- C. Cover other work subject to damage from fall-out or overspray of fireproofing materials during application. Provide temporary enclosure as required to confine spraying operations, protect the environment and ensure maintaining adequate ambient conditions for optimal temperature and ventilation.
- D. Install metal lath, anchorage devices and accessories where necessary to comply with tested fire resistance rating and with recommendations of fireproofing manufacturer for conditions of exposure and intended use. Securely attach lath to substrate in position required for support and reinforcement of fireproofing.

### **3.03 APPLICATION:**

- A. Comply with fireproofing manufacturer's instructions as applicable to the particular conditions of installation and as required to achieve fire-resistance ratings indicated.
- B. Match fireproofing design and assemblies per UL or other testing and inspecting agency acceptable to authorities having jurisdiction. Apply fireproofing in thicknesses indicated for each area in approved shop drawings.
- C. Coat substrate with adhesive prior to applying fireproofing where required to achieve fire-resistance rating or as recommended by fireproofing manufacturer for material and application indicated.
- D. Extend fireproofing in full thickness over entire area of each substrate to be protected. Unless otherwise recommended by fireproofing manufacturer, install body of fireproof covering in a single course.
- E. Apply fireproofing materials by sprayed-on method to maximum extent possible. Following the spraying operation in each area, complete the coverage by trowel application or other placement method recommended by manufacturer.
- F. Where sealers are used, apply products that are tinted to differentiate them from the sprayed-on fireproofing over which they are applied.

### **3.04 CLEANING, CURING, REPAIR, AND PROTECTION:**

- A. Cleaning: Immediately after completing spraying operations in each containable area, remove material over-spray and fall-out from surfaces of other construction and clean exposed surfaces to remove evidence of soiling.
- B. Cure cementitious fireproofing materials according to fireproofing manufacturer's recommendations to prevent premature drying.
- C. Protect fireproofing, according to advice of fireproofing manufacturer and installer, from damage resulting from construction operations or other causes so that fireproofing will be without damage or deterioration at time of final acceptance.
- D. As installation of other construction proceeds, inspect fireproofing and patch any areas where fireproofing was removed or damaged.
- E. Repair or replace work that has not been successfully protected.

**END OF SECTION**

**SECTION 07841  
FIRESTOPPING**

**PART 1 - GENERAL**

**1.01 DESCRIPTION:**

- A. This Section perimeter fire containment systems and specifies through-penetration firestop systems for penetrations through the following fire-resistance-rated assemblies:
  - 1. Floors.
  - 2. Roofs.
  - 3. Walls and partitions.
  - 4. Construction enclosing compartmentalized areas.
  - 5. Smoke barriers
  
- B. Related Work Specified Elsewhere:
  - 1. Cast-in-Place Structural Concrete: Section 03300 for construction of openings in concrete slabs and walls.
  - 2. Division 15 Sections specifying duct and piping penetrations.
  - 3. Division 16 Sections specifying cable and conduit penetrations.

**1.02 PERFORMANCE REQUIREMENTS:**

- A. General: For the following constructions, provide through-penetration firestop systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of assembly penetrated.
  - 1. Fire-resistance-rated non-load-bearing walls, including partitions, with fire-protection-rated openings.
  - 2. Fire-resistance-rated floor assemblies
  - 3. Fire-resistance-rated roof assemblies.
  
- B. F-Rated Systems: Provide through-penetration firestop systems with F-ratings indicated, as determined per ASTM E 814, but not less than that equaling or exceeding fire-resistance rating of constructions penetrated.
  
- C. T-Rated Systems: For the following conditions, provide through-penetration firestop systems with T-ratings indicated, as well as F-ratings, as determined per ASTM E 814, where systems protect penetrating items exposed to potential contact with adjacent materials in occupiable floor areas:
  - 1. Penetrations located outside wall cavities.
  - 2. Penetrations located outside fire-resistive shaft enclosures.
  - 3. Penetrations located in construction containing fire-protection-rated openings.
  - 4. Penetrating items larger than 4-inch diameter nominal pipe or 16 sq. in. in overall cross-sectional area.
  
- D. For through-penetration firestop systems exposed to view, traffic, moisture, and physical damage, provide products that after curing do not deteriorate when exposed to these conditions both during and after construction.
  - 1. For piping penetrations for plumbing and wet-pipe sprinkler systems, provide moisture-resistant through-penetration firestop systems.
  - 2. For floor penetrations with annular spaces exceeding 4 inches in width and exposed to possible loading and traffic, provide firestop systems capable of supporting floor loads involved either by installing floor plates or by other means.

3. For penetrations involving insulated piping, provide through-penetration firestop systems not requiring removal of insulation.
- E. For through-penetration firestop systems exposed to view, provide products with flame-spread ratings of less than 25 and smoke-developed ratings of less than 450, as determined per ASTM E 84.

### **1.03 SUBMITTALS:**

- A. Submit the following for approval in accordance with the Special Conditions and with the additional requirements as specified for each:
  - B. Product Data: For each type of through-penetration firestop system product indicated.
  - C. Shop Drawings: For each through-penetration firestop system, show each kind of construction condition penetrated, relationships to adjoining construction, and kind of penetrating item. Include firestop design designation of testing and inspecting agency acceptable to authorities having jurisdiction that evidences compliance with requirements for each condition indicated.
    1. Submit documentation, including illustrations, from a qualified testing and inspecting agency that is applicable to each through-penetration firestop system configuration for construction and penetrating items.
  - D. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.
  - E. Certification: Signed by manufacturers of through-penetration firestop system products certifying that products furnished comply with requirements.

### **1.04 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
  1. Comply with codes and regulations of the jurisdictional authorities.
  2. ASTM E 84, E 814.
  3. UL - 1479.
- B. Installer Qualifications: An experienced installer who has completed through-penetration firestop systems similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.
- C. Source Limitations: Obtain through-penetration firestop systems, for each kind of penetration and construction condition indicated, from a single manufacturer.
- D. Fire-Test-Response Characteristics: Provide through-penetration firestop systems that comply with the following requirements and those specified in "Performance Requirements" Article:
  1. Through-penetration firestop systems are identical to those tested per ASTM E 814. Provide rated systems complying with the following requirements:
    - a. Through-penetration firestop system products bear classification marking of qualified testing and inspecting agency.
    - b. Through-penetration firestop systems correspond to UL in Fire Resistance Directory reference to through-penetration firestop system designations listed by the following:

### **1.05 DELIVERY, STORAGE, AND HANDLING:**

- A. Deliver through-penetration firestop system products to Project site in original, unopened containers or packages with intact and legible manufacturers' labels identifying product and manufacturer; date of manufacture; lot number; shelf life, if applicable; qualified testing and inspecting agency's classification marking applicable to Project; curing time; and mixing instructions for multicomponent materials.
- B. Store and handle materials for through-penetration firestop systems to prevent their deterioration or damage due to moisture, temperature changes, contaminants, or other causes.

### **1.06 PROJECT CONDITIONS:**

- A. Environmental Limitations: Do not install through-penetration firestop systems when ambient or substrate temperatures are outside limits permitted by through-penetration firestop system manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.
- B. Ventilate through-penetration firestop systems per manufacturer's written instructions by natural means or, where this is inadequate, forced-air circulation.

### **1.07 COORDINATION:**

- A. Coordinate construction of openings and penetrating items to ensure that through-penetration firestop systems are installed according to specified requirements.
- B. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate through-penetration firestop systems.
- C. Do not cover up through-penetration firestop system installations that will become concealed behind other construction until the Engineer has examined each installation.

## **PART 2 - PRODUCTS**

### **2.01 FIRESTOPPING, GENERAL:**

- A. Compatibility: Provide through-penetration firestop systems that are compatible with one another, with the substrates forming openings, and with the items, if any, penetrating through-penetration firestop systems, under conditions of service and application, as demonstrated by through-penetration firestop system manufacturer based on testing and field experience.
- B. Accessories: Provide components for each through-penetration firestop system that are needed to install fill materials and to comply with "Performance Requirements" Article. Use only components specified by through-penetration firestop system manufacturer and approved by the qualified testing and inspecting agency for firestop systems indicated. Accessories include, but are not limited to, the following items:
  - 1. Permanent forming/damming/backing materials, including the following:
    - a. Slag-/rock-wool-fiber insulation.
    - b. Sealants used in combination with other forming/damming/backing materials to prevent leakage of fill materials in liquid state.
    - c. Fire-rated form board.
    - d. Fillers for sealants.
  - 2. Temporary forming materials.

3. Substrate primers.
4. Collars.
5. Steel sleeves.

## 2.02 FILL MATERIALS:

- A. General: Provide through-penetration firestop systems containing the types of fill materials indicated in the Through-Penetration Firestop System Schedule at the end of Part 3 by reference to the types of materials described in this Article. Fill materials are those referred to in directories of the referenced testing and inspecting agencies as fill, void, or cavity materials.
- B. Cast-in-Place Firestop Devices: Factory-assembled devices for use in cast-in-place concrete floors and consisting of an outer metallic sleeve lined with an intumescent strip, a radial extended flange attached to one end of the sleeve for fastening to concrete formwork, and a neoprene gasket.
- C. Latex Sealants: Single-component latex formulations that after cure do not re-emulsify during exposure to moisture
- D. Firestop Devices: Factory-assembled collars formed from galvanized steel and lined with intumescent material sized to fit specific diameter of penetrant.
- E. Intumescent Composite Sheets: Rigid panels consisting of aluminum-foil-faced elastomeric sheet bonded to galvanized steel sheet.
- F. Intumescent Putties: Nonhardening dielectric, water-resistant putties containing no solvents, inorganic fibers, or silicone compounds.
- G. Intumescent Wrap Strips: Single-component intumescent elastomeric sheets with aluminum foil on one side.
- H. Mortars: Prepackaged, dry mixes consisting of a blend of inorganic binders, hydraulic cement, fillers, and lightweight aggregate formulated for mixing with water at Project site to form a nonshrinking, homogeneous mortar.
- I. Pillows/Bags: Reusable, heat-expanding pillows/bags consisting of glass-fiber cloth cases filled with a combination of mineral-fiber, water-insoluble expansion agents and fire-retardant additives.
- J. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.
- K. Silicone Sealants: Moisture-curing, single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below:
  1. Grade for Horizontal Surfaces: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces.
  2. Grade for Vertical Surfaces: Nonsag formulation for openings in vertical and other surfaces.

## 2.03 PERIMETER FIRE-CONTAINMENT SYSTEMS:

- A. Where indicated for gaps between the perimeter edge of fire-resistance-rated floor assemblies and non-fire-resistance-rated exterior curtain walls, provide a perimeter fire-containment system with the fire-test response characteristics indicated, as determined by

testing identical systems per UBC Standard 26-9 and UL 2079 by UL or another testing and inspecting agency acceptable to authorities having jurisdiction. Materials shall be identified with appropriate markings of applicable testing and inspecting agency.

### **PART 3 - EXECUTION**

#### **3.01 EXAMINATION:**

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.02 PREPARATION:**

- A. Surface Cleaning: Clean out openings immediately before installing through-penetration firestop systems to comply with written recommendations of firestop system manufacturer and the following requirements:
  - 1. Remove from surfaces of opening substrates and from penetrating items foreign materials that could interfere with adhesion of through-penetration firestop systems.
  - 2. Clean opening substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with through-penetration firestop systems. Remove loose particles remaining from cleaning operation.
  - 3. Remove laitance and form-release agents from concrete.
- B. Priming: Prime substrates where recommended in writing by through-penetration firestop system manufacturer using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.
- C. Masking Tape: Use masking tape to prevent through-penetration firestop systems from contacting adjoining surfaces that will remain exposed on completion of Work and that would otherwise be permanently stained or damaged by such contact or by cleaning methods used to remove smears from firestop system materials. Remove tape as soon as possible without disturbing firestop system's seal with substrates.

#### **3.03 THROUGH-PENETRATION FIRESTOP SYSTEM INSTALLATION:**

- A. General: Install through-penetration firestop systems to comply with "Performance Requirements" Article and firestop system manufacturer's written installation instructions and published drawings for products and applications indicated.
- B. Install forming/damming/backing materials and other accessories of types required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire ratings indicated.
- C. Install fill materials for firestop systems by proven techniques to produce the following results:
  - 1. Fill voids and cavities formed by openings, forming materials, accessories, and penetrating items as required to achieve fire-resistance ratings indicated.
  - 2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.
  - 3. For fill materials that will remain exposed after completing Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

#### **3.04 FIELD QUALITY CONTROL:**

- A. Where deficiencies are found, repair or replace through-penetration firestop systems so they comply with requirements.

**3.05 IDENTIFICATION:**

- A. In areas not exposed to public view, identify through-penetration firestop systems with pressure-sensitive, self-adhesive, preprinted vinyl labels. Attach labels permanently to surfaces of penetrated construction on both sides of each firestop system installation where labels will be visible to anyone seeking to remove penetrating items or firestop systems. Include the following information on labels:
  - 1. The words: "Warning--Through-Penetration Firestop System--Do Not Disturb."

**3.06 CLEANING AND PROTECTION:**

- A. Clean off excess fill materials adjacent to openings as Work progresses by methods and with cleaning materials that are approved in writing by through-penetration firestop system manufacturers and that do not damage materials in which openings occur.
- B. Provide final protection and maintain conditions during and after installation that ensure through-penetration firestop systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated through-penetration firestop systems immediately and install new materials to produce through-penetration firestop systems complying with specified requirements.

**3.07 THROUGH-PENETRATION FIRESTOP SYSTEM SCHEDULE:**

- A. Where UL-classified systems are indicated, they refer to the alpha-alpha-numeric designations listed in UL's "Fire Resistance Directory" under product Category XHEZ.
- B. Firestop Systems for Metallic and Non-metallic Conduit, Tubing, Sleeves, Cable Trays and Cables:
  - 1. UL-1479: Fire rated for 3 hours.
  - 2. Type of fill materials: One or more of the following:
    - a. Silicone sealant.
    - b. Intumescent putty.
    - c. Silicone foam.
- C. Firestop Systems for Insulated Pipes: Comply with the following:
  - 1. UL- 1479: CAJ 5087.
  - 2. Type of Fill Materials: Intumescent putty.
- D. Firestop Systems for Miscellaneous Mechanical Penetrations: Comply with the following:
  - 1. UL- 1479: CAS 8033.
  - 2. Type of Fill Materials: Mortar.
- E. Firestop Systems for Ductwork: Comply with the following:
  - 1. UL- 1479: WJ7007.
  - 2. Type of Fill Materials: Intumescent sealant.

**END OF SECTION**

## SECTION 07900

### SEALS AND SEALANTS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing compression seals and sealants not specified elsewhere.
- B. Related Work Specified Elsewhere:
  - 1. Rabbet for compression seal in granite edging: Section 04415.
  - 2. Expansion joint cover assemblies and systems: Sections 05810 and 05811.
  - 3. Sealant for metal thresholds: Section 08710.
  - 4. Glazing sealant: Section 08800.
  - 5. Acoustical sealant: Section 09255.
  - 6. Ceramic tile sealant: Section 09320.
  - 7. Caulk for painting preparation: Section 09920.
  - 8. Paver tile sealant: Section 09340.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ASTM: C920, C1193, D412, D1752, D2628.
- B. Manufacturer Qualification:
  - 1. General: Provide the products of established manufacturers. Insofar as possible, provide products from a single manufacturer.
  - 2. Sealant color-selection capability: Have color-selection capability resolved early in the submittals process to prevent delay of the work.
    - a. Where sealants are exposed, provide products of a manufacturer who can match the colors of adjacent materials by either having an acceptable range of standard colors or by factory blending custom colors as acceptable to the Engineer and at no additional cost to the Authority.
    - b. Where a manufacturer's colors are insufficient for proper color-match, use acceptable colors from another acceptable manufacturer.
  - 3. On-site representation: Use only a sealant manufacturer who has a local, knowledgeable representative who can visit the project site prior to construction and at least twice during sealant installation to observe conditions and recommend solutions at no additional cost to the Authority.
- C. Design Criteria:
  - 1. Designed width of exterior joints: Joint widths indicated on drawings are shown at their designed width. This is measured when the joint would be at the average air temperature for the year, which is approximately 50F, based on an average minimum air temperature of zero degrees F and an average maximum air temperature of 100F.
  - 2. Designed width of interior joints: Joint widths indicated on the drawings are shown at their designed width at 50F.
  - 3. Joint width at time of seal or sealant application: Make joint widths at time of installation never less than the calculated width, which at 0 degrees F is 25 percent wider than the designed width and at 100F is 25 percent narrower than the designed width for exterior joints and 1-1/2 percent smaller than the designed width for each

degree the ambient temperature exceeds 50F, and 1-1/2 percent larger than the designed width for each degree the ambient temperature is less than 50F.

- a. It is recommended that seals and sealant be installed when the average daily air temperature is 50 degrees F plus or minus five degrees, when joint should be at its designed width.
  - b. If joints are less than the calculated width at the time of proposed installation, take corrective action, which may include saw cutting of joint or other remedial measures approved by the Engineer and by the seal or sealant manufacturer.
  - c. If the joint depth is not sufficient for the designed width of the joint, sealant and backup, cut out the joint to the required depth for the sealant and backup.
  - d. Perform cutting and remedial measures that are acceptable to the Engineer. Cost of cutting and remedial measures are at no additional cost to the Authority.
4. Joint size and sealant size: Except as otherwise indicated, make sealant at least 1/4-inch wide x 1/4-inch deep. In joints 3/8 inches wide, make sealant 1/4-inch deep. In joints wider than 3/8-inch and up to 1-inch wide, make sealant depth 1/2 of the joint width. For joints wider than 1 inch, make sealant depth as recommended by the sealant manufacturer.

### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Samples:
    - a. Material samples: Four of each type of the following materials used in the work:
      - 1) Compression seals: 12 inches long, plus each factory-made corner unit.
      - 2) Sealant and lubricant-adhesive: Half-pint containers.
      - 3) Sealant colors: Fully cured beads of each color used, each six inches long.
      - 4) Backup material: 12 inches long.
      - 5) Joint filler: 12 inches long.
      - 6) Color chips: 12 inches long, one for each color used in the work.
    - b. Demonstration samples: Make demonstration installation of each seal and sealant installation type and color. Use approved materials, installed and cured as required. Remove demonstration samples as directed. Perform testing on sealant demonstration samples as specified under Field Testing.
  2. Shop Drawings:
    - a. General: Submit manufacturers technical product data for each product proposed to be used, together with standard and custom color-selection samples.
    - b. Compression seals: Detail correct size and placement of each type and size of compression seal in its joint.
    - c. Test results: Inspection and adhesion test results performed by sealant manufacturer.
  3. Certification by each manufacturer that the products provided will perform as required and will not stain adjacent materials.

**1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Deliver products to jobsite in original unopened containers clearly marked with manufacturer's name and brand designation, referenced specification number, type and class as applicable.
- B. Store products in approved dry area and protect from contact with soil and from exposure to the elements. Keep products dry.
- C. Handle products to prevent breakage of containers and damage to products.

**1.05 JOB CONDITIONS:**

- A. Environmental Requirements:
  - 1. Application of seals or sealants, including their related products, when ambient temperature is lower than 40F or when there is ice, frost or dampness visible on surfaces to be sealed is prohibited.
  - 2. Comply with manufacturer's environmental recommendation.

**PART 2 - PRODUCTS**

**2.01 COMPRESSION-SEAL MATERIALS:**

- A. Preformed compression seals: ASTM D2628, rectangular design unless otherwise shown.
  - 1. Width: Size compression seals for full amount of joint movement as required, plus the thickness of the compressed seal as recommended by the manufacturer.
  - 2. Corners: Provide factory pre-molded or factory pre-cut and welded corner units for angular changes in direction, vertically as well as horizontally, including 30, 60, 45, 90, 120, 135, and 150 degrees as required by joint location.
- B. Lubricant-adhesive, general: One-part moisture-curing polyurethane as recommended by compression seal manufacturer, with the following additional requirements:

Physical Property	Requirement	ASTM Test Method
Average weight per gallon	8.00 pounds plus-or-minus 10 percent	-
Solids content	65 - 74 percent by weight	-
Adhesive	Fluid from 5F to 120F	-
Film strength	1200 psi, minimum	D412
Elongation	250 percent	D412

- C. Lubricant-adhesive for compression seal in granite: Same as above, but also tested for nonstaining over a three-month period on samples of granite to be used.

**2.02 SEALANT AND ACCESSORIES:**

- A. General: Provide joint sealant, backup rod, primer, and other related materials that are compatible with one another and with the joint substrates under conditions of service and application, as demonstrated by sealant manufacturer based on field experience and submitted test reports.
- B. Sealant (Polyurethane): Polyurethane-based or epoxidized polyurethane based, multi-part elastomeric sealant, ASTM C920, Type M (multi-component), Class 25 (withstands an increase or decrease of 25 percent of the joint width) as follows:
  - 1. For joints in horizontal surfaces: Grade P (pourable or self-leveling), Uses T (traffic areas), M (on masonry) or O (other than standard substrates).
  - 2. For joints in sloped surfaces: Grade NS (nonsag), Uses T (traffic areas), M (on masonry) or O (other than standard substrates).
  - 3. For joints in overhead and vertical surfaces: Grade NS (nonsag), Uses NT (nontraffic areas), M (on masonry), A (on aluminum), or O (other than standard substrates).
- C. Primer: Colorless, nonstaining liquid material of types suited to each substrate surface, as tested and recommended in writing by the manufacturer of each sealant to be used.
- D. Backup Rod: Preformed, compressible, resilient, non-waxed, non-extruding, nonstaining, closed-cell rod stock of polyethylene or polyethylene-jacketed foam which will maintain a uniform round or oval cross-sectional shape when compressed into the joint.
  - 1. Select backup rods as recommended by the manufacturer of each sealant to be used; compatible with joint substrates, sealants, primers, and other joint fillers; that will not bond with sealants and primers; and are approved for applications indicated based on field experience and laboratory testing.
  - 2. Select backup rod of the sizes and shapes to suit the various conditions and at about 30 percent wider than the joint width.
    - a. Where depth of joint is too shallow for round backup rod use 1/2-round backup rod, factory manufactured with cut surface fused by heat process so that it cannot release gas.
    - b. Where depth is too shallow for 1/2-round rod, use bond breaker tape.
- E. Bond-Breaker Tape: Polyethylene tape, as recommended by the manufacturer of each sealant to be used, for preventing sealant from adhering to joint-filler materials or joint surfaces at back of joint where such adhesion would promote sealant failure, or result in less than optimal performance. Provide tape sized properly for the joint. Provide self-adhesive tape where applicable.
- F. Cleaning Agent: Joint cleaning compound tested and recommended in writing by sealant manufacturer for cleaning joint surfaces before priming. Use only a cleaner which is nonstaining, non-harmful to masonry, does not leave oily residues, and does not have a detrimental effect on adhesion or in-service performance.
- G. Weep Tubes: Vinyl tubing, 3/8-inch diameter.
- H. Masking Tape: Nonstaining, nonabsorbent type, compatible with joint sealants and to surfaces adjacent to joints. Use only a masking tape which will easily come off entirely, including adhesive.
- I. Joint Filler for Sealant Joints : Nonstaining joint filler compatible with backer rod and sealant:
  - 1. Sponge rubber: Preformed strips complying with ASTM D1752 Type I.
- J. Joint Filler for Pavers and Walkways: Nonstaining joint filler compatible with backer rod and sealant; one of the following. Where filler is not shown covered by sealant, see Section 03300:
  - 1. Cork: Preformed strips complying with ASTM D1752 Type II.

2. Self-expanding cork: Preformed strips complying with ASTM D1752 Type III.

### **PART 3 - EXECUTION**

#### **3.01 INSPECTION AND PREPARATION:**

- A. Inspection:
  1. With installer present, examine joints for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting the performance of joint seals and sealants.
  2. Have sealant manufacturer's representative visit the site and review the project joint conditions and details for sealant work of this Project and perform adhesion testing. Have sealant manufacturer representative report to the Engineer in writing the results of his inspections and tests.
  3. Do not proceed with work of this section until unsatisfactory conditions have been corrected.
- B. Preparation: Comply with the recommendations of ASTM C1193 and the following:
  1. Cleaning:
    - a. Clean joint surfaces receiving seals or sealants. Ensure that they are sound, smooth, clean, dry, and free of foreign substances and contaminants, including curing compounds and release agents.
    - b. Remove factory or field-applied coatings that will be detrimental to adhesion of seals, sealants or primers.
  2. Masking: Use masking where required to prevent contact of sealant and primers with adjoining surfaces that otherwise would be stained or damaged by such contact or by cleaning methods required to remove sealant or primer smears.
- C. Priming: Unless sealant manufacturer specifically recommends in writing against priming, apply primer to prepared surfaces that will receive sealant. Apply primer on clean, dry surfaces, and prior to installation of backup rod. Completely wet both inner faces of the joint with primer.
- D. Backup rod: Install backup rod in joints (after primer is dry) to provide backup and give proper shape for sealant bead. Where there is insufficient joint depth for backup rod, install half-round backup rod or bond breaker tape as approved in lieu of backup rod.
  1. Proper cross-sectional shape for sealant bead is a very slight hourglass shape with back and front faces having slight concave curvature, unless indicated otherwise. Use special blunt T-shaped tool or roller to install backup rod to the proper and uniform depth required for the sealant.
  2. Install size of backup rod that will provide approximately 30 percent compression.
  3. Do not stretch, twist, braid, puncture, or tear backup rod. A broken surface will emit gas (out-gassing) that blisters the installed sealant, thereby requiring complete removal and reinstallation of primer, backup rod, and sealant.
  4. Tightly butt backup rods at joints and intersections. At outside corners, provide sufficient length of backer rod so that rod can be bent around corner rather than cut at corner, so that out-gassing will not occur.
- E. Bond breaker tape: Where space for a backup rod is inadequate, use bond breaker tape to prevent three-sided adhesion. Install bond breaker tape smoothly over back of joints so that sealant adheres to the sides of joint but not to the back of joint.

#### **3.02 INSTALLATION:**

- A. Compression Seals:
1. If adjacent surfaces are to receive waterproofing, install compression seals prior to application of waterproofing.
  2. Prime interfaces, edges and corners of joints as necessary.
  3. Prime and lubricate joints by coating both sides of joint with lubricant-adhesive to wet-film thickness of 20 mils.
  4. While lubricant-adhesive is still wet, install compression seals to depth shown.
  5. Recess exposed edges slightly behind adjoining surfaces, unless otherwise shown, so that compressed units will not protrude from joints.
  6. Bond ends together with materials and methods recommended by manufacturer to ensure continuous watertight and airtight performance. Where factory pre-molded or pre-welded corner units are unavailable, miter-cut and bond ends at corners.
- B. Sealant:
1. Comply with ASTM C1193 and with manufacturer's recommendations, except where more stringent requirements are shown or specified.
  2. Set joint-filler units at depth or position in joint as shown to coordinate with other work, including installation of bond breakers, backer rods and sealants. Do not leave voids or gaps between ends of joint-filler units.
  3. Install back-up material, except where shown to be omitted or recommended to be omitted by sealant manufacturer for application used.
  4. Install bond-breaker tape where shown and where recommended by manufacturer to ensure that sealants will perform as intended.
  5. Employ installation techniques which will ensure that sealants are deposited in uniform, continuous ribbons without gaps or air pockets, with complete wetting of joint bond surfaces equally on opposite sides.
    - a. Except as otherwise shown, fill sealant rabbet to slightly concave surface, slightly below adjoining surfaces. Where horizontal joints are between horizontal surface and vertical surface, fill joint to form slight cove, so that joint will not trap moisture and dirt.
    - b. Fill joints to a depth equal to 50 percent of joint width, but not more than 1/2-inch deep nor less than 1/4-inch deep.
    - c. Ensure that temperature of sealant, as well as of substrates, at time of sealant application, is as recommended by sealant manufacturer and as specified herein. Apply sealant at optimum time after primer application.
    - d. Remove masking immediately after tooling of sealant and before sealant face starts to skin over. Do not cause dislocation of sealant, or migration of sealant to adjacent surfaces when removing masking tape.
  6. Spillage: Do not allow sealants or compounds to overflow from confines of joints, to spill onto adjoining work or to migrate into voids of exposed finishes. If spillage occurs, eliminate evidence of spillage to the Engineer's satisfaction.
  7. Seal joints in granite work with sealant, except granite-paving joints and pylon-apron joints that are shown to be grouted. Ensure joint depths of at least 3/4 inch before placing backup. If necessary, rake-out joints to a minimum depth of 3/4 inch.
  8. Weep Holes: Install weep tubes, sloping to expel water, where required to allow free drainage of hollow spaces. Where so shown, install tubes through sealant and backing to ensure an unobstructed drainage path. Do not seal over weep holes provided by other trades.

### **3.03 CURING AND PROTECTING:**

- A. Cure sealants in compliance with manufacturer's recommendations, to obtain high early bond strength, internal cohesive strength and surface durability.

- B. Cure and protect joint sealers during construction period, so that they will be without deterioration, soiling or damage, other than normal wear and weathering, at time of final acceptance.
- C. Cure and protect sealants so as to minimize increases in modulus of elasticity and other accelerated aging effects.
- D. Replace or restore sealants damaged or deteriorated during construction and from testing as directed. Cut out or remove damaged sealant immediately and properly prepare and reseal joint with new materials to produce sealant installation with repaired areas indistinguishable from other work.

#### **3.04 FIELD TESTING:**

- A. Sealant: Field test cured sealant installations in the presence of and where directed by the Engineer. Test each type of joint sealant for adhesion to joint substrates by hand-pull method as follows:
  - 1. Make knife cuts as follows: A transverse cut from one side of joint to the other, followed by parallel cuts approximately 2 inches long at each side of joint and meeting the transverse cut at the end of the 2-inch cuts. Place a mark 1 inch from the top of 2-inch piece.
  - 2. Use fingers to grasp the 2-inch piece of sealant just above the 1-inch mark; pull firmly away at a 90-degree angle while holding a ruler along side of sealant; pull sealant out of joint to the distance recommended by sealant manufacturer for testing adhesive capability, but not less than the distance equaling the specified maximum movement capability in extension; hold this position for 10 seconds.
  - 3. Report whether or not the sealant in joint (connected to pulled-out portion) failed to adhere to joint substrates or failed cohesively or adhesively. Include data on pull distance used to test each type of sealant and joint substrate.
  - 4. Sealants not evidencing adhesive failure from testing, in absence of other indications of noncompliance with requirements, will be considered acceptable, subject to certification of design and performance criteria by the manufacturer.
  - 5. Make a minimum of 10 such tests unless otherwise directed by the Engineer. Submit report of testing to the Engineer.

#### **3.05 CLEANING:**

- A. Immediately clean off excess primers, drippings, sealants and sealant smears as work progresses, using methods and with cleaning materials approved by manufacturer of each joint primer and sealant and by manufacturers of materials where joints occur.
- B. Use only materials and methods acceptable to the Engineer.

**END OF SECTION**

**DIVISION 8 - DOORS AND WINDOWS**

08110	HOLLOW METAL DOORS AND FRAMES
08305	ACCESS DOORS AND FRAMES
08331	OVERHEAD COILING DOORS
08334	OVERHEAD COILING GRILLES
08410	ALUMINUM ENTRANCES AND STOREFRONTS
08481	METAL CONCAVE MANDOORS
08520	ALUMINUM WINDOWS
08710	FINISH HARDWARE
08800	GLASS AND GLAZING

**END OF SECTION**

## SECTION 08110

### HOLLOW METAL DOORS AND FRAMES

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing metal doors and frames.
- B. Related Work Specified Elsewhere:
  - 1. Finish hardware: Section 08710.
  - 2. Glass and glazing: Section 08800.
  - 3. Field painting: Section 09920.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Details of construction, connections, anchors, schedules, setting diagrams and interface with work of other trades.
    - b. Schedule of doors and frames using the same reference numbers for details and openings as those on the Contract Documents.
  - 2. Certification.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. NFPA: 80 (Standard for Fire Doors and Fire Windows).
  - 3. UL: Building Materials Directory.
  - 4. NAAMM: Standards HMMA 861 and 862.
  - 5. SDI: 100.
  - 6. FS: TT-F-322.
  - 7. ASTM: A153, A366, A526, A569, A780, C236, C976.
  - 8. DHI (Door and Hardware Institute): A115, Recommended Locations for Builder's Hardware.
  - 9. ADA (Americans With Disabilities Act).
- B. Fire-Rated Assemblies: Where UL-listing, UL-label or UL Building Materials Directory is specified, another testing and inspection agency acceptable to the Engineer and to authorities having jurisdiction may be used.

##### 1.04 PRODUCT, DELIVERY, STORAGE AND HANDLING:

- A. Deliver products to the jobsite in original unopened containers or wrappings clearly labeled with manufacturer's name and brand designation, door schedule number, referenced specification number, type, class and rating as applicable.
- B. Store products in an approved dry area, protect from contact with soil and from exposure to the elements.
- C. Handle products so as to prevent breakage of containers and damage to products.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS:**

- A. Hot-Rolled Steel Sheets and Strip: Commercial quality carbon steel, pickled and oiled, complying with ASTM A569, free of scale, pitting or surface defects.
- B. Cold-Rolled Steel Sheets: Commercial quality, level, carbon steel, complying with ASTM A366.
- C. Galvanized Steel Sheets: Zinc-coated carbon steel sheets of commercial quality, complying with ASTM A526, G60 zinc coating, mill phosphatized.
- D. Shop-Applied Primer: Rust-inhibitive baked-on primer, suitable as base for specified finish paint systems.
- E. Finish Paint Systems: Section 09920.
- F. Supports and Anchors: Sheet steel, gauge in accordance with HMMA reference standards, unless specified otherwise. After fabricating, galvanize units to be built into or attached to exterior walls, wet areas such as doors to toilet rooms and janitor's room, or attached to slabs on grade; complying with ASTM A153, Class B.
- G. Inserts, Bolts and Fasteners: Manufacturer's standard units unless specified otherwise. Hot-dip galvanized items to be used in exterior walls, wet areas such as doors to toilet rooms and janitor's rooms, or attached to slabs on grade; complying with ASTM A153, Class C or D as applicable.
- H. Metallic Filler: FS TT-F-322.
- I. Galvanizing Repair Compound: Stick form, melting point 600F to 650F, GALVABAR or equal.

### **2.02 FABRICATION, GENERAL:**

- A. Fabricate hollow metal door and frame units to be rigid, neat in appearance, and free from defects, warp or buckle. Wherever practicable, fit and assemble units in manufacturer's plant. Clearly identify work that cannot be permanently factory-assembled before shipment, to ensure proper assembly at project site.
- B. Galvanize exterior door and frame assemblies, and wet area door and frame assemblies such as at toilet room and janitor's room; including but not limited to face sheets, reinforcements, closures, dust covers, mortar shields, glazing and louver beads, clips, anchor bolts, screws, rivets and welds.
- C. Exposed fasteners are not allowed on door frames and door faces; elsewhere, provide countersunk flat philips heads for exposed screws and bolts.
- D. Door Hardware Preparation:
  - 1. Prepare and reinforce doors and frames to receive mortised and concealed hardware in accordance with final Hardware Schedule and templates provided by hardware supplier. Comply with applicable requirements of DHI A115-series, Steel Door Prep Standards, for door and frame preparation for hardware.
  - 2. Reinforce doors and frames to receive surface-applied hardware. Drilling and tapping for surface-applied hardware may be done at project site.

3. Locate hardware as indicated on approved shop drawings or, if not indicated, in accordance with ADA requirements pertaining to operating hardware locations, and the Recommended Locations for Builder's Hardware, published by the DHI.
- E. Shop Painting:
1. Clean, treat and paint exposed surfaces of steel door and frame units, including galvanized surfaces.
  2. Chemically clean steel surfaces of mill scale, rust, oil, grease, dirt and other foreign materials before application of paint.
  3. Apply phosphate conversion pretreatment coating.
  4. Apply shop coat of prime paint of even consistency to provide a uniformly finished surface ready to receive finish paint. Apply primer immediately after surface preparation and pretreatment.
- F. Insulated Metal Assemblies: Where schedules, provide doors and frames fabricated as thermal-insulating assemblies and tested according to ASTM C236 or ASTM C976.

### **2.03 FRAMES:**

- A. General:
1. Fabricate frames to uniform profile as shown of full-welded unit construction, with corners mitered and reinforced. Continuously weld full depth and width of frame, except for knock-down frames.
  2. Mullions and Transom Bars: Provide closed or tubular mullions and transom bars where indicated.
    - a. Fasten mullions and transom bars at crossings and to jambs by butt welding, except for knock-down frames.
    - b. Reinforce joints between frame members with concealed clip angles or sleeves of the same metal and thickness as frame.
  3. Jamb anchors: Provide in accordance with NAAMM Standards HMMA 861 and 862:
    - a. Provide T-type anchors or strap-and-stirrup type anchors at new masonry.
    - b. Provide Z-type anchors at metal stud partitions.
    - c. Provide bolt-type anchors with pipe spacers at in-place construction.
  4. Floor anchors: Provide floor anchors for each jamb and mullion that extends to floor, formed of galvanized steel sheet, as follows:
    - a. Monolithic concrete slabs: Clip-type anchors, with two holes to receive fasteners, welded to bottom of jambs and mullions.
    - b. Separate topping concrete slabs: Adjustable type with extension clips, allowing not less than two-inch height adjustment. Terminate bottom of frames at finish floor surface.
  5. Head anchors: Provide two anchors at head of frames exceeding 42 inches wide for frames mounted in steel stud walls.
  6. Head strut supports:
    - a. Provide 3/8-inch by two-inch vertical steel struts extending from top of frame at each jamb to supporting construction above, unless frame is anchored to masonry or to other structural support at each jamb.
    - b. Bend top of struts to provide flush contact for securing to supporting construction above.
    - c. Provide adjustable bolted anchorage to frame jamb members.
  7. Structural reinforcing members: Provide structural reinforcing members as a part of frame assembly, where indicated at mullions, transoms or other locations which are to be built into frame.
  8. Spreader bars: Across bottom of welded frames, provide removable spreader bar, tack welded to jambs and mullions.
  9. Door silencers:

- a. Drill stop to receive three silencers on single door frames and two silencers on double door frames.
  - b. Install plastic plugs to keep holes clear during construction.
- 10. Plaster guards: Provide 18-gauge steel plaster guards or dust-cover boxes (galvanized at exterior locations), welded to frame, at back of hardware cutouts, where mortar or other materials might obstruct hardware installation or operation and to close off interior of openings.
- B. Interior Hollow Metal Frames: NAAMM Standard HMMA 861, Guide Specifications for Commercial Hollow Metal Doors and Frames except as follows:
  - 1. Openings over four feet wide: 12-gauge.
  - 2. Cart-storage rooms and other doors as indicated: Use security hollow metal frames specified below.
  - 3. Knock-down frames may be used in drywall construction as specified below.
- C. Exterior and Security Hollow Metal Frames: NAAMM Standard HMMA 862, Guide Specifications for Security Hollow Metal Doors and Frames, except as follows:
  - 1. Use for exterior doors and for indicated security doors including cart-storage room.
  - 2. Cart-storage-room frame anchors: Hot-dipped galvanized anchor bolts, not less than 1/2-inch by six inches, inaccessible from the safety walk, eight per frame.
- D. Interior Knock-Down Hollow Metal Frames: SDI 100, and as follows:
  - 1. Knock-down frames may be used only in interior drywall construction.
  - 2. Openings four foot wide or less: 16-gauge.
  - 3. Openings over four feet wide: 12-gauge.

#### **2.04 DOORS:**

- A. Thermal Insulation: Provide exterior doors and panels with internal thermal insulation of extruded polystyrene. Aged R-value of door or panel is to be 5.0 or greater.
- B. Interior Hollow Metal Doors: NAAMM Standard HMMA 861, Guide Specifications for Commercial Hollow Metal Doors and Frames except for cart-storage room and other doors as indicated.
- C. Exterior and Security Hollow metal Doors: NAAMM Standard HMMA 862, Guide Specifications for Security Hollow Metal Doors and Frames.
  - 1. Use for exterior doors and for indicated security doors including cart-storage room.

#### **2.05 FIRE-DOOR ASSEMBLIES:**

- A. Where fire-rated door and frame assemblies are required for code compliance, or are otherwise indicated, provide door, frame and hardware assemblies in compliance with NFPA 80, which are labeled and listed by UL.
- B. Fabrication and assembly requirements necessary to obtain labels will take precedence over requirements shown or specified, except where requirements shown or specified exceed sizes or gauges required for labeling.
- C. Where oversized fire doors are required, furnish manufacturer's certification that assembly has been constructed with materials and methods equivalent to labeled construction.
- D. Louvers: Equip louvers in fire-rated doors with UL-listed self-closing fire dampers with fusible links.

- E. Identify each fire door and frame with permanent UL labels, indicating the applicable fire rating of both the door and the frame. Secure labels to vertical edge of doors and frames where readily visible. Protect labels from painting operations.

## **2.06 TRANSOM ASSEMBLIES:**

- A. Removable Transom Bar: Formed as shown of same material as frame, with manufacturer's standard bolted connection.
- B. Removable Transom Panel: Formed as shown of the same construction as the door or doors below, through-bolted to frame eight inches on-center maximum.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION:**

- A. Deliver work, ready to set up and erect in place as rapidly as general construction work permits. Set work in place in accordance with approved shop drawings, plumb and level, strongly secured against displacement and with built-in anchors. In masonry construction, set frames in advance of masonry work. Limit field-cutting, drilling and punching to minimum necessary.
- B. Anchor metal frames in accordance with NAAMM Standards HMMA 861 and 862.
- C. Anchor fire-door assemblies in accordance with NFPA 80.
- D. Install doors after masonry work has been completed; accurately fit and adjust to work properly.
- E. Maintain installation clearances and tolerances in accordance with NAAMM Standards HMMA 861 and 862.
- F. Coat field welds and repair damage to zinc-coated surfaces in accordance with ASTM A780 and as follows:
  - 1. Wire-brush welds and other repair areas to bright metal.
  - 2. Apply galvanizing repair compound at rate of two ounces per square foot.
- G. Touch-up shop applied primer as recommended by manufacturer for compatibility with finish paint system.
- H. Application of finish hardware: Section 08710.
- I. Glazing materials and installation: Section 08800.

### **3.02 CLEAN UP:**

- A. Upon completion of installation, clean surfaces of doors and frames as recommended by door manufacturer.
- B. Remove from the site rubbish and debris caused by this work.
- C. Leave areas surrounding openings in broom-clean condition.

**END OF SECTION**

## SECTION 08305

### ACCESS DOORS AND FRAMES

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing wall and ceiling access doors and frames, fire-rated wall access doors and frames, access hatches, tile covered access hatches and passenger emergency-egress hatches.
- B. Work Specified Elsewhere:
  - 1. Cast-In-Place Concrete: Section 03300.
  - 2. Mortar, Grout and Masonry Accessories: Section 04050.
  - 3. Brick Masonry: Section 04125.
  - 4. Concrete Unit Masonry: Section 04220.
  - 5. Structural Steel: Section 05120.
  - 6. Roof Hatches: Section 07730.
  - 7. Finish Hardware: Section 08710.
  - 8. Tile: Section 09320.
  - 9. Paver Tile: Section 09340.
  - 10. Acoustical Panel Ceilings: Section 09511.
  - 11. Field Painting: Section 09920.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Product Data: For each type of door and frame indicated. Include construction details relative to materials, individual components and profiles, finishes, and fire ratings (if required) for access doors and frames.
  - 2. Shop Drawings: Show fabrication and installation details. Include plans, elevations, sections, hardware, fittings, fastenings, details, and attachments to other Work. Manufacturer's standard drawings may be submitted in lieu of Contractor prepared shop drawings if manufacturer's standard drawings show required details.
  - 3. Samples: For each door face material, at least 3 by 5 inches in size, in specified finish.
  - 4. Schedule: Provide complete door and frame schedule, including types, general locations, sizes, construction details, latching or locking provisions, and other data pertinent to installation.
  - 5. Coordination Drawings: Reflected ceiling plans drawn to scale and coordinating penetrations and ceiling-mounted items with concealed framing, suspension systems, piping, ductwork, and other construction. Show the following:
    - a. Method of attaching door frames to surrounding construction.
    - b. Ceiling-mounted items including access doors and frames, lighting fixtures, diffusers, grilles, speakers, sprinklers, and special trim.
  - 6. Certification:
    - a. Certification from manufacturer of steel gratings verifying that gratings are capable of supporting loading as shown.
    - b. Certified test reports of successful factory testing performed on passenger emergency-egress hatches. Certification of previous successful testing of hatches of same design furnished under similar Authority contracts acceptable in lieu of specified testing.
    - c. Certification that welding personnel are currently qualified in accordance

with AWS D1.1.

### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. AASHTO: Standard Specifications for Highway Bridges: HS-20-44 Loading.
  - 3. AGA: The Design and Fabrication of Galvanized Products.
  - 4. AISC: Specification for Structural Steel for Buildings-Allowable Stress Design
  - 5. ASTM: A36, A53, A90, A123, A143, A153, A167, A193, A276, A307, A384, A413, A501, A588, A593, A633, A666, A780, A786, B221, B633, D1187, F594.
  - 6. AWS: D1.1, D1.2, D1.3, D1.4.
  - 7. FS; FF-B-588, FF-P-395, FF-S-325, RR-G-661, TT-P-664.
  - 8. MS: MIL-P-21305.
  - 9. NAAMM: Metal Finishes Manual for Architectural Metal Products
  - 10. NFPA: 101 (Fire Exit Hardware), 252 (Standard Method of Fire Tests for Door Assemblies)
  - 11. SSPC: SP 11, Paint 12.
  - 12. UL: 10B (Fire Tests of Door Assemblies)
  
- B. Source Limitations: Obtain doors and frames through one source from a single manufacturer.
  
- C. Fire-Rated Access Doors and Frames: Units complying with NFPA 80 that are identical to access door and frame assemblies tested for fire-test-response characteristics per the following test method and that are labeled and listed by UL, ITS, or another testing and inspecting agency acceptable to authorities having jurisdiction:
  - 1. [NFPA 252] [or] [UL 10B] for vertical access doors.
  
- D. Size Variations: Obtain the Engineer's acceptance of manufacturer's standard-size units, which may vary slightly from sizes indicated.
  
- E. Welding: Qualify procedures and personnel according to the following:
  - 1. AWS D1.1, "Structural Welding Code-Steel."
  - 2. AWS D1.2, "Structural Welding Code-Aluminum."
  - 3. AWS D1.3, "Structural Welding Code-Sheet Steel."
  - 4. AWS D1.4, "Structural Welding Code-Reinforcing Steel."
  - 5. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification. Such certification is to remain in force for the duration of the welding operations under this Contract.
  
- F. Passenger Emergency-Egress Hatches Meeting AASHTO HS-20-44 Loading:
  - 1. Performance Requirements:
    - a. Design exit hardware so that:
      - 1) Force of not more than 15 pounds on pull ring will actuate release bar and latches and outward force of not exceeding 30 pounds will open hatch.
      - 2) Force of not more than 50 pounds on pull ring will actuate release bar and latches when latched leaf is subjected to outward force of 250 pounds applied against latching edge adjacent to latch or to flush grip handle in direction in which latch opens.
    - b. Provide one-inch minimum distance between bar and other door parts, when bar has traveled to fully open position.
    - c. Provide sufficient supports on latch bars to prevent damage and misalignment.

- d. Design and provide sufficient latch bar springs for proper operation.
  - e. Coordinate design with design-specialty applications which interface with hatch design
  - f. Make recommendations for specialty-design actions to be performed by other specialties.
2. Factory testing:
- a. Perform endurance testing in which hatch leaf is attached to frame assembly and, complete with exit hardware, is subjected to 1,000 opening-and-closing cycles. Hatch, including release mechanism, exit hardware and latches, to operate without failure and show no signs of excessive wear.
  - b. Perform opening tests in which hatch leaf is subjected to the 15-pound test before and after endurance test and in which hatch leaf is subjected to 250-pound-outward-force test after endurance test. With spring scales, or by other approved means, test and record force required to open hatch. Opening force not to exceed 30 pounds for normal test and 50 pounds for 250-pound-outward-force test.
  - c. Test data to be recorded and certified by the manufacturer.
  - d. Notify the Authority at least 14 calendar days prior to each test.
3. Covers: Shall be reinforced to support a minimum live load of 300 psf (1464 kg/m<sup>2</sup>) with a maximum deflection of 1/150th of the span. Operation shall be smooth and easy with controlled operation throughout the entire arc of opening and closing. Operation shall not be affected by temperature.
4. AASHTO-HS-20-44 load or higher load if required by the jurisdictional authority where the hatch is installed: Structural steel plate with load-carrier beams.

#### **1.04 PROJECT CONDITIONS:**

- A. Field Measurements: Where doors and hatches are indicated to fit in walls and other construction, verify dimensions by field measurements before fabrication and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.
  - 1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating metal fabrications without field measurements. Coordinate construction to ensure that actual dimensions correspond to established dimensions. Allow for trimming and fitting.

#### **1.05 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Deliver products undamaged
- B. Store products so as to prevent rust
- C. Handle products so as to prevent damage.
- D. After completion of factory testing, package and ship hatches as directed.

#### **1.06 COORDINATION:**

- A. Verification: Determine specific locations and sizes for access doors needed to gain access to concealed equipment, and indicate on a schedule.
- B. Concrete Work: Coordinate with concrete work so that frames are available for placing integrally with floor slabs or concrete walls unless frames are to be installed during related interior floor work.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS:**

- A. General Requirements:
  - 1. Insofar as practicable, furnish similar products of a single manufacturer.
  - 2. Metal Surfaces, General: For metal fabrications exposed to view in the completed Work, provide materials with smooth, flat surfaces without blemishes. Do not use materials with exposed pitting, seam marks, roller marks, rolled trade names, or roughness.

### **2.02 FERROUS METALS:**

- A. Structural Steel: Plates, shapes, bars and angles: ASTM A36.
- B. Rolled-Steel Floor Plate: ASTM A786/A786M, raised pattern floor plates from rolled-steel floor plate, galvanized after fabrication, of thickness and in pattern indicated below:
  - 1. Thickness: Minimum 1/4 inch, unless otherwise shown or calculated.
  - 2. Pattern: No. 2, or as selected from manufacturer's standard patterns; flat back.
- C. Load-carrier beams: ASTM A588.
- D. Structural Tubing: ASTM A501.
- E. Steel Pipe: ASTM A53, standard weight (Schedule 40), unless another weight is indicated or required by structural loads. Galvanized unless otherwise shown or specified.
- F. Pipe Sleeves and Pipe Fittings: ASTM A53. Galvanized unless otherwise shown or specified.
- G. Stainless Steel Sheets, Strips, Plates, Shapes, and Flat Bars: ASTM A666, Type 304. Type 316L for corrosive environments.
- H. Stainless Steel Bars and Shapes: ASTM A276, Type 304. Type 316L for corrosive environment.
- I. Guard Chain: ASTM A413, Class Grade 28, galvanized steel, 9/32-inch thick, complete with stainless steel eyes, spring-loaded catches and mounting components.
- J. Grating: Steel, bar and crossbar type shown, hot-dipped galvanized after fabrication and sizing, FS RR-G-661, Type 1, Class 1 or 2.

### **2.03 ALUMINUM:**

- A. Aluminum Extrusions: ASTM B221, Alloy 6063.
- B. Aluminum-Alloy Rolled Tread Plate: ASTM B 632, alloy 6061.

### **2.04 FASTENERS:**

- A. General: Provide Type 302 or 316 stainless steel fasteners for exterior use and zinc-plated fasteners complying with ASTM B633, Class Fe/Zn 5, where built into exterior walls. Select fasteners for type, grade, and class required.
- B. Screws: Material, type and size to suit purpose; steel, except stainless., cadmium-plated.

1. Stainless steel, ASTM A193, Alloy S30400.
- C. Machine Bolts: Material, type and size best suited to the purpose. Minimum tensile strength 60,000 psi.
1. Carbon steel: ASTM A307, Grade B, galvanized.
  2. Stainless steel: ASTM A193, Class 1A.
- D. Toggle bolt: FS FF-B-588.
- E. Drive stud: FS FF-S-325, Group 6.
- F. Expansion shield: FS FF-S-325 Group I, Type 2, Class 2, Style 1; Group II, Type 3, Class 1; Group IV, Type 1; best suited to the purpose.
- G. Screw anchors: Lead or plastic for wood or metal screws.
- H. Anchor bolt sleeve: Corrugated high-density polyethylene plastic.
- I. Powder actuated: FS FF-P-395.
- J. Expansion Anchors: Anchor bolt and sleeve assembly of material indicated below with capability to sustain, without failure, a load equal to six times the load imposed when installed in unit masonry and equal to four times the load imposed when installed in concrete, as determined by testing per ASTM E488, conducted by a qualified independent testing agency.
1. Material: Alloy Group 1 or 2 stainless steel bolts complying with ASTM F593 and nuts complying with ASTM F594.

## **2.05 CONCRETE AND GROUT:**

- A. Nonshrink Grout: Section 04050.
- B. Surface hardener: Water-soluble, inorganic fluosilicate compound for curing, hardening and dustproofing fresh concrete.

## **2.06 COATINGS:**

- A. Shop Primer for Ferrous Metals: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with performance requirements in FS TT-P-664; selected for good resistance to normal atmospheric corrosion, compatibility with finish paint systems indicated, and capability to provide a sound foundation for field-applied topcoats despite prolonged exposure.
- B. Galvanizing (zinc-coating by hot-dipped process): ASTM A90, ASTM A123, or ASTM A143, ASTM A153 or ASTM A384, as applicable.
- C. Zinc-rich paint: MS MIL-P-21305.
- D. Electro deposited zinc coating: ASTM B633.
- E. Galvanizing Repair Compound: Stick form, melting point 600-degree F to 650-degree F, GALVABAR or equal.
- F. Bituminous Coating: Cold-applied asphalt mastic complying with SSPC Paint 12, except containing no asbestos fibers, or cold-applied asphalt emulsion complying with ASTM D1187.

## **2.07 FABRICATION, GENERAL:**

- A. Shop Assembly: Preassemble items in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.
- B. Provide access door assemblies manufactured as integral units ready for installation.
- C. Fabricate and prepare products required to be galvanized in accordance with recommendations of AGA.
- D. Provide material that is free from mill scale, flake rust and mill pitting.
- E. Cut, reinforce, drill and tap metal fabrications as indicated to receive finish hardware, screws, and similar items. Provide plates welded on for mounting hardware.
- F. Shear and punch metals cleanly and accurately. Remove burrs.
- G. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners whenever possible. Use exposed fasteners of type indicated or, if not indicated, Phillips flat-head (countersunk) screws or bolts. Locate joints where least conspicuous.
- H. Ease exposed edges to a radius of approximately 1/32 inch, unless otherwise indicated. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
- I. Provide for anchorage of type indicated; coordinate with supporting structure. Fabricate and space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.
- J. Where miscellaneous access openings, with exception of gratings, occur in finished floor areas, include stainless steel edge rims of depth to accommodate floor finishing materials.
- K. Welding corners and seams continuously to comply with the following:
  - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
  - 2. Obtain fusion without undercut or overlap.
  - 3. Remove welding flux immediately.
  - 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- L. Fabricate joints that will be exposed to weather in a manner to exclude water, or provide weep holes where water may accumulate.
- M. Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges.
- N. Remove sharp or rough areas on exposed traffic surfaces.
- O. Painting: Shop paint (prime) before shipment. Phosphatize galvanized surfaces before priming.

## **2.08 WALL AND CEILING ACCESS DOORS AND FRAMES:**

- A. Access Doors: Steel, baked-enamel prime coat; 12-inches square, minimum size.
  - 1. Wall-mounted, sheet steel type: Sizes under four square feet.
    - a. Door:
      - 1) Fixed: 1/4-inch steel plate screwed to frame 18 inches on centers maximum, with flathead, countersunk, tap screws.
      - 2) Operable: Equipped with spring hinges and lockset conforming to requirements of Section 08710; locks keyed into group with mechanical rooms.
    - b. Frame: Structural steel shapes and corners mitered and welded. Strap anchors places not more than 18 inches on centers and extending 18 inches minimum into masonry or concrete.
  - 2. Wall-mounted, hollow metal type: Size over four square feet.
    - a. Door and frame: Conform to the requirements of Section 08110; galvanized in exterior walls.
    - b. Hardware: Equipped with spring hinges and lockset conforming to requirements of Section 08710; locks keyed into group with mechanical rooms.
    - c. Fire rated: UL 1-1/2 hour B-Label, with labeled hardware.
  - 3. Ceiling mounted: Galvanized steel, door and frame 16-gauge minimum; continuous piano hinge; with sleeve and plastic grommet for screwdriver from the room side; for gypsum board ceiling.
    - a. Door and frame: Flush with ceiling surface; flush metal door fitting neatly into the frame.
    - b. Size and locations: As required to access equipment indicated or as shown.
    - c. Insulation: Provide upper side of doors with one-inch thick mineral fiberboard permanently cemented in place.
    - d. Manufactured by the C. M. Walsh Company of Boston, Massachusetts, or equal.
  - 4. Wall or ceiling mounted in plaster walls or ceilings: Size 16 inches square.
    - a. Flush door panel mounted to frame on concealed spring hinges opening to 175 degrees.
    - b. Fire rated: UL 1-1/2 hour B-Label, with key operated flush lock.
    - c. Manufactured by MILCOR, K-access door or equal.

**2.09 ACCESS HATCH, TYPE A:**

- A. Fabricated by a manufacturer regularly engaged in the production of access hatches; and designed to meet the requirements of AASHTO-HS-20-44 load or higher load if required by the jurisdictional authority where the hatch is installed.
- B. Door:
  - 1. Grating: Steel, ASTM A36.
  - 2. Side Plate: Floor plate, diamond pattern, flat back.
  - 3. Bearing bars: 2-1/2 inches by 1/4 inch at 13/16-inch on centers and cross bars at four inches on centers.
- C. Frame: Structural steel angle framed on three sides, formed steel plate on the hinge side.
- D. Ferrous-metal components: Galvanized after fabrication.
- E. Hardware:
  - 1. Hinges: Forged brass with stainless steel pins.
  - 2. Lifting mechanism: Stainless steel compression-spring mechanism balancing door leaves through entire arc acting as check to downward motion. Force necessary to open the hatch not to exceed 50 pounds.

3. Hold-open devices: Automatic, 90-degree hold-open arms with vinyl-covered release handles.
4. Locking devices: Snap locks with handles on the underside and removable key handles on top side. Include removable plugs for concealing key holes.

#### **2.10 PASSENGER EMERGENCY-EGRESS HATCH:**

- A. Fabricated by a manufacturer regularly engaged in the production of access hatches; and designed to meet the following requirements:
- B. Door leaves: Fabricated in accordance with approved shop drawings.
  1. 250 pounds per-square-foot loading: Rolled Steel Floor plate, diamond pattern, flat back. Galvanized after fabrication.
- C. Frame: 1/4-inch structural steel with formed gutters with drainage couplings. Frames welded to eight-inch supporting channels on four sides with full flange around perimeter. Galvanized after fabrication.
- D. Drain Coupling: Provide a 1-1/2" drain coupling located in the right front corner of the channel frame (note: can be placed at a different location if directed by the Engineer).
- E. Hardware:
  1. Hinges: Forged brass or Type 316 stainless steel. Hinge pins of stainless steel. Each hinge equipped with two pressure-lubrication fittings, Lincoln No. 5012, or equal.
  2. Lifting Mechanism: Stainless steel compression-spring mechanism balancing door leaves through entire arc acting as check to downward motion. Force necessary to open the hatch when applied to inner edge of exit release bar not to exceed 30 pounds. Manufacturer shall provide the required number and size of compression spring operators enclosed in telescopic tubes to provide, smooth, easy, and controlled cover operation throughout the entire arc of opening and to act as a check in retarding downward motion of the cover when closing. The upper tube shall be the outer tube to prevent accumulation of moisture, grit, and debris inside the lower tube assembly. The lower tube shall interlock with a flanged support shoe fastened to a formed 1/4" gusset support plate.
  3. Hold-open devices: Covers shall be equipped with a hold open arm which automatically locks the covers in the open position.
  4. Locking devices:
    - a. Interior: Stainless steel panic bar fabricated and installed to meet NFPA 101 requirements.
    - b. Exterior: A removable exterior turn/lift handle with a spring loaded ball detent shall be provided to open the leaf and the latch release shall be protected by a flush, gasketed, removable screw plug.
    - c. Miscellaneous: Flush grip handles, pull rings with removable caps, handrails on leaves and guard chains of type standard with manufacturer.

#### **2.11 TILE-COVERED FLOOR HATCH:**

- A. General: Commercially manufactured to support a uniformly distributed live load of 150 psf and a maximum deflection of 1/150 of the span. Custom sized heavy duty aluminum frame and cover with aluminum or brass exposed edges, and complete with reinforcing, support beams (where necessary), and related accessories.
- B. Aluminum Frames and Covers: Extruded aluminum, ASTM B 221, alloy 6063-T6, with

mitered and keyed corners and factory coated with zinc chromate primer or manufacturer's standard protective paint where surfaces will be in contact with concrete.

1. Exposed Edge Finishes: Mill finish, No. 385 alloy bronze.
  2. Cover Reinforcing: ASTM A 185 (mesh) or ASTM A 615 (bars), factory engineered to meet design load requirements for medium and heavy duty applications.
- C. Steel Support Beams: ASTM A 36, factory engineered to meet design load requirements where maximum spans for single cover are exceeded and elsewhere when required. 1. Furnish steel beam pocket and bearing plate for support beams
- D. Hardware:
1. Lifting/Locking Device: Lifting blocks (one each corner typically) secured to hatch cover and fitted with threaded bolt
    - a. Furnish threaded handle for lifting, with integral hex head drive for removing securing bolt (for covers equipped with double seals) or blanking bolt (for non-sealed covers).
  2. Seals: Continuous EPDM perimeter seal.
  3. Concrete Fill: Section 0330
- E. Fabrication:
1. Shop fabricate floor access hatches and covers in sizes and configurations shown for single unit pit access, or multiple unit trench access.
  2. Sizes (Single Unit Maximum): 48 inches square (clear opening).
    - a. Where size requirements exceed those shown, multiple covers can be joined together to obtain the desired sizes.
    - b. Where very large covers are required, a small inspection cover may be integrated into the large cover for convenience.
  3. Sizes (Multiple Units Maximum): 36 inches square (clear opening).
  4. Furnish reinforcement assembly loose for field positioning.
  5. All aluminum surfaces in contact with concrete shall receive a factory applied primer or protective paint.
  6. Dissimilar metals shall be protected against electrolytic action.

## 2.12 FINISHES:

- A. General:
1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
  2. Finish metal fabrications after assembly.
  3. Galvanize ferrous metal unless other finish is shown or specified.
- B. Galvanizing:
1. Clean ferrous metal thoroughly before applying zinc coating.
  2. Apply zinc coating to products after fabrication, by hot-dip method, using coating weighing not less than two ounces per-square-foot.
- C. Shop Paint:
1. Ferrous metal thoroughly cleaned as recommended by primer manufacturer and in accordance with SSPC SP11 and, except for items to be encased in concrete, given prime coat of paint.
  2. Zinc yellow iron-oxide primer or red-lead based primer applied so as to thoroughly cover surfaces without leaving runs or sags
- D. Stainless Steel: Remove tool and die marks and stretch lines or blend into finish. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of

- E. cross scratches. Run grain with long dimension of each piece.  
Aluminum: AA-M10 (Mechanical Finish: as fabricated, unspecified).

### **PART 3 - EXECUTION**

#### **3.01 PREPARATION:**

- A. Advise installers of other work about specific requirements relating to access door and floor door installation, including sizes of openings to receive access door and frame, as well as locations of supports, inserts, and anchoring devices.
- B. Examine the substrates and conditions under which the work is to be performed, and notify the General Contractor in writing of conditions detrimental to the proper and timely completion of the work. Do not proceed with the installation until unsatisfactory conditions have been corrected.
- C. Remove foreign substances from surfaces to receive metal items.
- D. Protect surrounding surfaces from damage while performing the work of this section.

#### **3.02 INSTALLATION, GENERAL:**

- A. Coordinate placement of doors with the work of other trades
- B. Comply with manufacturer's written instructions for installing all access doors and hatches.
- C. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing metal fabrications to in-place construction. Include threaded fasteners for concrete and masonry inserts, toggle bolts, through-bolts, lag bolts, wood screws, and other connectors.
- D. Cutting, Fitting and Placement: Perform cutting, drilling, and fitting required for installing doors and hatches. Set frames, doors and hatches accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.
- E. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry or similar construction.
- F. Provide anchors and inserts in sufficient numbers for proper fastening of doors and hatches.
- G. Provide bar anchors with turned ends extending six inches minimum into concrete and 12 inches minimum into masonry. Lay anchors flat in masonry joints.
- H. Embed anchors accurately in concrete to permit aligning door in proper position.
- I. For fabricated items, use fastenings and anchors of size and type shown on approved shop drawings or manufacturer's standard drawings.

#### **3.03 INSTALLING PASSENGER EMERGENCY-EGRESS HATCH:**

- A. Lift hatches by means of slings attached at four corners of each hatch frame.
- B. Set hatch in framed opening; shim as necessary to ensure even support of hatch and alignment with adjoining work and in accordance with manufacturer's recommendations. Shim pattern, as shown

- C. After shimming, ensure hatch is not racked and weld in place as shown.
- D. After welding is completed, repair damaged zinc-coating and abraded shop coatings.
- E. Field-weld steel inserts to hatch frame and opening frame at hatch hinge points and coat completely with galvanizing repair compound at rate of two ounces per-square-foot.
- F. Fill space between hatch and frame and framed opening with nonshrink grout.
- G. Install 1-1/2 inch steel, Schedule 40, piping from hatch frame drain to floor drain, or if no drain, to floor. Piping not to encroach on egress pathway or headroom clearance (six-feet,eight-inches, minimum). Drain not to discharge into egress pathway.

#### **3.04 TILE-COVERED ACCESS HATCHES:**

- A. Set aluminum frames in recess, level and in proper relationship to adjacent finished flooring. For multiple covers and where maximum span for single covers is exceeded, install beam pockets and set support beams on base plates grouted to required heights. Grout frames solid with Portland cement concrete.
- B. Place cover in frame properly aligned. Clip reinforcement assembly into proper position and fill cover with Portland cement concrete to height necessary to receive scheduled finish flooring material. Hand trowel to smooth dense surface.

#### **3.05 PAINTING AND REPAIRING COATED SURFACES:**

- A. Before erection or enclosing construction, paint items that support masonry or will be concealed in finish work, except items encased in concrete.
- B. Where shop coat is abraded or burned by welding, clean and touch-up.
- C. Touch-up primed surfaces with same material as coating.
- D. Where aluminum parts come in contact with concrete or steel, coat contact surfaces of aluminum with bituminous coating.
- E. Coat field welds and repair damage to zinc-coated surfaces in accordance with ASTM A780 and as follows:
  - 1. Wire brush areas to be coated to bright metal.
  - 2. Apply galvanizing repair compound at rate of two ounces per-square-foot.

#### **3.06 FIELD QUALITY CONTROL OF PASSENGER EMERGENCY-EGRESS HATCH:**

- A. Field Testing of Passenger Emergency-Egress Hatch:
  - 1. Upon completion of installation of passenger emergency-egress hatch, verify with spring scales that each leaf of each access hatch will open when force of 30 pounds or less is applied at inner end of exit release bar.
  - 2. Operate leaf no less than three times. Record opening force required each time. If adjustments are necessary to achieve specified results, repeat the test.
  - 3. Perform field tests in the presence of the Engineer.
  - 4. At the time of final inspection for substantial completion, repeat field tests as specified.
  - 5. If hatch fails field tests, make necessary adjustments until it operates as specified.
  - 6. During the life of the Contract, check operation of hatch leaves at periods not

exceeding 90 days. Lubricate moving parts and check for proper operation.

**3.07 ADJUSTING AND CLEANING:**

- A. Adjust doors and hardware after installation for proper operation.
- B. Remove and replace doors and frames that are warped, bowed, or otherwise damaged.
- C. Tile-Covered Access Hatches: If necessary for alignment after finish flooring is installed, exposed edges of frame and cover may be ground to remove up to 1/8 inch and provide flush surface.

**END OF SECTION**

## SECTION 08331

### OVERHEAD COILING DOORS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing overhead coiling doors.
- B. Related Work Specified Elsewhere:
  - 1. Miscellaneous Metal: Section 05500.
  - 2. Finish Hardware: Section 08710.
  - 3. Field Painting: Section 09920.

##### 1.02 DEFINITIONS:

- A. Operation Cycle: One complete cycle of a door begins with the door in the closed position. The door is then moved to the open position and back to the closed position.

##### 1.03 PERFORMANCE REQUIREMENTS:

- A. Structural Performance: Provide overhead coiling doors capable of withstanding the effects of gravity loads and the following loads and stresses without evidencing permanent deformation of door components:
  - 1. Wind Load: Uniform pressure (velocity pressure) of 20 lbf/sq. ft., acting inward and outward.
- B. Operation-Cycle Requirements: Design overhead coiling door components and operator to operate for not less than 20,000 cycles.

##### 1.04 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Product Data: For each type and size of overhead coiling door and accessory. Include details of construction relative to materials, dimensions of individual components, profiles, and finishes. Provide roughing-in diagrams, operating instructions, and maintenance information. Include the following:
    - a. Setting drawings, templates, and installation instructions for built-in or embedded anchor devices.
    - b. Summary of forces and loads on walls and jambs.
    - c. Motors: Show nameplate data and ratings; characteristics; mounting arrangements; size and location of winding termination lugs, conduit entry, and grounding lug; and coatings.
    - d. Fire-Rated Doors: Information describing fire-release system, including testing and resetting instructions.
  - 2. Shop Drawings: For special components and installations not dimensioned or detailed in manufacturer's data sheets.
    - a. Wiring Diagrams: Detail wiring for power, signal, and control systems. Differentiate between manufacturer-installed and field-installed wiring and between components provided by door manufacturer and those provided by others.
  - 3. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for units with factory-applied finishes.

4. Samples for Verification: Of each type of exposed finish required, prepared on Samples of size indicated below and of same thickness and material indicated for Work. Where finishes involve normal color and texture variations, include Sample sets showing the full range of variations expected.
  - a. Curtain Slats: 12-inch length.
  - b. Bottom Bar: 6-inch length
  - c. Guides: 6-inch length.
  - d. Brackets: 6 inches square.
  - e. Hood: 6 inches square.
5. Installer Certificates: Signed by manufacturer certifying that installers comply with specified requirements.

#### **1.05 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
  1. Comply with codes and regulations of the jurisdictional authorities.
  2. ASTM: A36, A123, A653, E84.
  3. NAAMM: Metal Finishes Manual for Architectural and Metal Products.
  4. NEMA: ICS 1, ICS 2, ICS 6, MG-1.
  5. NFPA: 70, 80.
  6. UL: 10B.
- B. Installer Qualifications: Engage an experienced installer who is an authorized representative of the overhead coiling door manufacturer for both installation and maintenance of units required for this Project.
- C. Source Limitations: Obtain overhead coiling doors through one source from a single manufacturer.
  1. Obtain operators and controls from the overhead coiling door manufacturer.
- D. Fire-Rated Door Assemblies: Provide assemblies complying with NFPA 80 that are identical to door and frame assemblies tested for fire-test-response characteristics per UL 10b, and that are labeled and listed for fire ratings by UL, FM, ITS/Warnock Hersey, or another testing and inspection agency acceptable to authorities having jurisdiction.
- E. Listing and Labeling: Provide electrically operated fixtures specified in this Section that are listed and labeled.
  1. The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100.

#### **1.06 PRODUCT DELIVERY, HANDLING AND STORAGE:**

- A. Deliver products in the original unopened packages, containers or bundles each bearing name of manufacturer, brand designation, referenced number, type and class as applicable.
- B. Store materials inside, under cover, and dry, protected from weather, direct sunlight, surface contamination, aging, corrosion, and damage from construction traffic and other causes. Use platforms or other means to protect products and materials from contact with the soil. Do not store materials on finished floors.
- C. Handle materials so as to preclude breakage of packages or containers and damage to materials.

### **PART 2 - PRODUCTS**

#### **2.01 DOOR CURTAIN MATERIALS AND CONSTRUCTION:**

- A. Door Curtain: Fabricate overhead coiling door curtain of interlocking slats, designed to withstand wind loading indicated, in a continuous length for width of door without splices. Unless otherwise indicated, provide slats of material thickness recommended by door manufacturer for performance, size, and type of door indicated, and as follows:
  - 1. Steel Door Curtain Slats: Structural-quality, cold-rolled galvanized steel sheets complying with ASTM A653, with G90 zinc coating.
    - a. Provide manufacturer's standard flat-profile slats.
  - 2. Insulation: Fill slat with manufacturer's standard rigid cellular polystyrene or polyurethane-foam-type thermal insulation with minimum aged R-value of 5.0 complying with maximum flame-spread and smoke-developed indices of 75 and 450, respectively, according to ASTM E84. Enclose insulation completely within metal slat faces.
  - 3. Inside Curtain Slat Face: To match material of outside metal curtain slat and as follows:
    - a. Galvanized Steel Sheet Thickness: Not less than 0.028 inch.
- B. Endlocks: Malleable-iron castings galvanized after fabrication, secured to curtain slats with galvanized rivets, or high-strength nylon. Provide locks on not less than alternate curtain slats for curtain alignment and resistance against lateral movement.
- C. Windlocks: Malleable-iron castings secured to curtain slats with galvanized rivets or high-strength nylon, as required to comply with wind load.
- D. Bottom Bar: Consisting of 2 angles, each not less than 1-1/2 by 1-1/2 by 1/8 inch thick, galvanized to suit type of curtain slats.
  - 1. Astragal: Provide a replaceable, adjustable, continuous, compressible gasket of flexible vinyl, rubber, or neoprene, between angles or fitted to shape, as a cushion bumper for interior door.
  - 2. Provide motor-operated doors with combination bottom astragal and sensor edge.
- E. Curtain Jamb Guides: Fabricate curtain jamb guides of steel angles, or channels and angles, with sufficient depth and strength to retain curtain, to allow curtain to operate smoothly, and to withstand loading. Build up units with not less than 3/16-inch-thick, galvanized steel sections complying with ASTM A36, and ASTM A123. Slot bolt holes for guide adjustment. Provide removable stops on guides to prevent overtravel of curtain and a continuous bar for holding windlocks.
- F. Wicket doors where shown, equipped with cylinder locks capable of operating with cylinders specified in Section 08710. Provide construction cylinders.
- G. Supports: Galvanized structural steel tubing and fastenings as shown and as specified in Section 05500.

## **2.02 HOODS AND ACCESSORIES:**

- A. Hood: Form to entirely enclose coiled curtain and operating mechanism at opening head and act as weatherseal. Contour to suit end brackets to which hood is attached. Roll and reinforce top and bottom edges for stiffness. Provide closed ends for surface-mounted hoods and fascia for any portion of between-jamb mounting projecting beyond wall face. Provide intermediate support brackets for doors over 14 feet in width or as required to prevent sag.
  - 1. Fabricate steel hoods, for steel doors, of not less than 0.028-inch-thick, hot-dip galvanized steel sheet with G90 zinc coating, complying with ASTM A653.
  - 2. Include automatic drop baffle to guard against passage of smoke or flame.

- B. Smoke Seals: Provide UL-listed and -tested smoke-seal perimeter gaskets.
- C. Weatherseals: Provide replaceable, adjustable, continuous, compressible weather-stripping gaskets fitted to bottom and at top of exterior doors, unless otherwise indicated. At door head, use 1/8-inch-thick, replaceable, continuous sheet secured to inside of curtain coil hood.
  - 1. Provide motor-operated doors with combination bottom weatherseal and sensor edge.
  - 2. In addition, provide replaceable, adjustable, continuous, flexible, 1/8-inch-thick seals of flexible vinyl, rubber, or neoprene at door jambs for a weathertight installation.
- D. Windows: Provide windows of 1/4-inch clear, transparent acrylic sheet, of size and in arrangement shown. Set glazing in vinyl, rubber or neoprene glazing channel secured to curtain slats.
- E. Slide Bolt: Fabricate with side locking bolts to engage through slots in tracks for locking by padlock, located on both left and right jamb sides, operable from coil side.
- F. Cylinder Locks: Provide cylinder locks capable of operating with cylinders specified in Section 08710. Provide construction cylinders.
- G. Chain Lock Keeper: Suitable for padlock.
- H. Where door unit is power operated, provide safety interlock switch to disengage power supply when door is locked.
- I. Provide automatic-closing device inoperative during normal operations, with governor unit complying with requirements of NFPA 80, with easily tested and reset release mechanism, and designed to be activated by the following:
  - 1. Governor: Oscillating type.
  - 2. Temperature rise and melting point of 165 deg F replaceable fusible links, interconnected and on both sides of wall of door opening.
  - 3. Building fire alarm and detection system and door-holder-release devices.

### **2.03 COUNTERBALANCING MECHANISM:**

- A. General: Counterbalance doors by means of adjustable-tension steel helical torsion spring, mounted around a steel shaft and contained in a spring barrel connected to door curtain with required barrel rings. Use grease-sealed bearings or self-lubricating graphite bearings for rotating members.
- B. Counterbalance Barrel: Fabricate spring barrel of hot-formed, structural-quality, welded or seamless carbon-steel pipe, of sufficient diameter and wall thickness to support rolled-up curtain without distortion of slats and to limit barrel deflection to not more than 0.03 in./ft. of span under full load.
- C. Provide spring balance of one or more oil-tempered, heat-treated steel helical torsion springs. Size springs to counterbalance weight of curtain, with uniform adjustment accessible from outside barrel. Provide cast-steel barrel plugs to secure ends of springs to barrel and shaft.
- D. Fabricate torsion rod for counterbalance shaft of cold-rolled steel, sized to hold fixed spring ends and carry torsional load.
- E. Brackets: Provide mounting brackets of manufacturer's standard design, 1/4-inch minimum thickness, galvanized cold-rolled steel plate with bell-mouth guide groove for curtain.

#### **2.04 FINISHES, GENERAL:**

- A. General: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- B. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

#### **2.05 STEEL AND GALVANIZED STEEL FINISHES:**

- A. Factory Primer for Field Finish: Apply manufacturer's standard primer, compatible with field-applied finish according to coating manufacturer's written instructions for cleaning, pretreatment, application, and minimum dry film thickness. Field applied finish specified in Section 09920.
- B. Thermoset Finish: Apply manufacturer's standard baked finish consisting of primer and thermosetting topcoat according to coating manufacturer's written instructions for cleaning, pretreatment, application, thermosetting, and minimum dry film thickness.
- C. Field Painting: Section 07900.

#### **2.06 MANUAL DOOR OPERATORS:**

- A. Provide manual operators, unless electric door operators are indicated. When not shown, provide chain-hoist operator unit.
- B. Chain-Hoist Operator: Provide manual chain-hoist operator consisting of endless steel hand chain, chain pocket wheel and guard, and gear-reduction unit with a maximum 35-lbf effort for door operation, equipped with weatherproof enclosure when mounted in exterior locations. Provide alloy steel hand chain with chain holder secured to operator guide.

#### **2.07 ELECTRIC DOOR OPERATORS:**

- A. General: Provide electric door operator assembly of size and capacity recommended and provided by door manufacturer for door and operational life specified, with electric motor and factory-prewired motor controls, starter, gear-reduction unit, solenoid-operated brake, clutch, remote-control stations, control devices, integral gearing for locking door, and accessories required for proper operation
- B. Comply with NFPA 70.
- C. Disconnect Device: Provide hand-operated disconnect or mechanism for automatically engaging sprocket-chain operator and releasing brake for emergency manual operation while disconnecting motor, without affecting timing of limit switch. Mount disconnect and operator so they are accessible from floor level. Include interlock device to automatically prevent motor from operating when emergency operator is engaged.
- D. Design operator so motor may be removed without disturbing limit-switch adjustment and without affecting emergency auxiliary operator.
- E. Provide control equipment complying with NEMA ICS 1, NEMA ICS 2, and NEMA ICS 6, with NFPA 70 Class 2 control circuit, maximum 24-V, ac.

- F. Door-Operator Type: Provide wall-, hood-, or bracket-mounted, jackshaft, gear-head hoist-type door operator unit consisting of electric motor, enclosed worm-gear running-in-oil primary drive, chain and sprocket secondary drive, and auxiliary chain-hoist for manual operation with interlock to prevent motor operation when chain is engaged; operable with maximum chain pulling force of 35-lbf and floor level disconnect.
- G. Electric Motors: Provide high-starting torque, reversible, continuous-duty, Class A insulated, electric motors, complying with NEMA MG 1, with overload protection, sized to start, accelerate, and operate door in either direction, from any position, at 2/3 fps, without exceeding nameplate ratings or considering service factor, from a push-button station, minimum 3/4 HP, 460-volt ac, three-phase.
  - 1. Geared limit switches and solenoid-operated brakes.
  - 2. Motor removable without affecting chain operation or limit-switch setting.
  - 3. Weatherproof enclosure for use when mounted in exterior locations.
  - 4. Electric control for motor-operated unit: 24-volt, ac.
  - 5. Coordinate wiring requirements and electric characteristics of motors with building electrical system
- H. Remote-Control Station: Provide momentary-contact, 3-button control station with push-button controls labeled "Open," "Close," and "Stop."
  - 1. Provide interior units, full-guarded, surface-mounted, heavy-duty type, with general-purpose NEMA ICS 6, Type 1 enclosure.
  - 2. Provide exterior units, full-guarded, standard-duty, surface-mounted, weatherproof type, NEMA ICS 6, Type 4 enclosure, key operated.
- I. Obstruction Detection Device: Provide each motorized door with indicated external automatic safety sensor able to protect full width of door opening. Activation of sensor immediately stops and reverses downward door travel.
  - 1. Photoelectric Sensor: Manufacturer's standard system designed to detect an obstruction in door opening without contact between door and obstruction.
    - a. Self-Monitoring Type: Provide self-monitoring sensor designed to interface with door operator control circuit to detect damage to or disconnection of sensing device. When self-monitoring feature is activated, door operates to close only with constant pressure on close button.
- J. Limit Switches: Provide adjustable switches, interlocked with motor controls and set to automatically stop door at fully opened and fully closed positions.

## **PART 3 - EXECUTION**

### **3.01 PREPARATION:**

- A. Verify dimensions before proceeding; obtain measurements at structure for work to be fitted to other construction, including wall-to-wall dimensions, floor-to-ceiling dimensions and those controlled by other trades.
- B. Remove foreign substances from surfaces receiving doors.

### **3.02 INSTALLATION:**

- A. Coordinate work of this section with work of other trades.

- B. Install door and operating equipment complete with necessary hardware, jamb and head mold strips, anchors, inserts, hangers, and equipment supports according to approved Shop Drawings, manufacturer's written instructions, and as specified.
- C. Install fire-rated doors to comply with NFPA 80.

**3.03 ADJUSTING:**

- A. Lubricate bearings and sliding parts; adjust doors to operate easily, free from warp, twist, or distortion and fitting weathertight for entire perimeter.

**3.04 DEMONSTRATION:**

- A. Startup Services: Engage a factory-authorized service representative to perform startup services and to train Owner's maintenance personnel as specified below:
  - 1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
    - a. Test door closing when activated by detector or alarm connected fire-release system. Reset door-closing mechanism after successful test.
  - 2. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, preventive maintenance, and procedures for testing and resetting release devices.
  - 3. Review data in the maintenance manuals.

**3.05 CLEANING:**

- A. Remove from site rubbish and debris caused by this work..
- B. Leave areas surrounding doors in broom-clean condition.

**END OF SECTION**

## SECTION 08334

### OVERHEAD COILING GRILLES

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing overhead coiling grilles.
- B. Related Work Specified Elsewhere:
  - 1. Lock cylinders: Section 08710.

##### 1.02 PERFORMANCE REQUIREMENTS:

- A. Operation-Cycle Requirements: Design overhead coiling grille components and operator to operate for not less than 20,000 cycles.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Product Data: For each type and size of overhead coiling grille and accessory. Include details of construction relative to materials, dimensions of individual components, profiles, and finishes. Provide roughing-in diagrams, operating instructions, and maintenance information. Include the following:
    - a. Setting drawings, templates, and installation instructions for built-in or embedded anchor devices.
    - b. Summary of forces and loads on walls and jambs.
    - c. Motors: Show nameplate data and ratings; characteristics; mounting arrangements; size and location of winding termination lugs, conduit entry, and grounding lug; and coatings.
  - 2. Shop Drawings: For special components and installations not dimensioned or detailed in manufacturer's data sheets.
    - a. Wiring Diagrams: Detail wiring for power, signal, and control systems. Differentiate between manufacturer-installed and field-installed wiring and between components provided by grille manufacturer and those provided by others.
  - 3. Samples for Verification: Of each type of exposed finish required, prepared on Samples of size indicated below and of same thickness and material indicated for Work. Where finishes involve normal color and texture variations, include Sample sets showing the full range of variations expected.
    - a. Grille Curtain: 12 inches square.
    - b. Grille Curtain with Glazed Panels: Not less than 12 inches square, with full-size panels.
    - c. Bottom Bar: 6-inch length
    - d. Guides: 6-inch length
    - e. Brackets: 6 inches square.
    - f. Hood: 6 inches square.
  - 4. Certification.

##### 1.04 QUALITY ASSURANCE:

- A. Reference Codes and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.

2. NFPA 70.
  3. NAAMM.
  4. ASTM: A666.
  5. NEMA.
  6. ADA.
- B. Installer Qualifications: Engage an experienced installer who is an authorized representative of the overhead coiling grille manufacturer for both installation and maintenance of units required for this Project.
- C. Source Limitations: Obtain overhead coiling grilles through one source from a single manufacturer.
1. Obtain operators and controls from the overhead coiling grille manufacturer.

#### **1.05 PRODUCT DELIVERY, STORAGE, AND HANDLING:**

- A. Deliver products to the jobsite in original unopened containers clearly labeled with manufacturer's name and brand designation, referenced specification number, type and class as applicable.
- B. Store products in an approved area, protect from contact with soil and from exposure to the elements. Keep products dry.
- C. Handle products so as to prevent breakage of containers and damage to products.

### **PART 2 - PRODUCTS**

#### **2.01 GRILLE CURTAIN MATERIALS AND CONSTRUCTION:**

- A. General: Fabricate overhead coiling grille curtain consisting of a network of 5/16-inch minimum diameter horizontal rods, or rods covered with tube spacers, spaced as indicated. Interconnect rods by vertical links approximately 5/8 inch wide, spaced as indicated and rotating on rods.
1. Space rods at approximately 2 inches o.c.
  2. Space links in line at approximately 9 inches apart.
  3. Stainless-Steel Grilles: ASTM A 666, Type 300 series.
- B. Endlocks: Continuous end links, chains, or other devices at ends of rods, locking and retaining grille curtain in guides against excessive pressures, maintaining curtain alignment, and preventing lateral movement.
- C. Bottom Bar: Manufacturer's standard continuous channel, tubular shape, or 2 angles, finished to match grille.
1. Astragal: Provide a replaceable, adjustable, continuous, compressible gasket of flexible vinyl, rubber, or neoprene, between angles or fitted to shape, as a cushion bumper for interior grille.
  2. Provide motor-operated grilles with combination bottom astragal and sensor edge.
- D. Curtain Jamb Guides: Manufacturer's standard extruded-aluminum shape having curtain groove with return lips or bars to retain curtain. Provide continuous integral wear strips to prevent metal-to-metal contact and minimize noise of travel. Provide removable stops on guides to prevent overtravel of curtain.

#### **2.02 HOODS AND ACCESSORIES:**

- A. Hood: Form to entirely enclose coiled curtain and operating mechanism at opening head. Contour to suit end brackets to which hood is attached. Roll and reinforce top and bottom edges for stiffness. Provide closed ends for surface-mounted hoods and fascia for any portion of between-jamb mounting projecting beyond wall face. Provide intermediate support brackets as required to prevent sag.
  - 1. Fabricate hoods of stainless-steel sheet, complying with ASTM A 666, Type 300 series, and not less than 0.025-inch thick, for stainless-steel grilles..
  - 2. Provide removable metal soffit when hood is mounted above ceiling of same material and finish of curtain, unless otherwise indicated.
- B. Fabricate locking device assembly with lock, spring-loaded dead bolt, operating handle, cam plate, and adjustable locking bar to engage through slots in tracks.
  - 1. Locking Bars: Single-jamb side, operable from inside only.
  - 2. Lock cylinder is specified in another Section 08710.
- C. Chain Lock Keeper: Suitable for padlock.
- D. Where grille unit is power operated, provide safety interlock switch to disengage power supply when grille is locked.

## **2.02 COUNTERBALANCING MECHANISM:**

- A. General: Counterbalance grille by means of adjustable-tension steel helical torsion spring, mounted around a steel shaft and contained in a spring barrel connected to the curtain. Use grease-sealed bearings or self-lubricating graphite bearings for rotating members.
- B. Counterbalance Barrel: Fabricate spring barrel of hot-formed, structural-quality, welded or seamless carbon-steel pipe, of sufficient diameter and wall thickness to support rolled-up curtain without distortion of curtain and to limit barrel deflection to not more than 0.03 in./ft. of span under full load.
- C. Provide spring balance of one or more oil-tempered, heat-treated steel helical torsion springs. Size springs to counterbalance weight of curtain, with uniform adjustment accessible from outside barrel. Provide cast-steel barrel plugs to secure ends of springs to barrel and shaft.
- D. Fabricate torsion rod for counterbalance shaft of case-hardened steel, sized to hold fixed spring ends and carry torsional load.
- E. Brackets: Provide mounting brackets of manufacturer's standard design, either cast-iron or cold-rolled steel plate.

## **2.03 FINISHES, GENERAL:**

- A. General: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- B. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast. Revise Article title below if galvanized surfaces are not finish painted. Always retain priming of bare steel.

## **2.04 STAINLESS-STEEL FINISHES:**

- A. General: Remove or blend tool and die marks and stretch lines into finish.
  - 1. Grind and polish surfaces to produce uniform, directional textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.
- B. No. 4 Finish.
- C. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

## **2.05 ELECTRIC GRILLE OPERATORS:**

- A. General: Provide electric grille operator assembly of size and capacity recommended and provided by grille manufacturer for grille and operational life specified, with electric motor and factory-prewired motor controls, starter, gear-reduction unit, solenoid-operated brake, clutch, remote-control stations, control devices, integral gearing for locking grille, and accessories required for proper operation.
- B. Comply with NFPA 70.
- C. Disconnect Device: Provide hand-operated disconnect or mechanism for automatically engaging sprocket-chain operator and releasing brake for emergency manual operation while disconnecting motor, without affecting timing of limit switch. Mount disconnect and operator so they are accessible from floor level. Include interlock device to automatically prevent motor from operating when emergency operator is engaged.
- D. Design operator so motor may be removed without disturbing limit-switch adjustment and without affecting emergency auxiliary operator.
- E. Provide control equipment complying with NEMA ICS 1, NEMA ICS 2, and NEMA ICS 6, with NFPA 70 Class 2 control circuit, maximum 24-V, ac or dc.
- F. Grille-Operator Type: Provide wall-, hood-, or bracket-mounted, jackshaft, gear-head hoist-type grille operator unit consisting of electric motor, enclosed worm-gear running-in-oil primary drive, chain and sprocket secondary drive, and auxiliary chain hoist and floor level disconnect.
- G. Electric Motors: Provide high-starting torque, reversible, continuous-duty, Class A insulated, electric motors, complying with NEMA MG 1, with overload protection, sized to start, accelerate, and operate grille in either direction, from any position, at not less than 2/3 fps and not more than 1 fps, without exceeding nameplate ratings or considering service factor.
  - 1. Type: single phase.
  - 2. Service Factor: According to NEMA MG 1, unless otherwise indicated.
  - 3. Coordinate wiring requirements and electric characteristics of motors with building electrical system.
  - 4. Provide open dripproof-type motor, and controller with NEMA ICS 6, Type 1 enclosure.
- H. Remote-Control Station: Provide momentary-contact, 3-button control station with push-button controls labeled "Open," "Close," and "Stop."
  - 1. Provide exterior units, full-guarded, standard-duty, surface-mounted, weatherproof type, NEMA ICS 6, Type 4 enclosure, key operated.
- I. Obstruction Detection Device: Provide each motorized grille with indicated external automatic safety sensor able to protect full width of grille opening. Activation of sensor immediately stops and reverses downward grille travel.

1. Sensor Edge: Provide each motorized grille with an automatic safety sensor edge, located within astragal or weather stripping mounted to bottom bar. Contact with sensor immediately stops and reverses downward grille travel. Connect to control circuit using manufacturer's standard take-up reel or self-coiling cable.
  - a. Provide pneumatically actuated automatic bottom bar.
- J. Limit Switches: Provide adjustable switches, interlocked with motor controls and set to automatically stop grille at fully opened and fully closed positions.
- K. Provide electric operators with ADA-compliant audible alarm and visual indicator lights.
- L. Emergency Egress Release: Provide grille with flush, wall-mounted handle mechanism, for ADA-compliant egress feature, not dependent on electric power, that allows grille to open to permit passage and automatically resets motor drive, without affecting limit switches, with return of handle to original position.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION:**

- A. General: Install grilles and operating equipment complete with necessary hardware, according to Shop Drawings, manufacturer's written instructions, and as specified.

#### **3.02 ADJUSTING:**

- A. Lubricate bearings and sliding parts; adjust grilles to operate easily, free from warp, twist, or distortion and fitting tight for entire perimeter.

#### **3.03 DEMONSTRATION:**

- A. Startup Services: Engage a factory-authorized service representative to perform startup services and to train Owner's maintenance personnel as specified below.
  1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
  2. Train Authority's personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, preventive maintenance, and procedures for testing and resetting release devices.
  3. Review data in the approved maintenance manuals.

**END OF SECTION**

## SECTION 08410

### ALUMINUM ENTRANCES AND STOREFRONTS

#### PART 1 -GENERAL

##### 1.01 SUMMARY:

- A. This Section specifies provision of exterior aluminum entrances and storefronts including doors, hardware, weatherstripping, and framing members.
- B. Related Work Specified Elsewhere:
  - 1. Section 08800: Glass and Glazing.
  - 2. Section 08710: Finish Hardware.

##### 1.02 QUALITY ASSURANCE:

- A. Installer Qualifications: Engage an experienced installer to assume engineering responsibility and perform work of this Section who has specialized in installing entrances similar to those required for this Project and who is acceptable to manufacturer.

##### 1.03 DESCRIPTION:

- A. General: Provide aluminum entrances and storefronts capable of withstanding loads and thermal and structural movement requirements indicated without failure. Failure includes the following:
  - 1. Air infiltration and water penetration exceeding specified limits.
  - 2. Framing members transferring stresses, including those caused by thermal and structural movement, to glazing units.
- B. Glazing: Physically and thermally isolate glazing from framing members.
- C. Thermally Broken Construction: Provide aluminum entrances and storefronts that isolate aluminum exposed to exterior from aluminum exposed to interior with a material of low thermal conductance.
- D. Wind Loads: Provide aluminum entrances and storefronts, including anchorage, capable of withstanding wind-load design pressures calculated according to requirements of authorities having jurisdiction or the American Society of Civil Engineers' ASCE 7, "Minimum Design Loads for Buildings and Other Structures," 6.4.2, "Analytical Procedure," whichever are more stringent.
  - 1. Deflection of framing members in a direction normal to wall plane is limited to 1/175 of clear span or 3/4 inch whichever is smaller, unless otherwise indicated.
  - 2. Static-Pressure Test Performance: Provide aluminum entrances and storefronts that do not evidence material failures, structural distress, failure of operating components to function normally, or permanent deformation of main framing members exceeding 0.2 percent of clear span when tested according to ASTM E 330.
    - a. Pressure: 150 percent of inward and outward wind-load design pressures.
    - b. Duration: As required by design wind velocity; fastest 1 mile of wind for relevant exposure category.
- E. Dead Loads: Provide entrance-members that do not deflect an amount which will reduce glazing bite below 75 percent of design dimension when carrying full dead load.

1. Provide a minimum 1/8-inch clearance between members and top of glazing or other fixed part immediately below.
- F. Air Infiltration: Provide aluminum entrances and storefronts with permanent resistance to air leakage through fixed glazing and frame areas of not more than 0.06 cfm/sq. ft. of fixed wall area when tested according to ASTM E 283 at a static-air-pressure difference of 1.57 lbf/sq. ft
- G. Water Penetration: Provide aluminum entrances and storefronts that do not evidence water leakage through fixed glazing and frame areas when tested according to ASTM E331 at minimum differential pressure of 20 percent of inward-acting wind-load design pressure as defined by ASCE 7, "Minimum Design Loads for Buildings and Other Structures," but not less than 6.24 lbf/sq. ft. Water leakage is defined as follows:
1. Uncontrolled water infiltrating aluminum entrances and storefronts or appearing on normally exposed interior surfaces from sources other than condensation. Water controlled by flashing and gutters that is drained back to the exterior and cannot damage adjacent materials or finishes is not water leakage.
- H. Thermal Movements: Provide aluminum entrances and storefronts, including anchorage, that accommodate thermal movements of aluminum entrances and storefronts and supporting elements resulting from the following maximum change (range) in ambient and surface temperatures without buckling, damaging stresses on glazing, failure of joint sealants, damaging loads on fasteners, failure of doors or other operating units to function properly, and other detrimental effects.
1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.
- I. Structural-Support Movement: Provide aluminum entrances and storefronts that accommodate structural movements including, but not limited to, sway and deflection.
- J. Condensation Resistance: Provide aluminum entrances and storefronts with condensation resistance factor (CRF) of not less than 45 when tested according to AAMA 1503.1.
- K. Dimensional Tolerances: Provide aluminum entrances and storefronts that accommodate dimensional tolerances of building frame and other adjacent construction.

#### **1.04 SUBMITTALS:**

Submit the following in accordance with requirements elsewhere in this Contract and with the additional requirements as specified for each:

- A. Product Data: For each product specified. Include details of construction relative to materials, dimensions of individual components, profiles, and finishes.
- B. Shop Drawings: For aluminum entrances and storefronts show details of fabrication and installation, including plans, elevations, sections, details of components, glazing provisions for expansion and contraction, and attachments to other work.
  1. For aluminum entrances and storefronts, include hardware schedule and indicate operating hardware types, quantities, and location
- C. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for factory-applied color finishes.
- D. Samples for Verification: Of each type of exposed finish required. Where finishes involve normal color and texture variations, include Sample sets showing the full range of variations expected.

- E. Cutaway Sample: Of vertical-to-horizontal framing intersection, made from minimum 6-inch lengths of full-size components and showing details of the following:
  - 1. Joinery.
  - 2. Anchorage.
  - 3. Expansion provisions.
  - 4. Glazing.
  - 5. Flashing and drainage.

#### **1.05 WARRANTY:**

- A. Warranty Period: 1 year in addition to the warranty requirements specified elsewhere in this Contract, for a total of 2 years from date of Substantial Completion.
  - 1. Failures include, but are not limited to, the following:
  - 2. Failure of aluminum entrances and storefronts to meet performance requirements.
  - 3. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
  - 4. Failure of operating components to function normally.
  - 5. Water leakage through fixed glazing and frame areas.

### **PART 2 - PRODUCTS**

#### **2.01 MATERIALS:**

- A. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated, complying with the requirements of standards indicated below.
  - 1. Sheet and Plate: ASTM B 209.
  - 2. Extruded Bars, Rods, Shapes, and Tubes: ASTM B 221.
  - 3. Extruded Structural Pipe and Tubes: ASTM B 429.
  - 4. Bars, Rods, and Wire: ASTM B 211.
  - 5. Aluminum Finish: Dark bronze integral color anodized Class 1 finish, NAAMM AA-M12C22A44.
    - a. Provide all material, free of scratches and surfaces blemishes.
- B. Glazing as specified in Section 08800.
- C. Glazing Gaskets: Manufacturer's standard pressure-glazing system of black, resilient glazing gaskets, setting blocks, and shims or spacers, fabricated from an elastomer of type and in hardness recommended by system and gasket manufacturer to comply with system performance requirements. Provide gasket assemblies that have corners sealed with sealant recommended by gasket manufacturer. Insert specific gasket-material requirements, if any.
- D. Bituminous Paint: Cold-applied asphalt-mastic paint complying with SSPC-Paint 12 requirements, except containing no asbestos, formulated for 30-mil thickness per coat.
- E. Sill Mastic: Butyl: Polymerized butyl rubber and inert fillers (pigments), solvent-based with minimum 75-percent solids, non-sag consistency, tack-free time of 24 hours or less, paintable, non-staining, and complying with FS TT-S-001657.

#### **2.02 COMPONENTS:**

- A. Doors: Provide manufacturer's standard 1-3/4-inch thick glazed doors with minimum 0.125-inch-thick, extruded tubular rail and stile members as approved. Mechanically fasten corners with reinforcing brackets that are deep penetration and fillet welded or that incorporate concealed tie-rods.

1. Glazing Stops and Gaskets: Provide manufacturer's standard snap-on extruded-aluminum glazing stops and preformed gaskets, as approved.
  2. Stile Design: As shown.
- B. Brackets and Reinforcements: Provide manufacturer's standard brackets and reinforcements that are compatible with adjacent materials, as approved. Provide nonstaining, nonferrous shims for aligning components as approved.
- C. Fasteners and Accessories: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding fasteners and accessories compatible with adjacent materials, as approved.
1. Reinforce members as required to retain fastener threads.
  2. Do not use exposed fasteners, except for hardware application. For hardware application, use countersunk Phillips flat-head machine screws finished to match framing members or hardware being fastened, unless otherwise indicated.
- D. Concealed Flashing: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding flashing, compatible with adjacent materials, and of type approved.
- E. Weather Stripping: ANSI/BHMA A156.22, Finish 628 (satin aluminum clear anodized) with stainless steel sheet-metal screws and as follows:
1. Head and jamb: Head and jamb type, stop-applied; National Guard A626 or equal. Provide nylon brush gasketing or equal.
  2. Sill: Drip strip at sill; National Guard 15 or equal.
  3. Sweep: Door sweep type, surface mounted at bottom of door; National Guard D608 nylon brush gasketing or equal. Provide sweep on side opposite to drip strip where scheduled.

### **2.03 FINISH HARDWARE:**

- A. General: Provide heavy-duty hardware units indicated in sizes, number, and type recommended by manufacturer for entrances indicated as specified in Section 08710, and as approved. Finish exposed parts to match door finish, unless otherwise indicated.
- B. Offset Pivots where approved: ANSI/BHMA A156.4, Grade 1 with exposed parts of cast-aluminum alloy. Provide top, bottom, and intermediate pivots at each door leaf.
- C. Ball-Bearing Butts: ANSI/BHMA A156.1, Grade 1, 5-knuckle, ball-bearing butts. Provide nonremovable pins at hinges exposed to door outside and provide full-mortise Type 1 slip-in nonferrous hinges for applications exposed to weather. Provide 3 hinges at each leaf for doors up to 36 inches wide and 80 inches tall; provide 4 hinges at each leaf for taller doors.
- D. Closers, General: Comply with manufacturer's recommendations for closer size, depending on door size, exposure to weather, and anticipated frequency of use.
1. Closing Cycle: Comply with requirements of authorities having jurisdiction or the Americans with Disabilities Act (ADA), "Accessibility Guidelines for Buildings and Facilities (ADAAG)," whichever are more stringent.
  2. Opening Force: Comply with the following maximum opening-force requirements for locations indicated:
    - a. Exterior Doors: 15 lbf.
  3. Surface Mounted Overhead Closers: ANSI/BHMA 156.4, Grade 1, provide cover and the following:
    - a. Mounting: parallel arm, interior locations (room side of door unless otherwise specified).
    - b. Cushion stop: Adjustable at angle directed by the Engineer from manufacturer's standard options.

4. Door Stops: ANSI/BHMA A156.16, Grade 1, floor- or wall-mounted door stop, as appropriate for door location indicated, with integral rubber bumper. Retain appropriate cylinder requirements below.
- E. Cylinders and Keying for Yard Buildings: Match the Authority's existing keying and interchangeable core system as follows and at no additional cost to the Authority.
1. Cylinders: Finish 630.
    - a. For locksets: ANSI/BHMA A156.5, interchangeable-core type, designed to accept the Authority's existing Russwin Recore System. One core furnished for each lock, stamped with visual key control.
    - b. High security: Interlocking-pin type, Emhart High-Security Locking System or equal
  2. Construction cores: Provide construction cylinders until final cylinders and keying is approved and installed.
  3. Keys and keying:
    - a. Keys: Stamped with the inscription TRANSIT AUTHORITY - DO NOT DUPLICATE and with visual key-control data.
    - b. Quantity: Three keys for each core plus blanks equal to 10-percent of total keys furnished.
  4. Key tags and holders: ANSI/BHMA A156.5, inscribed with key-change number and key-control symbol.
  5. Cylinder Guard: Manufacturer's standard hardened-steel security ring with retainer plate for inside stile wall that protects lock cylinder from removal by wrenches, prying, or sawing.
- F. Deadlatch Locks: Manufacturer's standard mortise deadlatch with minimum 1/2-inch-12.7-mm- long latch bolt and auxiliary bolt located below latch bolt and complying with ANSI/BHMA A156.5, Grade 1 requirements.
1. Lever Handles: Manufacturer's standard cast-aluminum-alloy, inside-lever, deadlatch operating unit.
  2. Latch Paddle Devices: Manufacturer's standard extruded-aluminum deadlatch operating paddle.
    - a. Provide units for push applications.
    - b. Provide units for push and pull applications. Hook-bolt locks are recommended for pairs of doors, since they provide additional resistance to prying.
  3. Lockset Faceplates: Manufacturer's standard extruded-aluminum faceplate for lock type indicated that lays flush with door stile.
    - a. Provide radiused faceplate with weather sweep extending full length of lock at meeting stiles of pairs of doors.
  4. Flat Face Strikes: Manufacturer's standard stainless-steel, flat face strike with steel mounting plate and black-plastic dustbox.
  5. Retain one flush-bolt requirement below if required for inactive leaf of pairs of doors. Model codes prohibit manual flush bolts on means of egress doorways. If exit devices are not required, consider specifying 2- or 3-point locking systems listed above or inserting requirements for automatic flush bolts that comply with requirements of authorities having jurisdiction.
  6. Manual Flush Bolts: ANSI/BHMA A156.16, edge-mortised, lever-extension-type flush bolts.
    - a. Locate flush bolts at bottom of inactive leaf of pairs of doors.
    - b. Locate flush bolts at top and bottom of inactive leaf of pairs of doors.
- G. Pull Handles: Aluminum pull handles as indicated on Drawings.
- H. Push Bars: Aluminum push bars as indicated on Drawings.

- I. Thresholds: At exterior doors, provide manufacturer's standard threshold with cutouts coordinated for operating hardware, with anchors and jamb clips, and not more than 5/16-inch, with beveled edges providing a floor level change with a slope of not more than 1:2, and in the following material:
  - 1. Material: Aluminum, mill finish.
- J. Weatherstripping: ANSI/BHMA A156.22, Finish 628 (satin aluminum clear anodized) with stainless steel sheet-metal screws and as follows:
  - 1. Head and jamb: Head and jamb type, stop-applied; National Guard A626 or equal or compression type gasketing as approved.
  - 2. Sill: Drip strip at sill; National Guard 15 or equal.
  - 3. Sweep: Door sweep type, surface mounted at bottom of door; National Guard D608 nylon brush gasketing or equal. Provide sweep on side opposite to drip strip where scheduled.
- K. Special Security Alarmed Exit Device for Parking Structures: To sound alarm at unauthorized entry or exit at locations indicated and as required and approved.

## **2.04 FABRICATION:**

- A. General: Fabricate components that, when assembled, will have accurately fitted joints with ends coped or mitered to produce hairline joints free of burrs and distortion. After fabrication, clearly mark components to identify their locations in Project according to Shop Drawings.
- B. Forming: Form shapes with sharp profiles, straight and free of defects or deformations, before finishing.
- C. Prepare components to receive concealed fasteners and anchor and connection devices.
- D. Fabricate components to drain water passing joints and condensation and moisture occurring or migrating within the aluminum entrances and storefronts to the exterior.
- E. Welding: Weld components to comply with referenced AWS standard. Weld before finishing components to greatest extent possible. Weld in concealed locations to greatest extent possible to minimize distortion or discoloration of finish. Remove weld spatter and welding oxides from exposed surfaces by descaling or grinding.
- F. Glazing Channels: Provide minimum clearances for thickness and type of glass indicated according to FGMA's "Glazing Manual."
- G. Metal Protection: Where aluminum will contact dissimilar metals, protect against galvanic action by painting contact surfaces with primer or by applying sealant or tape recommended by manufacturer for this purpose.
- H. Entrances: Fabricate door framing in profiles indicated. Reinforce as required to support imposed loads. Factory assemble door and frame units and factory install hardware to greatest extent possible. Reinforce door and frame units as required for installing hardware indicated. Cut, drill, and tap for factory-installed hardware before finishing components.
  - 1. Exterior Doors: Provide nylon brush gasketing or compression weather stripping where indicated as approved.

## **PART 3 - EXECUTION**

### **3.01 EXAMINATION:**

- A. Examine areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of aluminum entrances and storefronts. Do not proceed with installation until unsatisfactory conditions have been corrected.

### **3.02 INSTALLATION:**

- A. General: Protect and handle aluminum entrances and storefronts components to prevent damage; do not install damaged components. Fit frame joints to produce hairline joints free of burrs and distortion. Rigidly secure nonmovement joints. Seal joints watertight.
- B. Metal Protection: Where aluminum will contact dissimilar metals, protect against galvanic action by painting contact surfaces with primer or by applying sealant or tape recommended by manufacturer for this purpose.
- C. Install components to drain water passing joints and condensation and moisture occurring or migrating within the aluminum entrances and storefronts to the exterior.
- D. Set continuous sill members and flashing in a full sealant bed to provide weathertight construction, unless otherwise indicated. Comply with requirements as specified in Section 07900.
- E. Install framing components plumb and true in alignment with established lines and grades without warp or rack of framing members.
- F. Install entrances plumb and true in alignment with established lines and grades without warp or rack. Lubricate operating hardware and other moving parts according to hardware manufacturers' written instructions.
  - 1. Install surface-mounted hardware in accordance with Section 08710 and according to manufacturer's written instructions using concealed fasteners to greatest extent possible.
- G. Install glazing to comply with requirements of Section 08800, unless otherwise indicated. Delete subparagraphs below if no structural-sealant-glazed systems.
- H. Install perimeter sealant to comply with manufacturer's requirements and Section 08800, unless otherwise indicated.
- I. Erection Tolerances: Install entrance and storefront aluminum entrances and storefronts to comply with the following maximum tolerances:
  - 1. Variation from Plane: Limit variation from plane or location shown to 1/8 inch in 12 feet 1/4 inch over total length.
  - 2. Alignment: Where surfaces abut in line, limit offset from true alignment to 1/16 inch. Where surfaces meet at corners, limit offset from true alignment to 1/32 inch.
  - 3. Diagonal Measurements: Limit difference between diagonal measurements to 1/8 inch.

### **3.03 FIELD QUALITY CONTROL:**

- A. Water Spray Test: After completing the installation of test areas indicated, test aluminum entrances and storefronts for water penetration according to AAMA 501.2 requirements.
- B. Repair or remove and replace Work as directed by the Engineer that does not meet requirements or that is damaged by testing; replace to conform to specified requirements.

**3.04 ADJUSTING:**

- A. Adjust doors and hardware to provide tight fit at contact points and weather stripping, smooth operation, and weathertight closure.

**3.05 PROTECTION:**

- A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure aluminum entrances and storefronts are without damage or deterioration at the time of Substantial Completion.

**END OF SECTION**

## SECTION 08481

### METAL CONCAVE MANDOORS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing and installing metal concave mandoors, frames and hardware.
- B. Related Work Specified Elsewhere:
  - 1. Mortar, Grout and Masonry Accessories: Section 04050.
  - 2. Metal Doors and Frames: Section 08110.
  - 3. Finish Hardware: Section 08710.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with additional requirements as specified for each:
  - 1. Shop-Drawings:
    - a. Details of construction, connections, anchors schedules, setting diagrams and interface with work of other trades.
  - 2. Certifications.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications.
  - 1. Codes and regulations of the jurisdictional authorities.
  - 2. ASTM: A36, A90, A366.
  - 3. UL: Building Materials Directory.
  - 4. NFPA: 80.
- B. Loading: Positive and Negative Air Pressure; 10 psi.
- C. Manufacturer and installer must have experience in the manufacturing and successful installations of high static pressure doors and frames.
- D. Fire-Rated Assemblies: Where UL-listing, UL-label or UL Building Materials Directory is specified, another testing and inspection agency acceptable to the Engineer and to authorities having jurisdiction may be used.

##### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver products to the job site in original unopened containers or wrappings clearly labeled with manufacturer's name and brand designation, door schedule number, referenced specification number, type, class and rating as applicable.
- B. Store products in an approved dry area, protect from contact with soil and from exposure to the elements.
- C. Handle products so as to prevent damage to products.

#### PART 2 - PRODUCTS

## 2.01 MATERIALS:

- A. Door Frames:
  - 1. Basic Materials: ASTM A36 structural steel for frames.
  - 2. Hardware Reinforcement: Steel
    - a. Torsion spring closing assembly constructed of stainless steel 2-5/8" inside diameter by 0.235" thickness by 6". Aluminum alloy spring fitting shall provide for adjustment of the spring to ensure proper door closing at all times.
    - b. Upper and lower door supports constructed of 1/4" mild steel plate, 1" stainless steel shafts and heavy-duty self aligning flange bearings.
  - 3. Door Stops: 1/8 inch minimum thickness steel stops. Stops shall be provided on both sides of door.
  - 4. Finish: Hot dipped galvanized coating unless indicated otherwise.
- B. Doors:
  - 1. Door panel: Constructed of 1/8" mild roll-formed steel sheet, ASTM A366. Upper and lower panel supports constructed of 1/4" mild steel plate and are to be secured to the door panel by a continuous weld.
  - 2. Door Frame: Constructed of structural steel ASTM A36 with 1" x 1" x 1/8" welded angles to control maximum door travel.
  - 3. Push/pull handle: 3/8 inch minimum thickness. Handle allows ease of rotating door to facilitate access.
  - 4. Bearings: The door shall be equipped with sealed support bearing at both the top and bottom of the door.
  - 5. All components of doors shall be hot dipped galvanized.
- C. Clips, Anchors, Bolts, Screws and Rivets: Hot dipped galvanized Steel types standard with manufacturer.
- D. Concave Mandoor Locking Mechanism:
  - 1. Locking mechanism, shall be Adams Rite Latch paddle device 4590. Paddle shall be extruded aluminum (satin anodized). Escutcheon to be zinc alloy (black) to house steel operating mechanism. Dead latch shall be Adams Rite 4722. Case shall be steel, plated for corrosion, resistance, and aluminum faceplate shall be satin anodized. Latch bolt shall be all metal construction with hardened steel pin. Mortise cylinder cam to be provided. See Section 802 for lock cylinder. Provide temporary lock cylinders.

## 2.02 FABRICATION:

- A. Frame:
  - 1. Formed to be installed into walls and locations shown.
  - 2. Welded for installation into wall of sheet steel construction.
  - 3. Corners and connections continuously welded with exposed welds ground flush and smooth.
  - 4. Reinforcement continuously welded in place as necessary for hardware application. Provide cutouts for hardware.
- B. Door:
  - 1. Hardware reinforcement continuously welded in place to support hardware application.

## 2.03 HOT DIPPED GALVANIZED:

- A. Galvanizing (zinc coating by hot dip process): ASTM A90 or similar galvanizing process.
- B. Galvanizing repair compound: Stick form, melting point 600F to 650F, GALVABAR or equal.

**2.04 FINISH HARDWARE COORDINATION:**

- A. The metal door and frame shall be prepared at factory for application of finish hardware at job site. Obtain templates from finish hardware manufacturer to ensure accurate preparation of doors and frames in accordance with hardware specified.

**PART 3 - EXECUTION**

**3.01 INSTALLATION:**

- A. Deliver work , ready to set up and erect in place as rapidly as general construction work permits. Set work in place in accordance with approved shop drawings, plumb and level, strongly secured against displacement and with built-in anchors. Limit field-cutting, drilling and punching to minimum necessary
- B. Anchor metal frames to slab with angle clips and minimum of two expansion bolts in each clip.
- C. Provide four adjustable anchors on each jamb. See Section 04050 for grouting of door frame.
- D. Install doors after hardware installation; accurately fit and adjust to work properly.
- E. Seal open joints at bottom of door frames, and between door frames and adjoining concrete.
- F. Install fire-rated door assemblies in accordance with NFPA 80.
- G. Upon completion of installations clean surfaces of doors and frame as recommended by door manufacturer.
  - 1. Remove from the site rubbish and debris caused by this work.
  - 2. Leave areas surrounding openings in broom-clean condition.

**END OF SECTION**

## SECTION 08520

### ALUMINUM WINDOWS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing extruded aluminum windows with fixed and operating sash.
- B. Related Work Specified Elsewhere:
  - 1. Seals and Sealants: Section 07900.
  - 2. Glass and Glazing: Section 08800.
  - 3. Aluminum Entrances and Storefronts: Section 08410.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Codes and regulations of the jurisdictional authorities.
  - 2. AAMA: 608.1, 101.
  - 3. ASTM: A123, B221.
  - 4. FS: RR-W-365.
  - 5. SSPC: 20.

##### 1.03 SUBMITTALS:

- A. Shop Drawings:
  - 1. Product Data: Provide component dimensions, anchorage and fasteners, glass, internal drainage details.
  - 2. Shop Drawings: Indicate opening dimensions, framed opening tolerances, affected related work; installation requirements
  - 3. Submit two samples 12 x 12 inches in size illustrating window frame section, mullion section screen and frame, factory finished aluminum surfaces, glass units and glazing materials.
  - 4. Submit two samples of operating hardware.

##### 1.04 DELIVERY, STORAGE, AND PROTECTION:

- A. Transport, handle, store, and protect products.
- B. Handle work of this section in accordance with AAMA - Curtain Wall Manual #10.
- C. Protect factory finished aluminum surfaces with wrapping strippable coating. Do not use adhesive papers or sprayed coatings that bond when exposed to sunlight or weather.

#### PART - PRODUCTS

##### 2.01 MATERIALS:

- A. Extruded Aluminum: ASTM B221, 6063 alloy, T5 temper.
- B. Steel Sections: Profiled to suit mullion sections.
- C. Fasteners: Stainless steel.

## **2.02 COMPONENTS:**

- A. Frames: thermally broken with interior portion of frame insulated from exterior portion flush glass stops of snap-on type
- B. Reinforced Mullion: extruded aluminum with integral reinforcement of shaped steel structural section.
- C. Sills: extruded aluminum; sloped for positive wash: one piece full width of opening.
- D. Insect Screen Frame: Rolled aluminum steel frame of rectangular sections; fit with adjustable hardware; nominal size similar to operable glazed unit.
- E. Insect Screens: FS RR-W-365, woven aluminum mesh 14/18 mesh size.
- F. Operable Sash Weather Stripping: Wool pile permanently resilient, profiled to effect weather seal.
- G. Fasteners: Stainless steel.
- H. Window Washing Anchors: Stainless steel.
- I. Insulated Metal Infill Panels: Section 08410.

## **2.03 GLASS AND GLAZING MATERIALS:**

- A. Glass and Glazing Materials: Insulating glass units as specified in Section 08800.

## **2.04 SEALANT MATERIALS:**

- A. Sealant and Backing Materials: Section 07900.

## **2.05 HARDWARE:**

- A. Operator: Lever action handle fitted to projecting sash arms with limit stops.
- B. Projecting Sash Arms: Cadmium Zinc plated steel, friction pivot joints with nylon bearings, removable pivot clips for cleaning.
- C. Sash lock: Lever handle with cam lock.

## **2.06 FABRICATION:**

- A. Fabricate components with minimum clearances and shim spacing around perimeter of assembly, yet enabling installation and dynamic movement of perimeter seal.
- B. Accurately fit and secure joints and corners. Make joints flush, hairline, and weatherproof.
- C. Prepare components to receive anchor devices. Fabricate anchors.
- D. Arrange fasteners and attachments to ensure concealment from view.
- E. Prepare components with internal reinforcement for operating hardware.
- F. Provide internal reinforcement in mullions with galvanized steel members to maintain rigidity.

- G. Permit internal drainage weep holes and channels to migrate moisture to exterior. Provide internal drainage of glazing spaces to exterior through weep holes.
- H. Assemble insect screen frame, miter and reinforced frame corners. Fit mesh taut into frame and secure. Fit frame with retainers.
- I. Double weatherstrip operable units.

## **2.07 FINISHES:**

- A. Finish Coatings: Conform to AAMA 608.1.
- B. Exposed Aluminum Surfaces: AA A44 anodized to Dark Bronze color.
- C. Operator and Exposed Hardware: Enameled to color as selected.
- D. Touch-Up Primer for Galvanized Steel Surfaces: SSPC Paint 20 zinc rich.
- E. Concealed Steel Items: Galvanized in accordance with ASTM A123 to 2.0 oz/sq ft.
- F. Apply coats of bituminous paint to concealed aluminum and steel surfaces in contact with treated wood, cementitious, or dissimilar materials.

## **PART 3 - EXECUTION**

### **3.01 EXAMINATION:**

- A. Verification of existing conditions before starting work.
- B. Verify wall openings and adjoining air and vapor seal materials are ready to receive work of this Section.

### **3.02 INSTALLATION**

- A. Install window assembly in accordance with AAMA 101.
- B. Attach window frame and shims to perimeter opening to accommodate construction tolerances and other irregularities.
- C. Align window plumb and level, free of warp or twist. Maintain dimensional tolerances and alignment with adjacent work.
- D. Install sill.
- E. Provide thermal isolation where components penetrate or disrupt building insulation. Pack fibrous insulation in shim spaces at perimeter of assembly to maintain continuity of thermal barrier.
- F. Coordinate attachment and seal of perimeter air barrier and vapor retarder materials.
- G. Install operating hardware.
- H. Install glass and infill panels in accordance with Section 08800 and Section 08410.
- I. Install perimeter sealant backing materials, and installation criteria in accordance with Section 07900.

### **3.03 CLEANING**

- A. Remove protective material from factory finished aluminum surfaces.
- B. Wash surfaces by method recommended and acceptable to sealant and window manufacturer; rinse and wipe surfaces clean.
- C. Remove excess sealant by moderate use of mineral spirits or other solvent acceptable to sealant and window manufacturer.

**END OF SECTION**

## SECTION 08710

### FINISH HARDWARE

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing finish hardware.
- B. Related Work Specified Elsewhere:
  - 1. Access Doors and Frames including locks and cylinders: Section 08305.
  - 2. Overhead Coiling Doors: Section 08331.
  - 3. Overhead Coiling Grilles: Section 08334.
  - 4. Cremone bolt to receive lock and chain provided under this section: Section 02877.
  - 5. Hollow Metal Doors and Frames: Section 08110.
  - 6. Aluminum Entrances and Storefronts: Section 08410.
  - 7. Metal Concave Mandoors: Section 08481.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulation of the jurisdictional authorities.
  - 2. ANSI/BHMA: A156-Series Standards for Builders Hardware.
  - 3. ASTM: A413
  - 4. FS: TT-S-001657.
  - 5. ADA: ADAAG.
  - 6. NFPA: 80, 101, 130.
  - 7. DHI: Recommended Locations for Builders Hardware for Standard Steel Doors and Frames, Recommended Locations for Builders Hardware for Custom Steel Doors and Frames.
- B. Hardware Supplier Qualifications: A recognized architectural finish hardware supplier, with warehousing facilities in the Project's vicinity, that has a record of successful in-service performance for supplying finish hardware similar in quantity, type, and quality to that indicated for this Project and that employs an experienced architectural hardware consultant (AHC) who is available to the Engineer and Contractor, at reasonable times during the course of the Work for consultation.
  - 1. Require supplier to have his AHC develop the hardware schedule.
  - 2. Require supplier's AHC to meet with the Engineer to discuss and finalize lock-functions and keying requirements.
- C. Fire-Rated Openings: Provide hardware for fire-rated openings that complies with NFPA 80 and requirements of authorities having jurisdiction. Provide only items of hardware that are listed and are identical to products tested by UL, Warnock Hersey, FM, or other testing and inspecting organization acceptable to authorities having jurisdiction for use on types and sizes of doors indicated in compliance with requirements of fire-rated door and door frame labels.
  - 1. Equip labeled doors with hinges of steel or stainless steel base metal, closers, and automatic latching devices in addition to the hardware requirements in the specified hardware sets.
  - 2. If a conflict appears between this paragraph and the hardware sets scheduled, the requirements of this paragraph govern.

- D. Americans With Disabilities Act (ADA): Comply with the ADA Accessibility Guidelines (ADAAG).

### 1.03 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

A. Shop Drawings:

1. Product Data: Manufacturers' technical literature and catalog cuts, edited as necessary to indicate each item of hardware, model, selected options, finish, installation instructions, maintenance of operating parts and finish, and other information necessary to show compliance with requirements. Make coordinated submittals packages complete with all supporting data.
2. Hardware Schedule: Hardware schedule coordinated with doors, frames, gates and related work to ensure proper size, thickness, hand, function, design and finish of hardware. Base Hardware Schedule on hardware sets indicated in PART 3 of this section. Indicate complete designations of each item required for each door or opening, including the following information:
  - a. Explanation of each abbreviation, symbol, and code contained in hardware schedule. Schedules with unidentified notations will be rejected without review.
  - b. Door and frame number, size, and materials.
  - c. Type, style, function, size, and finish of each hardware item. Include lockset functions, angle of closer operation, lever and handle designs, lengths of flush bolts, types of stops, sizes of armor and kick plates, and other such data.
  - d. Name and manufacturer of each item.
  - e. Fastenings and other pertinent information.
  - f. Location of each hardware set cross-referenced to indications on Drawings, both on floor plans and in door schedule.
  - g. Mounting locations for hardware.
  - h. Keying information.
3. Submittal sequence: Submit hardware schedule at earliest possible date particularly where acceptance of hardware schedule must precede fabrication of other work that is critical in the Project construction schedule. Include with hardware schedule the product data, samples, shop drawings of work affected by finish hardware, and other information essential to a coordinated review of hardware schedule.
4. Templates: Transmit hardware templates directly to trades fabricating related work specified to be prepared for the installation of finish hardware under this section. Submit record copy of these transmittals to the Engineer.
5. Coordinating hardware preparation by other trades: Check shop drawings of other trades to ensure that correct provisions from transmitted templates are made for locating and installing finish hardware to comply with indicated requirements.

B. Samples:

1. Finishes: Two, minimum four-inch squares of each finish to be furnished. Submit with shop drawings.
2. Hardware units: Each type of exposed hardware unit in approved finish and tagged with full description for coordination with hardware schedule. Submit unit samples prior to submission of final hardware schedule.
  - a. When requested, samples will be returned to the supplier. Accepted units that remain undamaged through the submittal, review, and field-comparison process may, after final check of operation, be used in the Work, within limitations of keying coordination requirements.

- b. Submit the following:
    - 1) One sample of a lockset including, trim, escutcheon, strike box, lever, cylinder, and key.
    - 2) One sample of hinge.
    - 3) One sample of each miscellaneous item of finish hardware.
    - 4) Provide finishes so that color and surface finish or polish of various items of the same designated finish match throughout the work. Hardware with non-matching finishes will be rejected.
  - c. The Authority reserves the right to require samples of each specific item to be furnished.
- C. Certification.
- D. Documentation:
- 1. Construction keying schedule.

**1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Deliver products to jobsite in original unopened packages, clearly labeled with manufacturer's name, brand, specification identification data and identification as shown on approved hardware schedule.
- B. Store products in an approved dry area, protect from contact with soil and from exposure to the elements. Keep products dry.
- C. Handle products so as to prevent breakage of containers and damage to products.

**1.05 MAINTENANCE TOOLS AND INSTRUCTIONS:**

- A. Furnish a complete set of specialized tools and maintenance instructions as needed for the Authority's continued adjustment, maintenance, removal and replacement of hardware.

**PART 2 - PRODUCTS**

**2.01 HARDWARE TYPES:**

- A. General:
  - 1. Hardware grade: Provide only Grade 1 hardware in accordance with ANSI/BHMA A156-Series Standards and with the additional requirements specified in this section, except where otherwise specified or approved in writing by the Engineer for each specific door number.
  - 2. Fire-rated hardware: Where applied to fire-rated labeled doors and frames, provide fire-rated listed hardware, tested by a fire-rating testing agency acceptable to authorities having jurisdiction.
  - 3. Finishes: Finish designations are ANSI/BHMA A156.18 standards and are subject to approval for color, texture and appearance.
    - a. Finish 630 (Formerly US 32D): Except where otherwise indicated, provide finish 630, satin-polish stainless steel on stainless steel base metal, matching sample on file with the Engineer.
    - b. Finish 626 (Formerly US 26D): Where indicated, provide finish 626, satin-polish chromium plated over nickel on brass or bronze base metal, matching finish 630 as specified above.
    - c. Finish 628 (Formerly US 28): Where indicated, provide finish 628, satin-polish aluminum clear anodized over aluminum base metal.

- d. Finish 652 (Formerly US 26D): Where indicated, provide finish 652, satin-polish chromium plated over nickel on steel base metal, matching finish 630 as specified above.
  - e. Finish 719 (Formerly US27): Mill finish aluminum uncoated.
  - f. Finish 613 (Formerly US10B): Where indicated, provide finish 613, satin-finish statuary bronze.
  - g. Finish 630 may be substituted for Finish 626 or Finish 652 at no additional cost to the Authority.
4. Single Source: Obtain each type of hardware from a single manufacturer.
- B. Hinges: ANSI/BHMA A156.1, full mortise butt hinges, anti-friction bearings, button tips (not flush), unless otherwise specified for each specific door number. Extruded butts may be used in lieu of wrought butts.
- 1. Quantity required per door leaf:
    - a. Doors 61 inches to 90 inches in height: 1-1/2 pairs.
    - b. Doors 91 inches to 120 inches in height: Two pairs.
  - 2. Types:
    - a. Exterior doors, doors from public passageways, and doors to wet areas such as showers: Stainless steel butts, Type A5111, finish 630.
    - b. Interior, non-public doors: Steel butts, Type A8111 (Grade 1), Finish 652.
    - c. Doors with reverse-bevel swing (out-swinging) having locks: Fit butts with non-removable pins effective when door is in closed position.
- C. Locksets:
- D. Hollow metal doors: ANSI/BHMA A156.13, full mortise, adjustable armored front, 3/4-inch-throw anti-friction latchbolt, one-inch-throw stainless steel deadbolt, Finish 630, Function as scheduled.
- 1. Trim design:
    - a. Cast lever handles, recurving to within 1/2-inch of door face, equal in appearance and dimensions to one of the following unless otherwise scheduled:
 

Series	Design	Producer
ML2200 Series	Newport NSA	Corbin/Russwin
8200 Series	KD rose, L lever	Sargent
8700 Series	PB lever, YK rose	Yale
    - b. Finish: 630 unless otherwise scheduled.
    - c. Roses: Concealed screw or screwless, 2-1/4 inch diameter.
    - d. Cylinder trim: Equip with flush or security-beveled solid cylinder collar as appropriate for flush or projecting cylinder.
  - 2. Aluminum doors in Yard Buildings:
    - a. Finish: 630 unless otherwise scheduled.
- E. Cylinders and Keying for all doors except aluminum doors in Parking Structures: Match the Authority's existing keying and interchangeable core system as follows and at no additional cost to the Authority.
- 1. Cylinders: Finish 630.
    - a. For locksets: ANSI/BHMA A156.5, interchangeable-core type, designed to accept the Authority's existing Russwin Recore System. One core furnished for each lock, stamped with visual key control.

- b. High security: Interlocking-pin type, Emhart High-Security Locking System or equal.
    - c. Construction cores: Provide construction cylinders until final cylinders and keying is approved and installed.
  - 2. Keys and keying:
    - a. Keys: Stamped with the inscription TRANSIT AUTHORITY - DO NOT DUPLICATE and with visual key-control data.
    - b. Quantity: Three keys for each core plus blanks equal to 10-percent of total keys furnished.
  - 3. Key tags and holders: ANSI/BHMA A156.5, inscribed with key-change number and key-control symbol.
- F. Push Plates and Door Pulls: ANSI/BHMA A156.6, Finish 630, with the following additional requirements:
  - 1. Push plate: 3/16 inch by 10 inches by 20 inches unless otherwise shown, with edges beveled.
  - 2. Door pull: 3/4-inch round bar, eight inches center-to-center, concealed fasteners; escutcheon plate same as push plate.
- G. Door Closers: ANSI/BHMA A156.4, Type C02xx1 (xx - indicates top-of-door-mounted, on interior side), Finish 630.
  - 1. Surface-mounted.
  - 2. Sweep period: Adjusted so that from an open position of 70 degrees, the door will take at least three seconds to move to a point 3 inches from the latch, measured to the leading edge of the door.
  - 3. Cover plate: Full metal cover, Finish 630.
  - 4. Parallel arms and drop brackets: Provide as necessary for mounting on interior side unless otherwise noted. Where hold-open feature is specified for closers, use type that permits doors to open 140 degrees, other conditions permitting.
  - 5. Maximum force for pushing or pulling open a door with closer (measured with a push-pull scale applied perpendicular to the door at the door opener or 30 inches from the hinged side, whichever is farther from the hinge):
    - a. Fire doors: Minimum opening force allowable by the jurisdictional authorities.
    - b. Interior hinged doors: 5 lbf.
- H. Stops:
  - 1. Overhead-type: ANSI/BHMA A156.8, Type C54511 holder/stop; holder deactivated on labeled doors, Finish 630.
  - 2. Wall-type: ANSI/BHMA A156.16, Type L02101, with vandal-resistant concealed fasteners, Finish 630. Use floor-type where wall-type is not practicable.
  - 3. Floor-type: ANSI/BHMA A156.16, Type L02141 or L02161 as necessary, with matching extender if necessary to properly engage door bottom, Finish 630.
- I. Flush Extension Bolts: ANSI/BHMA A156.8, Type L04081, Finish 630.
  - 1. Dustproof strikes, Type L04021, provided for bolts located at bottom of door leaf, except where metal thresholds are specified. Cut opening to suit bolt.
  - 2. Operating mechanism located approximately six feet from floor for top bolts and approximately 12 inches from floor for bottom bolts.
  - 3. Bolts located in edge of inactive leaf of pair of doors.
  - 4. Automatic Flush Bolts: Listed for 1-1/2 hour, B-labeled, Finish 630; Ives No. 559 or equal with strikes; with coordinator where recommended by manufacturer.
- J. Silencers: ANSI/BHMA A156.16, Type L03011. Provide silencers for each door:
  - 1. Three for each single door.

2. Two for each pair of doors.
- K. Exit Devices: ANSI/BHMA A156.3; complying with NFPA 80, listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction; lever trim as required for locksets; Finish 630.
1. Single door: Function F03 (mortise); latch bolt by push on crossbar inside and by key from outside; operation from outside is by lever.
  2. Double door: Active leaf Function F03 as above, inactive leaf (manual flush bolts) without outside trim.
  3. Maximum pushing force to operate exit device:
    - a. Fire doors: Minimum opening force allowable by the jurisdictional authorities.
    - b. Interior hinged doors: 5 lbf.
  4. Coordinators: ANSI/BHMA A156.3.
- L. Metal Thresholds: ANSI/BHMA A156.21; profiles as shown for each location; ADA compliant; metal thickness 0.125 inch; maximum height 5/16"; with countersunk matching screws.
1. Public passageways and mezzanines: Finish 630, stainless steel with abrasive finish or Finish 613, satin-finish statuary bronze.
  2. Other locations: Finish 719, mill finish aluminum with grooves.
- M. Weather Stripping /Smoke Seals: ANSI/BHMA A156.22, Finish 628 (satin aluminum clear anodized) with stainless steel sheet-metal screws and as follows:
1. Head and jamb: Head and jamb type, stop-applied; National Guard A626 or equal. Provide nylon brush gasketing or equal.
  2. Sill: Drip strip at sill; National Guard 15 or equal.
  3. Sweep: Door sweep type, surface mounted at bottom of door; National Guard D608 nylon brush gasketing or equal. Provide sweep in addition to drip strip where scheduled.
  4. Astragals: Provide nylon brush overlapping type: National Guard 600 or equal.
- N. Chain: ASTM A413, Class PT, case-hardened, carbon-steel security chain, 3/8-inch diameter.
- O. Padlock: Interchangeable-core type padlock, designed to accept the Authority's existing Russwin Recore System.
1. One core furnished for each lock, stamped with visual key control; with two keys, keyed and master-keyed as directed.
  2. Body: Solid extruded brass.
  3. Five-pin tumblers.
  4. Shackle: Hardened steel, zinc-plated, 1-3/4 inch opening height, self-locking spring-type.
- P. Deadlock: ANSI/BHMA A156.5 mortise dead lock, Grade 2 (1/2-inch minimum throw) with interchangeable-core cylinder; operation as scheduled.
- Q. Authority-Furnished Property:
1. Cross-bar lock: High-security locking bar with surface-mounted keepers, inside knob and high-security cylinder.

## 2.02 FASTENINGS:

- A. Provide hardware complete with screws, through-bolts and other fasteners of suitable type for secure anchorage to construction materials.

- B. Screws, through-bolts and other fasteners having spanner-type heads: As approved.
- C. Provide fasteners that harmonize in material, color and texture with finished appearance of hardware items.
- D. Provide concealed fastenings with door pull, flush pulls, wall door stops and other such items.
- E. Provide spanner-head through-bolts and hex bolts as applicable for surface-mounted hardware.
- F. Sheet-metal screws and self-tapping screws are prohibited except where specified.

**2.03 TEMPLATES:**

- A. Furnish templates of hardware to other trades, so that doors, frames and gates can be cut, reinforced and otherwise prepared in the shop for installation of finish hardware.

**2.04 THRESHOLD SEALANT:**

- A. Butyl: Polymerized butyl rubber and inert fillers (pigments), solvent-based with minimum 75 percent solids, non-sag consistency, tack-free time of 24 hours or less, paintable, non-staining, and complying with FS TT-S-001657.

**PART 3 - EXECUTION**

**3.01 INSTALLATION:**

- A. General:
  1. Coordinate work of this section with work of other trades.
  2. Install each hardware item in compliance with the manufacturer's instructions and recommendations.
  3. Apply finish hardware in a neat and workmanlike manner. Set units level, plumb, and true to line and location. Adjust and reinforce the attachment substrate as necessary for proper installation and operation.
  4. Cut mortises neat, clean and of proper net size. Drill and countersink units that are not factory prepared for anchorage fasteners. Space fasteners and anchors in accordance with industry standards.
  5. Where cutting and fitting is required to install hardware onto or into surfaces that are later to be painted or finished in another way, coordinate removal, storage, and reinstallation or application of surface protection with finishing work specified in other sections. Do not install surface-mounted items until finishes have been completed on the substrates involved.
  6. Provide keying in accordance with keying schedule prepared by and for the Contractor in accordance with the Authority's keying system. Deliver keying schedule and keys to the Engineer prior to final acceptance.
- B. Mounting Heights: Mount hardware units at heights indicated in the following publications, except as specifically indicated or required to comply with governing regulations and except as otherwise directed by the Engineer:
  1. Recommended Locations for Builders Hardware for Standard Steel Doors and Frames by DHI.
  2. Recommended Locations for Builders Hardware for Custom Steel Doors and Frames by DHI.
  3. ADA Accessibility Guidelines (ADAAG).

- C. Exterior Thresholds: Set thresholds for exterior doors in full bed of specified butyl sealant.
- D. Weatherstripping /*Smoke Seals*: Install weatherstripping around entire perimeter of door frame to form a complete seal and in accordance with manufacturers instructions.
  - 1. Position and install head and jamb weatherstripping so that door closes snugly against seal but does not inhibit latching of lockset.
  - 2. Position and install sill weatherstripping to seal snugly against threshold without inhibiting latching of lockset.
  - 3. Note that at fire-rated doors, lockset is to latch by closer operation only, without manual assistance.
- E. Adjustment: Adjust hardware to operate as designed and replace hardware that is missing, scratched, marred or otherwise damaged.
  - 1. Adjust and check each operating item of hardware and each door to ensure proper operation or function of every unit. Replace units that cannot be adjusted to operate freely and smoothly or as intended for the application made.
  - 2. Where door hardware is installed more than one month prior to acceptance or occupancy of a space or area, return to the installation during the week prior to acceptance or occupancy and make final check and adjustment of hardware items in such space or area. Clean operating items as necessary to restore proper function and finish of hardware and doors. Adjust door control devices to compensate for final operation of heating and ventilating equipment.
  - 3. Clean adjacent surfaces soiled by hardware installation.
- F. Instruction: At a time prescribed by the Engineer, have the hardware installer or knowledgeable operating-hardware-manufacturers' representatives instruct the Authority's personnel in the proper adjustment and maintenance of hardware and hardware finishes.

### **3.02 CLEAN-UP:**

- A. Remove from the site rubbish and debris caused by this work.
- B. Leave areas surrounding doors in broom-clean condition.

### **3.03 HARDWARE SETS:**

- A. Hardware Sets:
  - 1. Provide hardware sets in accordance with door schedule and the following set schedule.
  - 2. Provide the number of pairs of butt hinges in accordance with previously specified requirements.
  - 3. Designations used to describe hardware items by using a manufacturer's product name and number are for the purpose of describing a general level of quality and function. Products that are equal, complying with the requirements specified in this section may be used.

SET NO. 1

Quantity	Hardware
Previously Specified	Butt Hinges, 4-1/2 by 4-1/2
1 Each	Lockset, Function F09
1 Each	Door Closer
1 Each	Wall-Type Stop
1 Each	Metal Threshold

SET NO. 2

Quantity	Hardware
Previously Specified	Butt Hinges, 4-1/2 by 4-1/2
1 Each	Lockset, Function F07
1 Each	Door Closer
1 Each	Wall-Type Stop

SET NO. 3

Quantity	Hardware
As Necessary	Lock Cylinders *

\* Provide proper cam to engage lock mechanism by other trade.

SET NO. 4

Quantity	Hardware
1 Each	Deadlock, E06082

SET NO. 5

Quantity	Hardware
Previously Specified	Butt Hinges, 4-1/2 by 4-1/2
1 Each	Latchset, Function F01
1 Each	Door Closer
1 Each	Wall-Type Stop

SET NO. 6

Quantity	Hardware
Previously Specified	Butt Hinges, 4-1/2 by 4-1/2
1 Each	Exit Device, Function F03
1 Each	Door Closer
1 Each	Wall-Type Stop

SET NO. 7

Quantity	Hardware
Previously Specified	Butt Hinges, 4-1/2 by 4-1/2
1 Each	Lockset, Function F13
1 Each	Door Closer with Hold-Open
1 Each	Wall-Type Stop
1 Each	Cross-Bar Lock

SET NO. 8

Quantity	Hardware
Previously Specified	Butt Hinges, 4-1/2 by 4-1/2
1 Each	Lockset, Function F07
2 Each	Door Closer
2 Each	Wall-Type or Floor-Type Stop
2 Each	Automatic Flush Bolt
1 Each	Coordinator

SET NO. 9

Quantity	Hardware
Previously Specified	Butt Hinges, 4-1/2 by 4-1/2
1 Each	Lockset, Function F07
2 Each	Door Closer
2 Each	Overhead-Type Stop
1 Each	Metal Threshold
2 Each	Automatic Flush Bolt
1 Each	Coordinator
1 Set	Weatherstripping

SET NO. 10

Quantity	Hardware
Previously Specified	Butt Hinges, 4-1/2 by 4-1/2
2 Each	Door Pulls
2 Each	Door Closer with Hold-Open
2 Each	Wall-Type or Floor-Type Stop, As Necessary

SET NO. 11

Quantity	Hardware
Previously Specified	Butt Hinges, 4-1/2 by 4-1/2
1 Each	Lockset, Function F09
2 Each	Door Closer
1 Each	Wall-Type Stop
1 Each	Metal Threshold
2 Each	Automatic Flush Bolt
1 Each	Coordinator

SET NO. 12

Quantity	Hardware
Previously Specified	Butt Hinges, 4-1/2 by 4-1/2
1 Each	Lockset, Function F07
1 Each	Door Closer
1 Each	Overhead-Type Stop
1 Each	Metal Threshold
1 Set	Weatherstripping

SET NO. 13

Quantity	Hardware
Previously Specified	Butt Hinges, 4-1/2 by 4-1/2
1 Each	Lockset, Function F14
1 Each	Door Closer
1 Each	Overhead-Type Stop
1 Each	Metal Threshold
1 Set	Weatherstripping

**END OF SECTION**

## SECTION 08800

### GLASS AND GLAZING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing glass and glazing (sealing) of glass areas.
- B. Related Work Specified Elsewhere:
  - 1. Elevators: Division 14. <sup>\*1</sup>
  - 2. Granite edge: Section 04415.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ANSI: Z97.1.
  - 3. ASTM: C509, C542, C864, C920, C1036, C1048, C1172, C1281, D635, D1044, D1925, E774, E1300.
  - 4. CPSC: 16 CFR 1201, Category II.
  - 5. UL: 9, 10B.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Samples:
    - a. Three each of the following:
      - 1) Glass and safety plastic: 12 inches square, each material and type.
      - 2) Cast glass lens.
      - 3) Glazing compound: Pint containers.
      - 4) Setting blocks and edge blocks.
      - 5) Sealant: Cured color samples.
        - a) Sealant for sealing platform granite edge glass lenses: Clear silicone sealant,, one six-inch long bead.
      - 6) Gasket material: 12 inches long.
  - 2. Certification:
    - a. When glass is not cut to size by manufacturer and is furnished unlabeled from local stock, submit certification stating location to be installed, quality, thickness, type and manufacturer of each unit of glass furnished.
    - b. All tempered safety and laminated tempered safety glass to be permanently marked with the name or trademark of the manufacturer and designation of the applicable safety glazing standard.

##### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver products to the jobsite in original unopened containers clearly labeled with manufacturer's name and brand designation, referenced specification number, type, class and rating as applicable. Deliver glass with each light bearing manufacturer's label showing strength, grade, thickness, type, quality and safety marking. Do not remove labels from glass until it has been set and inspected.

- B. Store products in approved dry area; protect from contact with soil and from exposure to the elements.
- C. Handle products to prevent breakage of containers and damage to products.

#### 1.05 JOB CONDITIONS:

- A. Environmental Requirements:
  - 1. Do not install glass when the ambient temperature is below 40F or expected to fall below 40F, unless otherwise approved.
  - 2. Do not apply glazing materials to unprotected surfaces in wet weather or to surfaces on which ice, frost, water or dampness is visible.

### PART 2 - PRODUCTS

#### 2.01 MATERIALS:

- A. Glass:
  - 1. Plate glass: ASTM C1036, Type I (transparent glass, flat), Class 1 (clear), Quality q3.
  - 2. Safety glass: CPSC 16 CFR 1201, Category II and ANSI Z97.1 and as follows:
    - a. Tempered: ASTM C1048, Kind FT (fully tempered), Condition A (uncoated surfaces), Type I (transparent glass, flat), Class 1 (clear), Quality q3; 1/4-inch thick unless otherwise shown.
    - b. Laminated: ASTM C1172, Kind LT (fully tempered), 0.060-inch thick polyvinyl-butylal (PVB) interlayer factory-laminated between two pieces of tempered safety glass with protective edgecoat on the assembly to prevent contact of interlayer with water or joint materials; edgecoat such as Edgeseal by PPG, special polyurethane seal on Solaflex glazing by Monsanto, Sommer Macca Urethane E#2 by SX Chemical Company, or equal.
    - c. Laminated fritted glass:
      - 1) Construction: ASTM C1172, Kind LT, Laminated glass consisting of two pieces of fully tempered clear glass with one of the following fritting methods to make the laminated assembly translucent but not transparent:
        - a) A hue-white fritted surface permanently fused onto the laminated surface of one piece of glass with a clear 0.60-inch polyvinyl-butylal (PVB) interlayer between.
        - b) Two pieces of clear glass with a hue-white 0.30-inch PVB interlayer (fritting) sandwiched between two 0.15-inch clear PVB interlayers.
      - 2) Opacity: 80 percent coverage of translucent white fritting. Pattern of fritting to be selected by the Engineer from manufacturer's whole range of fritting patterns.
      - 3) Provide protective edgecoat to prevent contact of interlayers with water or joint materials.
  - 3. Wired: ASTM C1036, Type II (wired), Class 1 (translucent), Form 1 (wired, polished both sides), Quality q8; Mesh m1 (diamond), unless otherwise shown.
  - 4. Fire-rated glass (without wire): CPSC 16 CFR 1201 and ANSI Z97.1; fire-rated clear glass without wire; polished both sides.
    - a. Rating: 45 minutes or as shown, tested in accordance with UL9 (door assemblies) and UL10B (window assemblies).
    - b. Label: Each piece of glass bearing UL label for fire resistance.

- c. Thickness: As necessary to achieve the required fire rating; thickness coordinated with submitted shop drawings for the related doors and windows.
  - d. Sources: Subject to meeting the requirements, provide one of the following or equal:
    - 1) Premium FireLite by Nippon Electric Glass Company, Ltd. and distributed by Technical Glass Products, Kirkland, WA; 800/426-0279.
    - 2) Contraflam by Saint-Gobain and distributed by Euroglass Glasrep Corp., White Plains, NY; 914/683-6704.
    - 3) Inferno-Lite by Globe Amerada Glass Co., Elk Grove Village, IL; 800/323-8776.
- B. Insulating Glass: ASTM E774, Class CBA; factory preassembled, sealed insulating glass units with 1/2-inch air space; aluminum spacer tube with desiccant held captive within, and dual seal construction.
- 1. Outer lite: 1/4-inch clear plate glass or tempered safety glass as shown or specified, with low-emissivity (low-E) coating equal to Viracon's Solarscreen 80 on the number-two (inside) surface.
  - 2. Inner lite: 1/4-inch clear plate glass or tempered safety glass as shown or specified.
- C. Safety Plastic: Clear, monolithic polycarbonate sheet complying with the following:
- 1. Abrasion resistance: Maximum 3.1 percent change in haze when tested in accordance with ASTM D1044 for both surfaces.
  - 2. UV-resistance: Maximum 2.0 yellowing index after three years exposure per ASTM D1925.
  - 3. Flammability: Meet BOCA combustibility classification C1: Horizontal burn rate of one inch per minute or less when tested at a nominal thickness of 0.060 inch, or in the thickness intended for use, in accordance with ASTM D635.
- D. Glass Lens: Cast, clear glass, flat top with light sandblast texture, or acid etched if approved, to make it translucent, not transparent; vertical side (perimeter) roughened; top outer perimeter edge chamfered to 1/16 inch. Corning Glass Works, Pittsburgh Plate Glass Co., Blenko Glass Company distributed by Southern Plate Glass Company, or equal. Match texture, quality limiting defects, and translucency of existing units within the Metro system as directed by Engineer.
- 1. Defects shall be limited to a maximum of six air bubbles of 3/16 inch diameter or less with not more than three air bubbles occurring within the central three-inch diameter of lens.
  - 2. Single-component clear silicone sealant: ASTM C920, Type S, Grade NS, Class 25, Use T; as manufactured by Dow, GE and Pecora, or approved equal.
  - 3. Lead shims or lead rope: Section Shims die-cut from soft sheet lead; sized to suit field conditions, generally 6-1/2 inch outside diameter, five-inch inside diameter; 1/16-inch and 1/8-inch thicknesses as approved; ropes of lead wool may be substituted for shims as approved; fabricated to ensure that glass lenses can be set flush with granite.
- E. Glazing Accessories:
- 1. Sealant: Multi-component polyurethane; ASTM C920, Type M, Grade NS, Class 25, Use G; colored as required to match framing system in which installed.
  - 2. Glazing compound: Single-component polyurethane; ASTM C920, Type S, Grade NS, Class 25, Use G; colored as required to match framing system in which installed.
  - 3. Glazing tape: Preformed butyl tape, ASTM C1281; 100 percent solids, nonstaining and nonmigrating in contact with nonporous surfaces; with or without spacer rod (pre-shimming) as recommended in writing by tape and glass manufacturers for

application indicated; packaged on rolls with a release paper backing; by 3M Company, Tremco Manufacturing Co., or equal.

4. Pressure-sensitive tape: Vinyl electrical tape, 3M Company or equal.
5. Lock-Strip Gaskets: ASTM C542 dense neoprene extrusions; profile shown or required.
6. Compression Seal Gaskets: ASTM C864 neoprene extrusions; profile and hardness as shown or as required to maintain watertight seal.
7. Setting blocks: ASTM C864 neoprene extrusions, 70-90 durometer Shore A hardness; approximately full channel width, four inches long and high enough to afford correct cover and 3/8-inch edge clearance for the glass.
8. Edge blocks (spacers): ASTM C864 neoprene extrusions, 40-50 durometer Shore A hardness; approximately full channel width, three inches long and providing 3/8-inch edge clearance for the glass.
9. Glazing clips and points: Type, material and quantities as required and recommended by the manufacturers of the glazing media.
10. Glazing (face) gasket: Neoprene, formulated of compound meeting or exceeding physical property requirements of ASTM C509, continuous, 50 durometer hardness, providing 3/16-inch face clearance inside and outside.
11. Lead-shim ring: Continuous ring of sheet lead, of thickness required to bring top of cast glass lens level with surrounding granite.
12. Dielectric screw shield: Nylon expansion anchor, round head, sized to ensure snug fit in predrilled hole and to accommodate size of screw used.

### **PART 3 - EXECUTION**

#### **3.01 PREPARATION:**

- A. Verify dimensions before proceeding; obtain measurements at structure for work to be fitted to other construction, including wall-to-wall dimensions, floor-to-ceiling dimensions and those controlled by other trades.
- B. Remove dirt, dust, oil, moisture and other foreign substances from surfaces to receive glass and glazing accessories.
- C. Clean glass surfaces and wipe dry.

#### **3.02 INSTALLATION:**

- A. Coordinate work of this section with work of other trades.
- B. Use only tempered safety glass in doors, sidelights and transoms.
- C. Use only fire-rated glass in doors and windows located in fire-rated wall construction, except where wire glass is shown.
- D. Size glass by measuring actual frames or sash. Sizes shown are approximate and are intended for estimating purposes only. Cut glass to form 3/8-inch bite on all sides, except as otherwise required by manufacturer's product data as submitted and approved.
- E. Install glass or plastic using glazing gaskets or other glazing accessories as shown.
- F. Set glass on setting blocks at each quarter point of sill with equal bearing for entire width of each panel. Accurately cut glass to fit frames and provide smooth edges with no sharp or ragged surfaces. Provide edge blocks to prevent glass from contact with side frames.

- G. Unless otherwise shown, set glass in metal interior frames and doors or by back-face glazing with glazing compound; tape to prevent rattling. Reset glazing beads, if necessary, without marring or injuring finish.
- H. Tape Glazing:
  1. Position tape on fixed stops so that, when compressed by glass, exposed edges of tape are flush with or protrude slightly above sightline of stops.
  2. Install tape continuously, but not necessarily in one continuous length. Do not stretch tape to make it fit opening. Do not overlap butt ends. Cut tape with sharp shears. Place joints in tape at corners of opening with adjoining lengths butted together, not lapped.
  3. Seal joints in tape with compatible sealant approved by tape manufacturer.
  4. Where framing joints are vertical, cover these joints by applying tape to head and sill first and then to jambs. Where framing joints are horizontal, cover these joints by applying tape to jambs and then to head and sill.
  5. Place spacer or centering shims, three inches in length, 3/16 inch in height and 3/32 inch in thickness, every 18 inches under tape. Hold spacers in position by gently placing them in contact with underedge of tape.
  6. Position setting blocks for installation of glass. Use setting blocks 1/4 inch in height.
  7. Do not remove release paper from tape until just before each glazing unit is installed.
  8. Align glass carefully to opening and press glass firmly in place. Apply removable stops and repeat application of spacers or centering shims. Ensure that they are seated as deeply as possible in channel. Fill interior opening in conventional manner with glazing compound.
  9. Apply cap bead of sealant over exterior exposed edge of tape.
- I. Set glass in exterior metal windows and doors with neoprene setting blocks at quarter points and neoprene spacers two inches long placed 18 inches on center, and glaze with sealants.
- J. Install glass and glazing accessories in accordance with manufacturer's recommendations. Neatly apply sealants, compounds and tapes in straight lines parallel with glazing rebates and as shown.
- K. Perform direct glazing in dry weather, 40F or warmer.
- L. Tape edges of laminated glass and insulating glass with pressure-sensitive tape if sealant or glazing tape is incompatible with interlayer or seals of insulating glass. Do not expose edges of laminated glass to solvents, cleaners or prolonged contact with water.
- M. Set lead-shim rings on lips at bottom of openings and glass lenses. Set glass lenses to bring flat face level with the top of granite, centered in openings. Use spacers to maintain lenses in position while filling the annular space with backer rod and sealant as shown.

### **3.03 INSTALLATION OF ELEVATOR HOISTWAYS:**

- A. Install glazing at elevator hoistways as shown and in accordance with applicable requirements for glass and glazing.
- B. Size screw holes for dielectric screw shields to permit installation so as to prevent metal-to-metal contact between screws and frame.
- C. Apply sealant around entire frame, inside and outside of exterior hoistways only, and at other areas where metals are joined resulting in unfilled space. <sup>2</sup>

- D. Apply sealant around entire frame, inside and outside, and at other areas where metals are joined resulting in unfilled space. <sup>\*3</sup>

**3.04 INSTALLATION/RE-INSTALLATION OF PLATFORM GRANITE EDGE GLASS LENSES:**

- A. Install lead shims or lead rope.
- B. Install glass lenses.
- C. Apply sealant.

**3.05 FIELD QUALITY CONTROL:**

- A. Hose Tests:
  - 1. Upon completion of glazing and sealing, perform hose test against exterior glazing and framing members in the presence of the Engineer.
  - 2. Use 5/8-inch minimum diameter hose operated at 40-psi pressure for a minimum of 10 minutes. Repair leaks as soon as surfaces are dry; retest until approved.
- B. Breakage: Prior to final acceptance, replace damaged glass.
- C. Dielectric Testing:
  - 1. After installation at elevator hoistways, test for electrical isolation between screws and hoistway metal, using ohmmeter.
  - 2. Resistance requirement: 10,000 ohms.
  - 3. Replace screws and shields that do not meet resistance requirements and retest as for initial installation. Repeat as necessary until all screws meet resistance requirement.

**3.06 CLEAN-UP:**

- D. At completion of work, remove labels, except fire labels, clean glass and remove excess glazing compound and sealant from frames and surrounding finish work.
- E. Remove from site rubbish and debris resulting from work of this section.
- F. Leave areas surrounding work in broom-clean condition.

**SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.**

**ENDNOTES**

**\*1.** Add 1.1 B. including 1. modification to all contracts requiring glass and glazing work for elevator hoistways.

**\*2.** Use first version of 3.3 C. for all contracts requiring glass and glazing work for elevator hoistways.

**\*3.** Use second version of 3.3 C. for all contracts not requiring glass and glazing work for elevator hoistways.

**END OF SECTION**

**DIVISION 9 - FINISHES**

09205	FURRING AND LATHING
09215	PLASTER SYSTEMS
09220	PORTLAND CEMENT PLASTER
09255	DRYWALL SYSTEMS
09320	TILE
09340	PAVER TILE
09511	ACOUSTICAL PANEL CEILINGS
09650	RESILIENT FLOORING
09920	FIELD PAINTING

**END OF SECTION**

## SECTION 09205

### FURRING AND LATHING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing furring, lathing and accessories.
- B. Related Work Specified Elsewhere:
  - 1. Access Doors and Frames: Section 08305.
  - 2. Plaster systems: Section 09215.
  - 3. Portland cement plaster: Section 09220.

##### 1.02 PERFORMANCE REQUIREMENTS:

- A. Structural Performance of Ceiling Support Systems: Limit deflection of ceiling to less than 1/360 of span.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Product Data for each product specified.
  - 2. Shop Drawings: Furring layouts; locations of access panels, mechanical openings, light fixtures and electrical openings; and construction details.
  - 3. Samples:
    - a. Four of each of the following products used in the work:
      - 1) Furring Channels: 12 inches long
      - 2) Metal lath: 12 inches square.
      - 3) Studs, runner and caps: 12 inches long.
      - 4) Tie wire: 12 inches long.
      - 5) Fasteners, hangers and accessories.

##### 1.04 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ASTM: A36, A641, A653, B69, C645, C847, C1063, E488.
  - 3. ML/SFA: Guide Specifications for Metal Lathing and Furring.
- B. Mockups: At the start of installation, construct panels for each type of finish and application required to verify selections made under Sample submittals and to demonstrate aesthetic effects as well as qualities of materials and execution. The mockups shall be a part of the Work. The work must be approved by the Engineer before installation can continue. Delete below if no fire-rated plaster assemblies.

##### 1.05 PRODUCT DELIVERY, STORAGE, AND HANDLING:

- A. Deliver products in the original unopened packages, containers or bundles each bearing name of manufacturer, brand designation, referenced number, type and class as applicable.

- B. Store materials inside, under cover, and dry, protected from weather, direct sunlight, surface contamination, aging, corrosion, and damage from construction traffic and other causes. Use platforms or other means to protect products and materials from contact with the soil. Do not store materials on finished floors.
- C. Handle materials so as to preclude breakage of packages or containers and damage to materials.

## **PART 2 - PRODUCTS**

### **2.01 METAL SUPPORTS FOR SUSPENDED AND FURRED CEILINGS:**

- A. General: Size metal ceiling supports to comply with ASTM C1063, unless otherwise indicated.
- B. Cast-in-Place and Post-installed Anchors in Concrete: Anchors of type indicated below, fabricated from corrosion-resistant materials, with holes or loops for attaching hanger wires; and with capability to sustain, without failure, a load equal to 5 times that imposed by ceiling construction, as determined by testing according to ASTM E488 conducted by a qualified independent testing agency.
  - 1. Expansion anchor.
- C. Wire for Hangers: ASTM A641, Galvanized carbon-steel wire, eight-gauge minimum, medium-temper, Class 3 coating.
- D. Wire for Ties: ASTM A641, Galvanized carbon-steel wire, 16-gauge minimum for securing metal furring, 18-gauge minimum for securing metal lathe, medium-temper, Class 1 coating.
- E. Resilient Furring Channels: Galvanized steel, minimum 0.0209-inch-thick base (uncoated) metal, approved type, standard with the manufacturer, similar to RC-1, U.S. Gypsum Company.
- F. Channels: Cold-rolled steel, minimum 0.0598-inch-thick base (uncoated) metal and 7/16-inch-wide flanges, and as follows:
  - 1. Carrying Channels: 1-1/2 inches deep, 475 lb/1000 feet.
  - 2. Furring Channels: 3/4 inch deep, 300 lb/1000 feet.
  - 3. Finish: ASTM A653, G60 hot-dip galvanized coating for framing.
- G. Steel Studs for Furring Channels: ASTM C645, with flange edges of studs bent back 90 degrees and doubled over to form 3/16-inch-wide minimum lip (return), and complying with the following requirements for minimum thickness of base (uncoated) metal and for depth:
  - 1. Thickness: 0.0478 inch, unless otherwise indicated.
  - 2. Depth: As indicated.
  - 3. Protective Coating: ASTM A653, G40 galvanized coating.

### **2.02 STEEL STUDS AND RUNNERS:**

- A. General: Provide steel studs and runners complying with the following requirements:
  - 1. Protective Coating: ASTM A653, G40 hot-dip galvanized coating. Retain above or below. Verify availability and weight of galvanized coatings with manufacturers. Retain below if galvanized coating is only required at exterior and building perimeter locations.
- B. Non-Load-Bearing Studs and Runners: ASTM C645 and complying with the following requirements for minimum thickness of base (uncoated) metal and other characteristics:

1. Thickness: 0.0478 inch.
2. Depth: As indicated.

### **2.03 VERTICAL METAL FURRING:**

- A. General: Provide vertical furring complying with the following requirements:
  1. Protective Coating: ASTM A653, G40 hot-dip galvanized coating.
- B. Channel Furring and Braces: Cold-rolled steel, minimum 0.0598-inch-thick base (uncoated) metal and 3/4-inch-deep-by-7/16-inch-wide flanges, 300 lb/1000 feet.
- C. Hat Channels: Hat-shaped screwable furring channels, 7/8 inch deep, formed from zinc-coated (galvanized) steel sheet, minimum 0.0179-inch-thick, Grade 33.
- D. Furring Brackets: Serrated-arm type, minimum 0.0329-inch-thick base (uncoated) metal, adjustable from 1/4- to 2-1/4-inch wall clearance for channel furring.

### **2.04 LATH:**

- A. Expanded-Metal Lath: Comply with ASTM C847 for material, type, configuration, and other characteristics indicated below.
  1. Material: Fabricate expanded-metal lath from sheet metal conforming to the following:
    - a. Galvanized Steel: Structural-quality, zinc-coated (galvanized) steel sheet complying with ASTM A653, G60 minimum coating designation, unless otherwise indicated.
  2. Diamond-Mesh Lath: Comply with the following requirements:
    - a. For applications directly to masonry or concrete:
      - 1) Configuration: Self-furring.
      - 2) Weight: 2.5-lb/sq. Yd.
    - b. For reinforcing at corners of opening or at internal corners:
      - 1) Configuration: Flat.
      - 2) Weight: 2.5-lb/sq. Yd.
    - c. For all other applications:
      - 1) Configuration: Flat.
      - 2) Weight: 3.4-lb/sq. Yd.

### **2.05 ACCESSORIES:**

- A. General: Comply with material provisions of ASTM C1063 and the requirements indicated below; coordinate depth of accessories with thicknesses and number of plaster coats required.
  1. Galvanized Steel Components: Fabricated from zinc-coated (galvanized) steel sheet complying with ASTM A653, G40 minimum coating designation.
  2. Zinc-Alloy Components: ASTM B69, 99 percent pure zinc.
- B. Metal Corner Reinforcement: Expanded, large-mesh, diamond-metal lath fabricated from zinc-alloy or welded-wire mesh fabricated from 0.0475-inch-diameter, zinc-coated (galvanized) wire and specially formed to reinforce external corners of portland cement plaster on exterior exposures while allowing full plaster encasement.
- C. Cornerbeads: Small nose cornerbeads fabricated from the following metal, with expanded flanges of large-mesh diamond-metal lath allowing full plaster encasement.
  1. Zinc Alloy: Minimum 0.0207-inch-thick.
  2. Galvanized Steel: Minimum 0.0179-inch-thick.

- D. Casing Beads: Square-edged style, with expanded flanges of the following material: Retain 1 of first 4 below or retain last with 2 or more of first 4.
  - 1. Zinc Alloy: Minimum 0.0207-inch-thick.
  - 2. Galvanized Steel: Minimum 0.0179-inch-thick.
- E. Curved Casing Beads: Square-edged style, fabricated from aluminum coated with clear plastic, preformed into curve of radius indicated.
- F. Control Joints: Prefabricated, of material and type indicated below:
  - 1. Zinc Alloy: Minimum 0.0207-inch-thick.
  - 2. Galvanized Steel: Minimum 0.0179-inch-thick.
  - 3. One-Piece Type: Folded pair of nonperforated screeds in M-shaped configuration, with expanded or perforated flanges.
  - 4. Two-Piece Type: Pair of casing beads with back flanges formed to provide slip-joint action, adjustable for joint widths from 1/8 to 5/8 inch.
    - a. Provide removable protective tape on plaster face of control joints.
- G. Lath Attachment Devices: Material and type required by ASTM C1063 for installations indicated.
- H. Fasteners: Clips and nails, standard with furring and lathing manufacturer.
- I. Anchors: Stainless steel, Alloy 303 or 304, with the following additional requirements:
  - 1. Type: Through bolt in steel; expansion bolt in concrete; toggle bolt in CMU.
  - 2. Pull-out strength: 1,200 pounds minimum
  - 3. Shear strength: 1,500 pounds minimum.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION OF LATH AND FURRING, GENERAL:**

- A. Standards: Comply with ML/SFA 920, "Guide Specifications for Metal Lathing and Furring," and with the requirements of ASTM C841 and ASTM C1063.
- B. Install supplementary framing, blocking, and bracing at terminations in work and for support of fixtures, equipment services, heavy trim, grab bars, handrails, furnishings, and similar work to comply with details indicated or, if not otherwise indicated, to comply with applicable written instructions of lath and furring manufacturer.
- C. Isolation: Where lathing and metal support system abuts building structure horizontally and where partition or wall abuts overhead structure, sufficiently isolate from structural movement to prevent transfer of loading from building structure. Install slip- or cushion-type joints to absorb deflections but maintain lateral support.
  - 1. Frame both sides of control joints independently and do not bridge joints with furring and lathing or accessories.
- D. Install additional framing, furring, runners, lath, and beads, as required to form openings and frames for other work as indicated. Coordinate support system for proper support of framed work that is not indicated to be supported independently of metal furring and lathing system.

#### **3.02 INSTALLATION OF CEILING SYSTEMS:**

- A. Preparation and Coordination:

1. Do not install furring until pipe, conduits and other equipment are in place and inspected.
  2. Coordinate installation of ceiling suspension system with installation of overhead structural systems to ensure inserts and other structural anchorage provisions have been installed to receive ceiling hangers in a manner that will develop their full strength and at spacings required to support ceiling.
    - a. Furnish concrete inserts, and other anchorage devices indicated, to other trades for installations well in advance of time needed for coordination with other work.
    - b. Perform cutting of construction necessary to install furring and lathing around ducts, conduits, pipes and equipment.
- B. Hanger Installation: Attach hangers to structure above ceiling to comply with ML/SFA 920, "Guide Specifications for Metal Lathing and Furring," and with referenced standards.
1. Do not attach hangers to metal deck tabs.
- C. Install ceiling suspension system components of sizes and spacings indicated, but not in smaller sizes or greater spacings than those required by referenced lathing and furring installation standards.
1. Wire Hangers: Suspend hangers from overhead construction. Coordinate work with construction work from which it is suspended. Space wire hangers not over 42 inches o.c., parallel with and not over 36 inches perpendicular to direction of carrying channels, unless otherwise indicated, and within 6 inches of carrying channel ends. Wrap wire hanger around carrying channel so as to develop full strength of hangers.
  2. Carrying Channels: Space carrying channels not over 42 inches o.c. with 36-inch o.c. hanger spacing. Use shims or other methods, if necessary, to level channels before securing in place.
  3. Furring Channels to Receive Metal Lath: Space furring channels not over 12 inches o.c. Secure furring channels to carrying channels, saddle-tied with tie wire or fastened with approved clips.
- D. Where masonry partitions are erected to ceiling height only, continue suspended ceilings across partition tops without bearing on partitions. Place carrying channels, which are adjacent to and parallel to partitions, not more than six inches from face of partition.
- E. Where furred ceilings are shown or specified, attach furring channels directly to the overhead construction.
- F. Where shown or specified provide resilient furring channels in lieu of conventional furring channels.
- G. Provide additional rods, clips and other accessories as necessary to achieve complete furring and lathing job.

### **3.03 INSTALLATION OF STEEL STUD WALL AND PARTITION SUPPORT SYSTEMS:**

- A. General: Install components of systems to comply with written instructions of steel stud manufacturer for applications indicated and as follows:
1. For non-load-bearing stud systems, comply with ASTM C754.
- B. Steel Stud Systems to Receive Metal Lath: Comply with requirements of ML/SFA 920, "Guide Specifications for Metal Lathing and Furring," applicable to each installation condition and type of metal stud system indicated.
1. Extend and attach partition support systems to structure above suspended ceilings, unless otherwise indicated.

### **3.04 INSTALLATION OF VERTICAL METAL FURRING:**

- A. Install vertical metal furring components of sizes and spacings indicated, but not in smaller sizes or greater spacings than those required by referenced ML/SFA standard.
- B. For furring on interior side of exterior walls, provide furring brackets, unless otherwise indicated
- C. Metal Furring to Receive Metal Lath: Comply with requirements of ML/SFA 920, "Guide Specifications for Metal Lathing and Furring," applicable to each installation condition indicated.

### **3.05 INSTALLATION OF LATHING:**

- A. Install metal lath for the following applications where plaster base coats are required. Provide appropriate type, configuration, and weight of metal lath selected from materials indicated that comply with referenced ML/SFA specifications and ASTM lathing installation standards.
  - 1. For applications directly to masonry or concrete use 2.5-lb/sq. Yd. minimum weight, self-furring, diamond-mesh lath.
  - 2. For reinforcing at corners of opening or at internal corners 2.5-lb/sq. Yd. minimum weight, diamond-mesh lath.
  - 3. For all other applications use 3.4-lb/sq. Yd. minimum weight, diamond-mesh lath.
- B. Lathing on Ceilings:
  - 1. Apply metal lath with long dimension of sheet at right angle to furring channels.
  - 2. Securely tie metal lath to supporting framing with tie wire.
  - 3. Tie each sheet of lath at least four times in width to each support. Lap ends and sides of sheet not less than ½-inch and lace together at approximately six inches on center. Stagger ends of sheets.
- C. Lathing on Stud Partitions and Furred Walls:
  - 1. Provide metal lath where shown.
  - 2. Attach metal lath to furring channels and studs with tie wire. Insert other applications if required.

### **3.06 CLEANING:**

- A. Remove from site rubbish and debris caused by this work..
- B. Leave rooms and areas in broom-clean condition.

**END OF SECTION**

**SECTION 09215**  
**PLASTER SYSTEMS**

**PART 1 - GENERAL**

**1.01 DESCRIPTION:**

- A. This section specifies providing plaster systems.
- B. Related Work Specified Elsewhere:
  - 1. Furring and lathing: Section 09205.

**1.02 SUBMITTALS:**

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each.
  - 1. Shop Drawings:
    - a. Include manufacturer's product specifications and installation instructions for each material.
    - b. Samples: Panels at least 48 inches square of each type of finish for color, pattern and texture; showing the full range of variations.
  - 2. Certification.

**1.03 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ASTM: C28, C35, C150, C206, C842, C897, C926.

**1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Deliver products in the original unopened packages, containers or bundles each bearing name of manufacturer, brand designation, referenced number, type and class as applicable.
- B. Keep plaster and cementitious materials dry until ready to be used. Store materials off ground, under cover and away from sweating walls and other damp surfaces.
- C. Handle materials so as to preclude breakage of packages or containers and damage to materials.

**1.05 JOB CONDITIONS:**

- A. Environmental Requirements:
- B. Do not apply plaster unless temperature within areas to be plastered is at least 55F for 48-hour period prior to application of plaster. Maintain this minimum temperature during application and curing operation.
  - 1. Keep area fully enclosed in hot, dry weather for 24 hours after application of plaster and otherwise provide proper environment to properly dry plaster. Screen openings with polyethylene or similar approved materials.

**PART 2 - PRODUCTS**

**2.01 MATERIALS:**

- A. Neat Gypsum Plaster: ASTM C28.

- B. Portland Cement: ASTM C150, Type I.
- C. Hydrated Lime: ASTM C206, Type S.
- D. Sand for Gypsum Plaster: ASTM C35.
- E. Sand for Portland-Cement Plaster: ASTM C897.
- F. Water: Potable.

## **2.02 MIXES:**

- A. Gypsum Plaster:
  - 1. Mix for scratch coat and brown coats: Proportions of neat gypsum and sand in accordance with ASTM C842, Table 3.
  - 2. Lime putty with gypsum gauging: Proportions in accordance with ASTM C842, Table 4A.
- B. Portland-Cement Plaster:
  - 1. Mix in accordance with ASTM C926. Do not use masonry cement, blended cement or plastic cement.
- C. For Restoration Work:
  - 1. Mix to match existing adjacent plaster work.

## **PART 3 - EXECUTION**

### **3.01 PREPARATION:**

- A. Do not apply plaster directly on painted surfaces, old plastered surfaces, bituminous-coated surfaces, or surfaces covered with waterproofing agents. Before covering such surfaces, apply furring and lathing.
- B. Check metal grounds, corner beads, screeds and other accessories for alignment. Ensure that surfaces to receive plaster are square, plumb and level.
- C. Remove foreign matter from surfaces to receive plaster.
- D. Thoroughly wet masonry surfaces with fine fog spray of clean water to produce uniformly moist condition before plastering.

### **3.02 MIXING:**

- A. Mix plaster in mechanical mixer in accordance with ASTM C842 for gypsum and plaster and ASTM C926 for portland cement plaster. Clean mixer of set or hardened material before loading materials for new batch.
- B. Keep mixing tools and equipment clean. Mix each batch separately.
- C. Follow referenced specifications and manufacturer's directions for mixing sequence, cycle of operations, time and other mixing requirements.
- D. Do not mix plaster over finished floors.

### **3.03 APPLICATION:**

- A. Apply gypsum plaster in accordance with ASTM C842 for gypsum and plaster and ASTM C926 for portland cement plaster, except as otherwise specified.
- B. Perform plastering work under direction of competent superintendent or foreman in coordination with work of other trades.
- C. Provide three-coat plastering, except as backing for tile work.
- D. Do not retemper plaster. Do not use frozen, caked, lumpy or partially set plaster.
- E. Apply portland-cement plaster over metal lath to minimum overall thickness of 3/4 inch, measured from face of metal lath to finish plaster surface, unless otherwise shown or specified.
- F. Provide portland-cement plaster on metal lath for ceramic-tile backing.
  - 1. Apply base coat not less than 24 hours nor more than 60 hours before tile is to be set. Prior to final set, scratch or score base coat to produce suitable bond for leveling coat.
  - 2. Protect base coat and keep moist during curing period.
  - 3. Apply leveling coat to tolerance of 1/8-inch in 10 feet and bring base coat up to minimum thickness of 3/4-inch. Scratch leveling coat and cure for 24 hours. Leveling coat may be omitted if base coat meets tolerance and thickness requirements.

#### **3.04 PATCH AND FINISH:**

- A. When so directed and after other trades have finished their work, point-up and patch plastering where necessary, point-up around trim and other set work and leave plaster work complete and perfect at final completion.
- B. Replace plastering having cracks, blisters, pits, checks or discolorations. Leave plastering clean and perfect in every respect.
- C. Use same mixes for patching as used for original work.
- D. For one year after acceptance, repair cracks that develop.
  - 1. Cut plaster back to the full depth perpendicular to surface for junction with repair work.
  - 2. Remove entirely the plaster that has separated from its backing; back to soundly bonded plaster, to masonry, to furring or to lath undersurface, as necessary.
  - 3. Clean substrate of loose particles and dust. Then coat with an approved bonding agent and replaster as specified.

#### **3.05 PROTECT AND CLEAN:**

- A. Protect finish work, particularly wood, aluminum and glass during plastering; repair damage or replace damaged materials.
- B. Remove plaster from floors, glass and other surfaces, leaving entire work in first-class condition.
- C. Remove plaster rubbish from premises and leave in broom-clean condition.

**END OF SECTION**

## SECTION 09255

### DRYWALL SYSTEMS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing non-loadbearing drywall systems, including metal studs, metal furring and acoustical insulation.
- B. Related Work Specified Elsewhere:
  - 1. Seals and Sealants: Section 07900.
  - 2. Building Insulation: Section 07210.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements for approval and with the additional requirements as specified for each.
  - 1. Product Data: For each type of the product indicated.
  - 2. Samples:
    - a. Trim Accessories: Full-size sample in 12-inch long length for each trim accessory indicated.
    - b. Textured Finishes: Manufacturer's standard size for each textured finish indicated and on same backing indicated for Work.
  - 3. Certification.
    - a. Certificates from the gypsum-wallboard manufacturer verifying that materials furnished meet specified requirements.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ASTM: C36, C423, C475, C641, C645, C665, C754, C834, C840, C931, C954, C919, C1002, C1177, C1047, D226, E84, E90, E119, E413, E497.
  - 3. ASTM A 118.9, C 919.
- B. Fire-Test-Response Characteristics: For gypsum board assemblies with fire-resistance ratings, provide materials and construction identical to those tested in assembly indicated according to ASTM E 119 by an independent testing and inspecting agency acceptable to authorities having jurisdiction.
- C. Sound Transmission Characteristics: For gypsum board assemblies with STC ratings, provide materials and construction identical to those tested in assembly indicated according to ASTM E 90 and classified according to ASTM E 413 by a qualified independent testing agency.

#### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Deliver materials in original packages, containers, or bundles bearing brand name and identification of manufacturer or supplier.
- B. Store materials inside under cover and keep them dry and protected against damage from weather, direct sunlight, surface contamination, corrosion, construction traffic, and other causes. Stack gypsum panels flat to prevent sagging.

#### **1.05 JOB CONDITIONS:**

- A. Environmental Limitations: Comply with ASTM C 840 requirements or gypsum board manufacturer's written recommendations, whichever are more stringent.

### **PART 2 - PRODUCTS**

#### **2.01 STEEL PARTITION AND SOFFIT FRAMING:**

- A. Components, General: As follows:
  - 1. Comply with ASTM C 754 for conditions indicated.
  - 2. Steel Sheet Components: Complying with ASTM C 645 requirements for metal and with manufacturer's standard corrosion-resistant zinc coating.
- B. Steel Studs and Runners: ASTM C 645, non-loadbearing
  - 1. Minimum Base Metal Thickness: 20 ga.
  - 2. Depth: As shown.
- C. Deep-Leg Deflection Track: ASTM C 645 top runner with 2-inch- deep flanges.
- D. Proprietary Deflection Track: Steel sheet top runner manufactured to prevent cracking of gypsum board applied to interior partitions resulting from deflection of structure above; in thickness indicated for studs and in width to accommodate depth of studs.
- E. Proprietary Firestop Track: Top runner manufactured to allow partition heads to expand and contract with movement of the structure while maintaining continuity of fire-resistance-rated assembly indicated; in thickness not less than indicated for studs and in width to accommodate depth of studs.
- F. Flat Strap and Backing Plate: Steel sheet for blocking and bracing in length and width indicated.
- G. Cold-Rolled Channel Bridging: 0.0538-inch bare steel thickness, with minimum 1/2-inch- wide flange.
  - 1. Depth: As shown.
  - 2. Clip Angle: 1-1/2 by 1-1/2 inch, 0.068-inch-thick, galvanized steel.
- H. Hat-Shaped, Rigid Furring Channels: ASTM C 645.
- I. Resilient Furring Channels: 1/2-inch deep, steel sheet members designed to reduce sound transmission.

- J. Cold-Rolled Furring Channels: 0.0538-inch bare steel thickness, with minimum 1/2-inch-wide flange.
  - 1. Depth: As indicated.
  - 2. Furring Brackets: Adjustable, corrugated-edge type of steel sheet with minimum bare steel thickness of 0.0312 inch.
  - 3. Tie Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.0625-inch diameter wire, or double strand of 0.0475-inch diameter wire.
- K. Z-Shaped Furring: With slotted or nonslotted web, face flange of 1-1/4 inches, wall attachment flange of 7/8 inch, minimum bare metal thickness of 0.0179 inch, and depth required to fit insulation thickness indicated.
- L. Fasteners for Metal Framing: Of type, material, size, corrosion resistance, holding power, and other properties required to fasten steel members to substrates.

## **2.02 INTERIOR GYPSUM WALLBOARD**

- A. Panel Size: Provide in maximum lengths and widths available that will minimize joints in each area and correspond with support system indicated.
- B. Gypsum Wallboard: ASTM C 36.
  - 1. Regular Type: Regular-type gypsum panels are also available in 1/4- and 3/8-inch (6.4- and 9.5-mm) thicknesses for limited applications.
    - a. Thickness: 1/2 inch, unless otherwise indicated.
    - b. Long Edges: Tapered and featured (rounded or beveled) for prefilling.
    - c. Location: As indicated.
  - 2. Type X:
    - a. Thickness: 5/8 inch.
    - b. Long Edges: Tapered and featured (rounded or beveled) for prefilling.
    - c. Location: Where required for fire-resistance-rated assembly or as indicated
- C. Flexible Gypsum Wallboard: ASTM C 36, manufactured to bend to fit tight radii and to be more flexible than standard regular-type panels of the same thickness.
  - 1. Thickness: 1/4 inch.
  - 2. Long Edges: Tapered.
  - 3. Location: As indicated
- D. Sag-Resistant Gypsum Wallboard: ASTM C 36, manufactured to have more sag resistance than regular-type gypsum board.
  - 1. Thickness: 1/2 inch.
  - 2. Long Edges: Tapered.
  - 3. Location: Ceiling surfaces
- E. Proprietary, Special Fire-Resistive Type: ASTM C 36, having improved fire resistance over standard Type X.
- F. Foil-Backed Gypsum Wallboard: ASTM C 36.
- G. Proprietary Abuse-Resistant Gypsum Wallboard: ASTM C 36, manufactured to produce greater resistance to surface indentation and through-penetration than standard gypsum panels.

### **2.03 EXTERIOR GYPSUM PANELS FOR CEILINGS AND SOFFITS**

- A. Panel Size: Provide in maximum lengths and widths available that will minimize joints in each area and correspond with support system indicated.
- B. Exterior Gypsum Soffit Board: ASTM C 931/C 931M, with manufacturer's standard edges.
  - 1. Core: ½ inch, regular type or 5/8 inch Type X.
- C. Glass-Mat Gypsum Sheathing Board: ASTM C 1177/C 1177M.

### **2.04 TILE BACKING PANELS**

- A. Panel Size: Provide in maximum lengths and widths available that will minimize joints in each area and correspond with support system indicated.
- B. Cementitious Backer Units: ASTM A 118.9

### **2.05 TRIM ACCESSORIES:**

- A. Interior Trim: ASTM C 1047
  - 1. Material: , manufacturer's standard metal trim, formed from galvanized or aluminum-coated steel, or rolled zinc.
  - 2. Shapes:
    - a. Cornerbead: Use at outside corners.
    - b. Bullnose Bead: Use where indicated.
    - c. LC-Bead (J Bead): Use at exposed panel edges.
    - d. L-Bead: Use where indicated.
    - e. U-Bead: Use where indicated.
    - f. Expansion Joint Use where indicated.
    - g. Curved-Edge Cornerbead: With notched or flexible flanges; use at curved openings.
- B. Exterior Trim: ASTM C 1047.
  - 1. Material: Hot-dip galvanized steel sheet or rolled zinc.
  - 2. Shapes:
    - a. Cornerbead: Use at outside corners.
    - b. LC-Bead (J-Bead): Use at exposed panel edges.
    - c. Expansion (Control) Joint.

### **2.06 JOINT TREATMENT MATERIALS:**

- A. General: Comply with ASTM C 475.
- B. Joint Tape:
  - 1. Interior Gypsum Wallboard: Paper.
  - 2. Exterior Gypsum Soffit Board: Paper.
  - 3. Glass-Mat Gypsum Sheathing Board: 10-by-10 glass mesh.
- C. Joint Compound for Interior Gypsum Wallboard: For each coat use formulation that is compatible with other compounds applied on previous or for successive coats.
- D. Joint Compound for Exterior Applications:

1. Exterior Gypsum Soffit Board: Use setting-type taping and setting-type, sandable topping compounds.
  2. Glass-Mat Gypsum Sheathing Board: As recommended by manufacturer.
- E. Joint Compound for Tile Backing Panel:
1. Cementitious Backer Units: As recommended by manufacturer

## **2.07 ACOUSTICAL SEALANT:**

- A. Acoustical Sealant for Exposed and Concealed Joints: Nonsag, paintable, nonstaining, latex sealant complying with ASTM C 834 that effectively reduces airborne sound transmission through perimeter joints and openings in building construction.

## **2.08 AUXILIARY MATERIALS**

- A. General : Provide auxiliary materials that comply with referenced installation standards and manufacturer's written recommendations.
- B. Laminating Adhesive: Adhesive or joint compound recommended for directly adhering gypsum panels to continuous substrate.
- C. Steel Drill Screws: ASTM C 1002, unless otherwise indicated
1. Use screws complying with ASTM C 954 for fastening panels to steel members from 0.033 to 0.112 inch thick.
  2. For fastening cementitious backer units, use screws of type and size recommended by panel manufacturer.
- D. Isolation Strip at Exterior Walls:
1. Asphalt-Saturated Organic Felt: ASTM D 226, Type I (No. 15 asphalt felt), nonperforated.
  2. Foam Gasket: Adhesive-backed, closed-cell vinyl foam strips that allow fastener penetration without foam displacement, 1/8 inch thick, in width to suit steel stud size.
- E. Sound Attenuation Blankets: ASTM C 665, Type I (blankets without membrane facing) produced by combining thermosetting resins with mineral fibers manufactured from glass, slag wool, or rock wool.
1. Fire-Resistance-Rated Assemblies: Comply with mineral-fiber requirements of assembly.
- F. Thermal Insulation: As specified in Section 07210.
- G. Vapor Barrier: As specified in Section 07210.

## **2.09 TEXTURE FINISHES**

- A. Primer: As recommended by textured finish manufacturer.
- B. Polystyrene Aggregate Ceiling Finish: Water-based, job-mixed, polystyrene aggregate finish with flame-spread and smoke-developed indices of not more than 25 when tested according to ASTM E 84.

- C. Aggregate Finish: Water-based, job-mixed, aggregated, drying-type texture finish for spray application.
- D. Acoustical Finish: Water-based, chemical-setting or drying-type, job-mixed texture finish for spray application:
  - 1. Application Thickness: 1/2 inch.
  - 2. Fire-Test-Response Characteristics: Indices when tested according to ASTM E 84 as follows:
    - a. Flame Spread: Less than 25.
    - b. Smoke Developed: Less than 450.
  - 3. NRC: 0.55 according to ASTM C 423.

### **PART 3 - EXECUTION**

#### **3.01 EXAMINATION:**

- A. Examine areas and substrates, with Installer present, and including welded hollow-metal frames, cast-in anchors, and structural framing, for compliance with requirements and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.02 INSTALLING STEEL PARTITION AND SOFFIT FRAMING:**

- A. Install tracks (runners) at floors, ceilings, and structural walls and columns where gypsum board assemblies abut other construction.
  - 1. Where studs are installed directly against exterior walls, install asphalt-felt or foam-gasket isolation strip between studs and wall.
- B. Installation Tolerance: Install each steel framing and furring member so fastening surfaces vary not more than 1/8 inch3 mm from the plane formed by the faces of adjacent framing.
- C. Extend partition framing full height to structural supports or substrates above suspended ceilings, except where partitions are indicated to terminate at suspended ceilings. Continue framing over frames for doors and openings and frame around ducts penetrating partitions above ceiling to provide support for gypsum board.
  - 1. Cut studs 1/2 inch13 mm short of full height to provide perimeter relief.
  - 2. For fire-resistance-rated and STC-rated partitions that extend to the underside of floor/roof slabs and decks or other continuous solid-structure surfaces to obtain ratings, install framing around structural and other members extending below floor/roof slabs and decks, as needed to support gypsum board closures and to make partitions continuous from floor to underside of solid structure.
    - a. Terminate partition framing at suspended ceilings where indicated
- D. Install steel studs so flanges point in the same direction and leading edge or end of each panel can be attached to open (unsupported) edges of stud flanges first.
- E. Frame door openings to comply with GA-600 and with gypsum board manufacturer's applicable written recommendations, unless otherwise indicated. Screw vertical studs at jambs to jamb anchor clips on door frames; install runner track section (for cripple studs) at head and secure to jamb studs.
  - 1. Install two studs at each jamb, unless otherwise indicated.

2. Install cripple studs at head adjacent to each jamb stud, with a minimum 1/2-inch clearance from jamb stud to allow for installation of control joint.
  3. Extend jamb studs through suspended ceilings and attach to underside of floor or roof structure above.
  4. Frame openings other than door openings the same as required for door openings, unless otherwise indicated. Install framing below sills of openings to match framing required above door heads.
- F. Z-Furring Members:
1. Erect insulation vertically and hold in place with Z-furring members spaced 24 inches o.c.
  2. Except at exterior corners, securely attach narrow flanges of furring members to wall with concrete stub nails, screws designed for masonry attachment, or powder-driven fasteners spaced 24 inches o.c.
  3. At exterior corners, attach wide flange of furring members to wall with short flange extending beyond corner; on adjacent wall surface, screw-attach short flange of furring channel to web of attached channel. At interior corners, space second member no more than 12 inches from corner and cut insulation to fit.
  4. Until gypsum board is installed, hold insulation in place with 10-inch staples fabricated from 0.0625-inch- diameter, tie wire and inserted through slot in web of member.
- G. Vapor Barrier: Install to comply with requirements specified in Section 07210.

### **3.03 APPLYING AND FINISHING PANELS, GENERAL:**

- A. Gypsum Board Application and Finishing Standards: ASTM C 840 and GA-216.
- B. Install sound attenuation blankets before installing gypsum panels, unless blankets are readily installed after panels have been installed on one side.
- C. Install ceiling board panels across framing to minimize the number of abutting end joints and to avoid abutting end joints in the central area of each ceiling. Stagger abutting end joints of adjacent panels not less than one framing member.
- D. Install gypsum panels with face side out. Butt panels together for a light contact at edges and ends with not more than 1/16 inch of open space between panels. Do not force into place.
- E. Locate edge and end joints over supports, except in ceiling applications where intermediate supports or gypsum board back-blocking is provided behind end joints. Do not place tapered edges against cut edges or ends. Stagger vertical joints on opposite sides of partitions. Do not make joints other than control joints at corners of framed openings.
- F. Attach gypsum panels to steel studs so leading edge or end of each panel is attached to open (unsupported) edges of stud flanges first.
- G. Attach gypsum panels to framing provided at openings and cutouts.
- H. Do not attach gypsum panels across the flat grain of wide-dimension lumber, including floor joists and headers. Float gypsum panels over these members using resilient channels, or provide control joints to counteract wood shrinkage.

- I. Form control and expansion joints with space between edges of adjoining gypsum panels.
- J. Cover both faces of steel stud partition framing with gypsum panels in concealed spaces (above ceilings, etc.), except in chases braced internally.
- K. Unless concealed application is indicated or required for sound, fire, air, or smoke ratings, coverage may be accomplished with scraps of not less than 8 sq. ft. 0.7 sq. m in area.
- L. Fit gypsum panels around ducts, pipes, and conduits.
- M. Where partitions intersect open concrete coffers, concrete joists, and other structural members projecting below underside of floor/roof slabs and decks, cut gypsum panels to fit profile formed by coffers, joists, and other structural members; allow 1/4- to 3/8-inch- wide joints to install sealant.
- N. Isolate perimeter of non-load-bearing gypsum board partitions at structural abutments, except floors. Provide 1/4- to 1/2-inch- wide spaces at these locations, and trim edges with U-bead edge trim where edges of gypsum panels are exposed. Seal joints between edges and abutting structural surfaces with acoustical sealant.
- O. Floating Construction: Where feasible, including where recommended in writing by manufacturer, install gypsum panels over wood framing, with floating internal corner construction.
- P. STC-Rated Assemblies: Seal construction at perimeters, behind control and expansion joints, and at openings and penetrations with a continuous bead of acoustical sealant. Install acoustical sealant at both faces of partitions at perimeters and through penetrations. Comply with ASTM C 919 and manufacturer's written recommendations for locating edge trim and closing off sound-flanking paths around or through gypsum board assemblies, including sealing partitions above acoustical ceilings.
- Q. Space fasteners in gypsum panels according to referenced gypsum board application and finishing standard and manufacturer's written recommendations.
  - 1. Space screws a maximum of 12 inches o.c. for vertical applications.
- R. Space fasteners in panels that are tile substrates a maximum of 8 inches o.c.

### **3.04 PANEL APPLICATION METHODS:**

- A. Single-Layer Application:
  - 1. On ceilings, apply gypsum panels before wall/partition board application to the greatest extent possible and at right angles to framing, unless otherwise indicated.
  - 2. On partitions/walls, apply gypsum panels vertically (parallel to framing), unless otherwise indicated or required by fire-resistance-rated assembly, and minimize end joints.
    - a. Stagger abutting end joints not less than one framing member in alternate courses of board.
    - b. At stairwells and other high walls, install panels horizontally, unless otherwise indicated or required by fire-resistance-rated assembly.
  - 3. On Z-furring members, apply gypsum panels vertically (parallel to framing) with no end joints. Locate edge joints over furring members.

- B. Multilayer Application on Ceilings: Apply gypsum board indicated for base layers before applying base layers on walls/partitions; apply face layers in same sequence. Apply base layers at right angles to framing members and offset face-layer joints 1 framing member, 16 inches minimum, from parallel base-layer joints, unless otherwise indicated or required by fire-resistance-rated assembly.
- C. Multilayer Application on Partitions/Walls: Apply gypsum board indicated for base layers and face layers vertically (parallel to framing) with joints of base layers located over stud or furring member and face-layer joints offset at least one stud or furring member with base-layer joints, unless otherwise indicated or required by fire-resistance-rated assembly. Stagger joints on opposite sides of partitions.
1. Z-Furring Members: Apply base layer vertically (parallel to framing) and face layer either vertically (parallel to framing) or horizontally (perpendicular to framing) with vertical joints offset at least one furring member. Locate edge joints of base layer over furring members.
- D. Single-Layer Fastening Methods: Apply gypsum panels to supports with steel drill screws.
- E. Multilayer Fastening Methods: Fasten base layers and face layers separately to supports with screws.
- F. Laminating to Substrate: Where gypsum panels are indicated as directly adhered to a substrate (other than studs, joists, furring members, or base layer of gypsum board), comply with gypsum board manufacturer's written recommendations and temporarily brace or fasten gypsum panels until fastening adhesive has set.
- G. Curved Partitions:
1. Install panels horizontally and unbroken, to the extent possible, across curved surface plus 12-inch/300-mm-long straight sections at ends of curves and tangent to them.
  2. On convex sides of partitions, begin installation at one end of curved surface and fasten gypsum panels to studs as they are wrapped around curve. On concave side, start fastening panels to stud at center of curve and work outward to panel ends. Fasten panels to framing with screws spaced 12 inches o.c.
  3. For double-layer construction, fasten base layer to studs with screws 16 inches o.c. Center gypsum board face layer over joints in base layer, and fasten to studs with screws spaced 12 inches o.c.
- H. Exterior Soffits and Ceilings: Apply exterior gypsum soffit board panels perpendicular to supports, with end joints staggered and located over supports.
1. Install with 1/4-inch open space where panels abut other construction or structural penetrations.
  2. Fasten with corrosion-resistant screws.
- I. Tile Backing Panels:
1. Cementitious Backer Units: ANSI A108.11, at locations indicated to receive tile.
  2. Areas Not Subject to Wetting: Install standard gypsum wallboard panels to produce a flat surface except at showers, tubs, and other locations indicated to receive water-resistant panels.
  3. Where tile backing panels abut other types of panels in the same plane, shim surfaces to produce a uniform plane across panel surfaces.

### **3.05 INSTALLING TRIM ACCESSORIES:**

- A. General: For trim with back flanges intended for fasteners, attach to framing with same fasteners used for panels. Otherwise, attach trim according to manufacturer's written instructions.
- B. Control Joints: Install control joints at locations shown or indicated. Install control joints according to ASTM C 840 and in specific locations approved by the Engineer for visual effect.

### **3.06 FINISHING GYPSUM BOARD ASSEMBLIES:**

- A. General: Treat gypsum board joints, interior angles, edge trim, control joints, penetrations, fastener heads, surface defects, and elsewhere as required to prepare gypsum board surfaces for decoration. Promptly remove residual joint compound from adjacent surfaces.
- B. Prefill open joints, beveled edges, and damaged surface areas.
- C. Apply joint tape over gypsum board joints, except those with trim having flanges not intended for tape.
- D. Gypsum Board Finish Levels: Finish panels to levels indicated below, according to ASTM C 840, for locations indicated:
  - 1. Level 2: Embed tape and apply separate first coat of joint compound to tape, fasteners, and trim flanges where.
  - 2. Level 3: Embed tape and apply separate first and fill coats of joint compound to tape, fasteners, and trim flanges at surfaces receiving textured finish.
- E. Glass-Mat Gypsum Sheathing Board: Finish according to manufacturer's written instructions for use as exposed soffit board.
- F. Cementitious Backer Units: Finish according to manufacturer's written instructions.

### **3.07 APPLYING TEXTURE FINISHES:**

- A. Surface Preparation and Primer: Prepare and apply primer to gypsum panels and other surfaces receiving texture finishes. Apply primer to surfaces that are clean, dry, and smooth.
- B. Texture Finish Application: Mix and apply finish using powered spray equipment, to produce a uniform texture matching approved mockup and free of starved spots or other evidence of thin application or of application patterns.
- C. Prevent texture finishes from coming into contact with surfaces not indicated to receive texture finish by covering them with masking agents, polyethylene film, or other means. If, despite these precautions, texture finishes contact these surfaces, immediately remove droppings and overspray to prevent damage according to texture finish manufacturer's written recommendations.

### **3.08 FIELD QUALITY CONTROL:**

- A. Above-Ceiling Observation: Before Contractor installs gypsum board ceilings, Architect will conduct an above-ceiling observation and report deficiencies in the Work observed. Do not

proceed with installation of gypsum board to ceiling support framing until deficiencies have been corrected.

1. Notify the Engineer in advance of date and time when Project, or part of Project, will be ready for above-ceiling observation.
2. Before notifying the Engineer, complete the following in areas to receive gypsum board ceilings:
  - a. Installation of 80 percent of lighting fixtures, powered for operation.
  - b. Installation, insulation, and leak and pressure testing of water piping systems.
  - c. Installation of air-duct systems.
  - d. Installation of air devices.
  - e. Installation of mechanical system control-air tubing.
  - f. Installation of ceiling support framing.

**END OF SECTION**

## SECTION 09320

### TILE

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing ceramic tile, ceramic mosaic tile, quarry tile and marble thresholds, typically in restricted areas as shown.
- B. Related Work Specified Elsewhere:
  - 1. Cast-in-Place Structural Concrete: Section 03300.
  - 2. Seals and Sealants: Section 07900.
  - 3. Paver Tile: Section 09340.

##### 1.02 PERFORMANCE REQUIREMENTS:

- A. Static Coefficient of Friction: For tile installed on walkway surfaces, provide products with the following values as determined by testing identical products per ASTM C1028:
  - 1. Level Surfaces: Minimum 0.6.
  - 2. Ramp Surfaces (slope greater than 1:20): Minimum 0.8.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Product Data: For each type of tile, mortar, grout, and other products specified. Include recommendations for product application and use.
  - 2. Shop Drawings: For the following:
    - a. Tile patterns and locations.
    - b. Widths, details, and locations of expansion, contraction, control, and isolation joints in tile substrates and finished tile surfaces.
  - 3. Tile Samples for Initial Selection: Manufacturer's color charts consisting of actual tiles or sections of tiles showing the full range of colors, textures, and patterns available for each type and composition of tile indicated. Include Samples of accessories involving color selection.
  - 4. Grout Samples for Initial Selection: Manufacturer's color charts consisting of actual sections of grout showing the full range of colors available for each type of grout indicated.
  - 5. Samples for Verification: Of each item listed below, prepared on Samples of size and construction indicated. Where products involve normal color and texture variations, include Sample sets showing the full range of variations expected.
    - a. Ceramic and Ceramic Mosaic Tile: Three panels of each type and composition of tile and for each color and texture required, 12 inches square, mounted on 16 inches square by 1/4-inch thick hardboard with grouted joints using product complying with specified requirements and approved for completed work in color or colors selected by the Engineer.
    - b. Full-size units of each type of trim and accessory for each color required.
    - c. Quarry Tile: Four standard size units mounted on 16 inches square by 1/4-inch thick hardboard with grouted joints using product complying with specified requirements and approved for completed work in color or colors selected by the Engineer.
    - d. Marble Threshold: Three 12-inch lengths showing range of color, veining and finish.

6. Master Grade Certificates: For each shipment, type, and composition of tile, per ANSI A137.1, bearing TCA-Certification Mark, signed by tile manufacturer and Installer stating type and quality of material. Submit at time of shipment..
7. Product Certificates: Signed by manufacturers certifying that the products furnished comply with requirements.
8. Tile Test Reports: Certified test reports in accordance with ANSI A118.1 through A118.4.

#### **1.04 QUALITY ASSURANCE:**

- A. Codes Regulations, Reference Standards and Specifications:
  1. Comply with the codes and regulations of the jurisdictional authorities.
  2. ADA: Americans with Disabilities Act.
  3. ANSI: A108.1C, A108.5, A108.6, A108.10, A118.1, A118.2, A118.3, A118.4, A118.6, A137.1.
  4. ASTM: A82, A185, C144, C150, C206, C207, C241, C503, C920, C1028, D4397.
  5. FS: UU-B-790.
  6. TCA: Handbook for Ceramic Tile Installation.
- B. Installer Qualifications: Engage an experienced installer who has completed tile installations similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.
- C. Source Limitations for Tile: Obtain each color, grade, finish, type, composition, and variety of tile from one source with resources to provide products from the same production run for each contiguous area of consistent quality in appearance and physical properties without delaying the Work.
- D. Source Limitations for Setting and Grouting Materials: Obtain ingredients of a uniform quality for each mortar, adhesive, and grout component from a single manufacturer and each aggregate from one source or producer.
- E. Mockups: Before installing floor and wall tile, construct mockups for each form of construction and finish required to verify selections made under Sample submittals and to demonstrate aesthetic effects and qualities of materials and execution. Build mockups to comply with the following requirements, using materials indicated for completed Work.
  1. Mockups shall be minimum four feet square and in the location as directed by the Engineer.
  2. Notify the Engineer seven days in advance of the dates and times when mockups will be constructed.
  3. Demonstrate the proposed range of aesthetic effects and workmanship.
  4. Obtain the Engineer's approval of mockups before proceeding with final unit of Work.
  5. Approved mockups may become part of the completed Work.

#### **1.05 DELIVERY, STORAGE, AND HANDLING:**

- A. Deliver materials to the site in original unopened containers, clearly labeled with the manufacturer's name, brand designation, type, grade and color. Comply with requirement of ANSI A137.1 for labeling sealed tile packages.
- B. Store materials so as to prevent damage or contamination to materials by water, freezing, foreign matter, and other causes.
- C. Handle materials so as to prevent breakage of containers and damage to materials.

**1.06 PROJECT CONDITIONS:**

- A. Environmental Limitations: Do not start tile work unless ambient temperature of area in which work occurs is at least 50 deg. F and rising and is maintained at not less than 50 deg. F without interruption while work is being done and for at least 72 hours after completion.
- B. Substrate Conditions: Do not start tile work unless surfaces to receive tile are in satisfactory condition. Commencement of tile work constitutes Contractor's acceptance of the subfloor condition in accordance with ANSI A108-AN-2, General Requirements for Subsurfaces.

**1.07 EXTRA MATERIALS:**

- A. Deliver extra materials to Owner. Furnish and store extra materials in locations as directed on pallets and in original containers with protective covering for storage, and are clearly identified with labels describing contents and area of placement.
  - 1. Tile and Trim Units: Furnish quantity of full-size units equal to 5 percent of amount installed, for each type, composition, color, pattern, and size indicated.

**PART 2 - PRODUCTS**

**2.01 PRODUCTS, GENERAL:**

- A. ANSI Ceramic Tile Standard: Provide tile that complies with ANSI A137.1, "Specifications for Ceramic Tile," for types, compositions, and other characteristics indicated.
  - 1. Provide tile complying with Standard Grade requirements, unless otherwise indicated.
- B. ANSI Standards for Tile Installation Materials: Provide materials complying with ANSI standards referenced in "Setting and Grouting Materials" article.
- C. Colors, Textures, and Patterns: Where manufacturer's standard products are indicated for tile, grout, and other products requiring selection of colors, surface textures, patterns, and other appearance characteristics, provide specific products or materials complying with the following requirements:
  - 1. Provide Engineer's selections from manufacturer's full range of colors, textures, and patterns for products of type indicated.
  - 2. Provide tile trim and accessories that match color and finish of adjoining flat tile.
- D. Factory Blending: For tile exhibiting color variations within the ranges selected during Sample submittals, blend tile in the factory and package so tile units taken from one package show the same range in colors as those taken from other packages and match approved Samples.

**2.02 TILE PRODUCTS:**

- A. Unglazed Ceramic Mosaic Floor Tile: Provide factory-mounted flat tile complying with the following requirements:
  - 1. Composition: Porcelain or porcelain with abrasive admixture, as indicated.
  - 2. Module Size: 2 by 2 inches (nominal).
  - 3. Nominal Thickness: 1/4 inch.
  - 4. Face: Plain with cushion edges.
- B. Unglazed Quarry Tile: Provide square-edged flat tile complying with the following requirements:

1. Wearing Surface: Nonabrasive or abrasive aggregate embedded in surface, as indicated.
  2. Facial Dimensions: 6 by 6 inches (nominal).
  3. Thickness: 1/2 inch.
  4. Face: Plain.
- C. Glazed Wall Tile: Provide flat tile complying with the following requirements:
1. Module Size: 4-1/4 by 4-1/4 inches.
  2. Thickness: 5/16 inch.
  3. Face: Plain with cushion edges.
  4. Color: White.
- D. Trim Units: Provide tile trim units to match characteristics of adjoining flat tile and to comply with the following requirements:
1. Size: As indicated, coordinated with sizes and coursing of adjoining flat tile where applicable.
  2. Shapes: As follows, selected from manufacturer's standard shapes:
    - a. Base for Thin-Set Mortar Installations: Straight.
    - b. External Corners for Thin-Set Mortar Installations: Surface bullnose.
    - c. Internal Corners: Field-buttet square corners, except with coved base and cap angle pieces designed to member with stretcher shapes.

### **2.03 STONE THRESHOLDS:**

- A. General: Provide stone thresholds that are uniform in color and finish, fabricated to sizes and profiles indicated to provide transition between tile surfaces and adjoining finished floor surfaces.
1. Fabricate thresholds to heights indicated, but not more than 1/2-inch above adjoining finished floor surfaces, with transition edges beveled on a slope of no greater than 1:2.
- B. Marble Thresholds: Provide marble thresholds complying with ASTM C503 requirements for exterior use and with a minimum abrasive-hardness value (Ha) of 10 per ASTM C241.
1. Provide white, honed marble complying with the Marble Institute of America's Group A requirements for soundness.

### **2.04 SETTING AND GROUTING MATERIALS:**

- A. Portland Cement: ASTM C150, Type I.
- B. Sand: ASTM C144.
- C. Hydrated Lime: ASTM C206 or ASTM C207, Type S.
- D. Water: Potable.
- E. Portland Cement Mortar Installation Materials: Provide materials complying with ANSI A108.1A and as specified below:
1. Cleavage Membrane: Polyethylene sheeting ASTM D4397, 4.0 mils thick.
  2. Reinforcing Wire Fabric: Galvanized, welded wire fabric, 2 by 2 inches by 0.062-inch diameter; comply with ASTM A185 and ASTM A82, except for minimum wire size.
- F. Dry-Set Portland Cement Mortar: ANSI A118.1.

- G. Chemical-Resistant, Water-Cleanable, Ceramic Tile-Setting and -Grouting Epoxy: ANSI A118.3.
  - 1. Provide product capable of resisting continuous and intermittent exposure to temperatures of up to 140 deg F and 212 deg F, respectively, as certified by mortar manufacturer for intended use.
- H. Sand-Portland Cement Grout: ANSI A108.10, composed of white or gray cement and white or colored aggregate as required to produce color indicated.
- I. Dry-Set Grout: ANSI A118.6, color as indicated.
- J. Chemical-Resistant Epoxy Grout: ANSI A118.3, color as indicated.
  - 1. Provide product capable of resisting continuous and intermittent exposure to temperatures of up to 140 deg F and 212 deg F, respectively, as certified by mortar manufacturer for intended use.

#### **2.05 ELASTOMERIC SEALANTS AND BACKUP JOINT FILLER:**

- A. General: Provide manufacturer's standard chemically curing, elastomeric sealants of base polymer and characteristics indicated that comply with applicable requirements of Section 07900.
- B. Colors: Provide colors of exposed sealants to match colors of grout in tile adjoining sealed joints, unless otherwise indicated.
- C. One-Part, Mildew-Resistant Silicone Sealant: ASTM C920; Type S; Grade NS; Class 25; Uses NT, G, A, and, as applicable to nonporous joint substrates indicated, O; formulated with fungicide, intended for sealing interior ceramic tile joints and other nonporous substrates that are subject to in-service exposures of high humidity and temperature extremes.
- D. Multipart, Pourable Urethane Sealant for Use T: ASTM C920; Type M; Grade P; Class 25; Uses T, M, A, and, as applicable to joint substrates indicated, O.
- E. Backup Material: As recommended by sealant manufacturer and as required in Section 07900.
- F. Prime and Joint Cleaner: Use products as recommended by sealant manufacturer.

#### **2.06 MISCELLANEOUS MATERIALS:**

- A. Trowelable Underlayments and Patching Compounds: Latex-modified, portland-cement-based formulation provided or approved by manufacturer of tile-setting materials for installations indicated.
- B. Concrete Leveling Bed: In accordance with Section 03300, Class 3500 concrete, pea gravel course aggregate 1/4-inch minimum to 3/8-inch maximum. Adjust slump with plasticizers to maintain proper water-cement ratio.
- C. Building Paper: FS UU-B-790, red-rosin-sized building, Type I, Style 1B.
- D. Tile Cleaner: A neutral cleaner capable of removing soil and residue without harming tile and grout surfaces, specifically approved for materials and installations indicated by tile and grout manufacturers.

#### **2.07 MIXING MORTARS AND GROUT:**

- A. Mix mortars and grouts to comply with referenced standards and mortar and grout manufacturers' written instructions.
- B. Add materials, water, and additives in accurate proportions.
- C. Obtain and use type of mixing equipment, mixer speeds, mixing containers, mixing time, and other procedures to produce mortars and grouts of uniform quality with optimum performance characteristics for installations indicated.

## **PART 3 - EXECUTION**

### **3.01 EXAMINATION:**

- A. Examine substrates, areas, and conditions where tile will be installed, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of installed tile.
  - 1. Verify that substrates for setting tile are firm; dry; clean; free from oil, waxy films, and curing compounds; and within flatness tolerances required by referenced ANSI A108 series of tile installation standards for installations indicated.
  - 2. Verify that installation of grounds, anchors, recessed frames, electrical and mechanical units of work, and similar items located in or behind tile has been completed before installing tile.
  - 3. Verify that joints and cracks in tile substrates are coordinated with tile joint locations; if not coordinated, adjust latter in consultation with the Engineer.
- B. Do not proceed with installation until unsatisfactory conditions have been corrected.

### **3.02 PREPARATION:**

- A. Remove coatings, including curing compounds, and other substances that contain soap, wax, oil, or silicone and are incompatible with tile-setting materials by using a terrazzo or concrete grinder, a drum sander, or a polishing machine equipped with a heavy-duty wire brush.
- B. Provide concrete substrates for tile floors installed with dry-set or latex-portland cement mortars that comply with flatness tolerances specified in referenced ANSI A108 series of tile installation standards for installations indicated.
  - 1. Use trowelable leveling and patching compounds per tile-setting material manufacturer's written instructions to fill cracks, holes, and depressions.
  - 2. Remove protrusions, bumps, and ridges by sanding or grinding.
- C. Provide leveling course for masonry or concrete-wall when variation exceeds 1/4-inch in eight feet. Leveling course shall consist of dry-set mortar to which an equal volume of a mixture of one-part portland cement and 1-1/2 parts sand has been added. Apply leveling course to maximum thickness of 1/4-inch.
- D. Blending: For tile exhibiting color variations within the ranges selected during Sample submittals, verify that tile has been blended in the factory and packaged so tile units taken from one package show the same range in colors as those taken from other packages and match approved Samples. If not factory blended, either return to manufacturer or blend tiles at Project site before installing.

### **3.03 INSTALLATION, GENERAL:**

- A. ANSI Tile Installation Standards: Comply with parts of ANSI A108 series of tile installation standards in "Specifications for Installation of Ceramic Tile" that apply to types of setting and grouting materials and to methods indicated in ceramic tile installation schedules.
- B. TCA Installation Guidelines: TCA's "Handbook for Ceramic Tile Installation." Comply with TCA installation methods indicated in ceramic tile installation schedules.
- C. Coordinate tile work with work of other trades.
- D. Extend tile work into recesses and under or behind equipment and fixtures to form a complete covering without interruptions, unless otherwise indicated. Terminate work neatly at obstructions, edges, and corners without disrupting pattern or joint alignments.
- E. Accurately form intersections and returns. Perform cutting and drilling of tile without marring visible surfaces. Carefully grind cut edges of tile abutting trim, finish, or built-in items for straight aligned joints. Fit tile closely to electrical outlets, piping, fixtures, and other penetrations so plates, collars, or covers overlap tile.
- F. Jointing Pattern: Lay tile in grid pattern, unless otherwise indicated. Align joints when adjoining tiles on floor, base, walls, and trim are the same size. Lay out tile work and center tile fields in both directions in each space or on each wall area. Adjust to minimize tile cutting. Provide uniform joint widths, unless otherwise indicated.
  - 1. For tile mounted in sheets, use plastic spacers to make joints between tile sheets the same width as joints within tile sheets so joints between sheets are not apparent in finished work.

#### **3.04 FLOOR TILE INSTALLATION:**

- A. General: Install floor tile by the portland cement mortar method in accordance with ANSI A108.1C.
- B. Tile Type: Unglazed ceramic mosaic tile and quarry tile.
- C. Setting Bed and Grout: ANSI A108.1C with the following mortar and grout:
  - 1. Dry-set portland cement mortar.
  - 2. Dry-set grout.
- D. Joint Widths: Install tile on floors joint widths as recommended by the tile manufacturer.
- E. Grout: Dry-set grout in accordance with ANSI A108.10.
- F. Where depression is not provided for mortar setting bed, install floor tile by the epoxy method in accordance with ANSI A108.6.

#### **3.05 WALL TILE INSTALLATION:**

- A. General: Install wall tile by the dry-set mortar method in accordance with ANSI A108.5.
- B. Tile Type: Glazed wall tile.
- C. Setting Bed and Grout: ANSI A108.5 with the following mortar and grout:
  - 1. Dry-set portland cement mortar.
  - 2. Dry-set grout.
- D. Joint Widths: Install tile on floors joint widths as recommended by the tile manufacturer.

- E. Grout: Dry-set grout in accordance with ANSI A108.10.
- F. Where inside corners are shown as flat tiles, make corner joint a sealant joint as specified for expansion joints below.

**3.06 STONE THRESHOLD INSTALLATION:**

- A. Stone Thresholds: Install stone thresholds at locations indicated; set in same type of setting bed as abutting field tile, unless otherwise indicated.
  - 1. Set thresholds in latex-portland cement mortar for locations where mortar bed would otherwise be exposed above adjacent nontile floor finish.

**3.07 EXPANSION AND CONTROL JOINT INSTALLATION:**

- A. Provide expansion and control joints around floor perimeters, at interior corners of tiled walls, in tile surfaces directly above joints in concrete substrates and where recommended by the TCA Handbook for Ceramic Tile Installation.
- B. Do not saw-cut joints after installing tiles.
- C. Install removable divider strips of the same depth as the finished tile system, including setting bed, to keep sealant joints free of setting bed, mortar and grout. Remove strips after grouting and curing operations in order to install sealant.
- D. Install and cure sealant in accordance with manufacturer's instructions. Use primer unless sealant manufacturer recommends against priming.

**3.08 CLEANING AND PROTECTING:**

- A. Cleaning: On completion of placement and grouting, clean tile surfaces with warm water and washing compound in accordance with recommendations of tile manufacturer. Sponge and wash tile thoroughly and polish with clean dry cloths.
  - 1. The use of acid or acid cleaners on tile is prohibited.
- B. Finished Tile Work: Leave finished installation clean and free of cracked, chipped, broken, unbonded, and otherwise defective tile work.
- C. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure tile is without damage or deterioration at the time of Substantial Completion.
  - 1. When recommended by tile manufacturer, apply a protective coat of neutral protective cleaner to completed tile walls and floors. Protect installed tile work with building paper taped to tile to prevent staining, damage, and wear. Lay board walkways on floors to be used as passageways.
  - 2. Prohibit foot and wheel traffic from tiled floors for at least seven days after grouting is completed.
- D. Before final inspection, remove protective coverings and rinse neutral cleaner from tile surfaces.

**END OF SECTION**

## SECTION 09340

### PAVER TILE

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing paver tiles, typically in patron areas as shown. These tiles are noted on Drawings as:
  - 1. Paver tile.
  - 2. Truncated dome quarry tile.
- B. Related Work Specified Elsewhere:
  - 1. Concrete overlay: Section 03300.
  - 2. Expansion joint assembly: Sections 05810 and 05811.
  - 3. Sealant backup material and sealant joint installation requirements: Section 07900.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ANSI: A108-AN-2, A108.1C, A108.4, A108.5, A108.6, A108.10, A118.3, A118.4, A118.6, A136.1, A137.1.
  - 3. AASHTO: M153.
  - 4. ASTM: A185, C171, C501, C373, C485, C499, C836, C920, C1028.
  - 5. TCA: TCA Handbook for Ceramic Tile Installation.
  - 6. Americans With Disabilities Act (ADA).

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Product Data: Manufacturer's product data for each product required. Include recommendations for product application and use.
  - 2. Shop Drawings:
    - a. Include layout of paver tile, locations and sizes of expansion joints and control joints, details of installation, materials manufacturers' catalogs, recommendations and applicable specifications.
    - b. Indicate limits of ramps (surfaces with a slope greater than 1:20) and areas where tile with abrasive aggregate is required according to its coefficient of friction.
  - 3. Samples:
    - a. Three 24-inch square panels showing paver tile, bonding method, joint materials, expansion-joint sealants, color and texture.
    - b. Demonstration sample of platform edge paver installation where directed, minimum six feet wide by 16 feet long along platform edge granite. Approved sample may be used in work.
  - 4. Certification:
    - a. Master Grade Certificate: ANSI A137.1.
    - b. Mortar and grout manufacturer's certification that materials furnished are suitable for intended use and meet specified requirements.
    - c. Certified test reports by approved independent testing facility for specified properties and tests.

##### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver materials to site in original unopened moisture proof containers clearly labeled indicating manufacturer's name, type, grade and color.
- B. Provide mortar and grout materials with labels certifying compliance with specifications and that they are of the types recommended by manufacturer for this application.
- C. Store materials on pallets so as to prevent damage and moisture penetration.
- D. Handle materials so as to prevent breakage of containers and damage to materials.

#### 1.05 JOB CONDITIONS:

- A. Environmental Conditions:
  - 1. Do not start paver-tile work unless the ambient temperature of the area in which the work occurs is at least 50F and rising and is maintained at not less than 50F without interruption while the work is being done and for at least 72 hours after completion of the work.
- B. Substrate Conditions:
  - 1. Do not start paver-tile work unless surfaces to receive tile are in satisfactory condition.
  - 2. Commencement of paver-tile work constitutes Contractor's acceptance of the subfloor condition in accordance with ANSI A108-AN-2, General Requirement for Subsurfaces.

### PART 2 - PRODUCTS

#### 2.01 MATERIALS:

- A. Paver Tile:
  - 1. Standard Grade, ANSI A137.1, Section 5.3, Paver Tile.
  - 2. Types: Natural clay paver tile as follows:
    - a. Hexagonal: Either nominal eight inches or nominal six inches across flats by 3/4 inch thick; flat face, cushion (not square) edges.
    - b. Base: 8-inch by 12-inch by 3/4 inch thick.
    - c. Stair treads and risers: Bullnose tread, sizes as shown.
  - 3. Face of tile: Unglazed, slip-resistant wearing surface integral with body of tile. Furnish tiles with or without embedded abrasive aggregate, as required to provide the specific minimum slip resistance specified below for each area of work.
  - 4. Backs: Raised pattern.
  - 5. Compressive strength: 8,000-psi, minimum.
  - 6. Slip Resistance: Minimum static coefficients of friction as required by the ADA, tested in accordance with ASTM C1028, but not less than the following:
    - a. Level surfaces: 0.60 wet and dry.
    - b. Ramps (slope greater than 1:20): 0.80 wet and dry.
    - c. Stair treads: 0.80 wet and dry.
  - 7. Color and flash: Deep red color with factory-applied flash, matching samples on file with the Engineer. Make flashing natural in appearance across each paver unit; not linear, paint-like, or streaked; and with coverage varying from 10-percent to 50-percent of unit face area.
  - 8. Abrasive hardness: 50 or greater, ASTM C501.
  - 9. Water absorption: 0.5 percent to 3.0 percent, ASTM C373
  - 10. Dimensional tolerances:
    - a. Thickness: 0.040 inch maximum range of thickness, ASTM C499.

- b. Facial dimensions: 3.0 percent maximum facial-dimension variation, maximum 1.5-percent range of facial dimension variation; ASTM C499.
  - c. Warpage: 1.0 percent maximum along any edge, 0.75-percent maximum on either diagonal; ASTM C485.
- B. Truncated Dome Quarry Tile:
- 1. Standard Grade, ANSI A137.1, Section 5.3, Paver Tile (not quarry tile).
  - 2. Types: Natural clay paver tile as follows:
    - a. Domed form: Re-pressed tile to produce ADA-compliant raised domes.
      - 1) Nominal six-inch square by 1/2-inch thick at base of domes; square edges; actual measurement maximum 5-3/4 inch by 5-3/4 inch.
      - 2) Produce two projecting dome patterns, Style A and Style B, which are required to make a consistent ADA-required pattern for the detectable warning surface as shown.
    - b. Flat form: Nominal six-inch square tile by 1/2-inch thick; flat face, square edges; actual measurement maximum 5-3/4 inch by 5-3/4 inch.
  - 3. Face of tile: Unglazed, slip-resistant wearing surface integral with body of tile. Furnish tiles with or without embedded abrasive aggregate, as required to provide the specific minimum slip resistance specified below for each area of work.
  - 4. Backs: Raised pattern.
  - 5. Compressive strength: 8,000-psi, minimum.
  - 6. Slip Resistance: Minimum static coefficients of friction as required by the ADA, tested in accordance with ASTM C1028, but not less than the following:
    - a. Level surfaces: 0.60 wet and dry.
  - 7. Color and flash: Deep red color with factory-applied flash, matching samples on file with the Engineer. Make flashing natural in appearance across each paver unit; not linear, paint-like, or streaked; and with coverage varying from 10-percent to 50-percent of unit face area.
  - 8. Abrasive hardness: 50 or greater, ASTM C501.
  - 9. Water absorption: 0.5 percent to 3.0 percent, ASTM C373
  - 10. Dimensional tolerances:
    - a. Thickness: 0.040 inch maximum range of thickness, ASTM C499.
    - b. Facial dimensions: 3.0 percent maximum facial-dimension variation, maximum 1.5-percent range of facial dimension variation; ASTM C499.
    - c. Warpage: 1.0 percent maximum along any edge, 0.75-percent maximum on either diagonal; ASTM C485.
- C. Tile Mortar:
- 1. Type 1: Latex-portland cement mortar, ANSI A118.4.
  - 2. Type 2 (polyurethane adhesive): One-part or two-part polyurethane adhesive for exterior use, complying with the requirements of ASTM C836 and ANSI A136.1, with the following additional minimum requirements:
    - a. Shear strength, conditioned, dry; ANSI A136.1: 80 psi, no bond breakage.
    - b. Shear strength, conditioned, after water immersion; ANSI A136.1: 90 psi, no bond breakage.
    - c. Shear strength after accelerated aging; ANSI A136.1: 150 psi, no bond breakage.
    - d. Tensile bond strength: 350 psi minimum, for adhesive and for cohesive bond failure.
    - e. Viscosity: Non-sag, trowelable. If necessary to maintain viscosity at higher ambient temperatures, provide thickening agent which will not reduce required properties below the requirements.
    - f. Flammability when cured: Noncombustible.
    - g. Pot life: 60 minutes.
    - h. Primer: As recommended by manufacturer.

- i. Sources: Subject to compliance with requirements, use one of the following or equal:
  - 1) FX-552 Tile Adhesive by Fox Industries, Baltimore, MD, 301/243-8856.
  - 2) Hydroment Ultra-Set by Bostik Division of Emhart, Huntington Valley, PA, 800/523-6530.
  - 3) Planicrete-W by MAPEI U.S.A., Elk Grove Village, IL, 800/426-2734.
- D. Epoxy Mortar and Grout: ANSI A118.3.
- E. Tile Grout:
  - 1. Latex-portland-cement grout, ANSI A118.6.
  - 2. Commercial portland-cement grout, presanded and pigmented. For narrow joints, grade sand to maximum sieve size as required to ensure full joints.
  - 3. Latex manufactured or recommended by mortar and grout manufacturer; included in factory dry-mix or field-mixed with gauging liquid.
  - 4. Color matching color of paver tile.
- F. Polyurethane Sealant:
  - 1. ASTM C920, Type M, Grade P or Grade NS as required for slope, Class 25, Use T.
  - 2. Color matching grout color when moist.
  - 3. Primer and joint cleaner: Use products recommended by sealant manufacturer, unless sealant manufacturer recommends against using primer and joint cleaner.
- G. Sealant Backup Material: As recommended by the sealant manufacturer, and as required in Section 07900.
- H. Expansion Joint Assembly: Sections 05810 and 05811.
- I. Premolded Expansion-Joint Filler: AASHTO M153, Type I.
- J. Concrete Overlay: Section 03300, Class 5000 concrete, pea gravel course aggregate 1/4-inch minimum to 3/8-inch maximum.
- K. Mortar Bed for Bases: ANSI A108.1C.
- L. Welded Steel-Wire Fabric: ASTM A185, size as shown.
- M. Bond Breaker: Polyethylene sheeting, ASTM C171, minimum 0.004-inch thick.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION:**

- A. General Requirements:
  - 1. Saw-cut paver tiles; breaking is prohibited.
  - 2. Cutting domed tiles:
    - a. Plan layout of tiles to avoid cuts through domes of domed tiles to the greatest extent possible. If domes are cut grind the remaining area around the domes flush with the flat face of the tiles.
  - 3. Install paver tile on level surfaces and ramps to meet specified static coefficients of friction.
  - 4. Lay out work in advance for accurate spacing of surface bond patterns with uniform joint widths and for accurate locating of openings and movement-type joints.

5. Set truncated dome tiles, both domed and flat forms, with plastic joint spacers, except where such tiles are factory premounted at correct pattern and uniform spacing. Use two spacers along each side of a tile when field-setting. Remove spacers after mortar has fully cured, immediately prior to grouting.
  6. Use grout of moist but stiff consistency, not a slurry. At narrow joints 1/4-inch and less, fill joints in two or more layers from bottom to top, applied before each layer cures, tooling each layer to compact grout and eliminate voids. At wider joints, fill in layers where needed and tool thoroughly to compact grout and prevent voids.
  7. At sealant joints, execute work in accordance with Section 07900.
- B. Latex Portland-Cement Mortar Method:
1. Use for installation of paver-tile only in fully enclosed areas without exposure to weather, such as below-grade platforms and mezzanines except where epoxy mortar method is required.
  2. TCA Handbook Method F102 and ANSI A108.5, using tile mortar Type 1.
  3. Obtain 100-percent contact with raised pattern back of tile with mortar by applying not less than 1/32-inch thick layer of mortar on back of each tile prior to placement in freshly notched mortar.
  4. Grout installation: Use tile grout, ANSI A108.10.
- C. Epoxy Mortar Method, ANSI A108.6:
1. Use for installation on metal surfaces.
  2. Follow mortar manufacturer's recommendations.
- D. Polyurethane Adhesive Method:
1. Use for installation of paver tile work wholly or partly exposed to weather, except where epoxy mortar method is required.
  2. TCA Handbook Method F102-98 and ANSI A108.4, using tile mortar Type 2 and as follows, except as otherwise necessary to comply with the printed instructions of the polyurethane-adhesive manufacturer.
    - a. Prime substrate surface in accordance with manufacturer's instructions before applying polyurethane adhesive. Primer is required unless manufacturer provides written certification recommending against priming.
    - b. Allow primer to dry for 12 hours before applying polyurethane adhesive, unless otherwise recommended in writing by manufacturer.
    - c. Use the manufacturers recommended filler in the polyurethane adhesive so as to thicken adhesive sufficiently to accomplish the required application and also to accomplish filling the raised pattern back of tile with adhesive prior to placement. Adjust quantity of filler for the ambient temperature as instructed by manufacturer of adhesive.
    - d. Obtain 100 percent coverage of substrate with the adhesive, which also functions as a membrane waterproofing, in accordance with ANSI A108.4. Use no more mortar than is necessary to obtain adhesion and coating of substrate. Remove excess mortar between tiles and from sides of joints to accommodate grouting for full depth of tile.
    - e. Before allowing pedestrian traffic, allow set tiles to cure for 24 hours in temperatures between 60F and 90F. At temperatures between 50F and 60F, allow 72 hours.
  3. Grout installation: Use tile grout; ANSI A108.10.
- E. Portland Cement Mortar Bed Method:
1. Use for installation of paver tile base and wall finish.
  2. TCA Handbook Method W221-98 and ANSI A108.1C and A108.10.
  3. Back-butter tile with bond coat before setting.

**3.02 MAINTENANCE MATERIALS:**

- A. Furnish one-percent extra paver tile of each type and style.
- B. Store tile in original containers, clearly marked as to contents and area of placement, in location directed.

**END OF SECTION**

## SECTION 09511

### ACOUSTICAL PANEL CEILINGS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing lay-in acoustical panels and exposed suspension systems.
- B. Related Work Specified Elsewhere:
  - 1. Acoustical Snap-In Metal Pan Ceilings: Section 09513.

##### 1.02 DEFINITIONS:

- A. CAC: Ceiling Attenuation Class.
- B. LR: Light Reflectance coefficient.
- C. NRC: Noise Reduction Coefficient.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Product Data: For each type of product specified provide manufacturer's printed product information including maintenance information.
  - 2. Coordination Drawings: Reflected ceiling plans drawn to scale and coordinating penetrations and ceiling-mounted items. Show the following:
    - a. Ceiling suspension system members.
    - b. Method of attaching suspension system hangers to building structure.
    - c. Ceiling-mounted items including light fixtures; air outlets and inlets; speakers; sprinklers; and special moldings at walls, column penetrations, and other junctures of acoustical ceilings with adjoining construction.
    - d. Minimum Drawing Scale: 1/8 inch = 1 foot.
  - 3. Samples for Initial Selection: Manufacturer's color charts consisting of actual acoustical panels or sections of acoustical panels, suspension systems, and moldings showing the full range of colors, textures, and patterns available for each type of ceiling assembly indicated.
  - 4. Samples for Verification: Full-size units of each type of ceiling assembly indicated; in sets for each color, texture, and pattern specified, showing the full range of variations expected in these characteristics. Provide three of each type.
    - a. Full-size samples of each acoustical panel type, pattern, and color.
    - b. Set of 12-inch-long samples of exposed suspension system members, including moldings, for each color and system type required.
    - c. Fasteners: Each type.
    - d. Accessories.
  - 5. Product Test Reports: Indicate compliance of acoustical panel ceilings and components with requirements based on comprehensive testing of current products.

##### 1.04 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Codes and regulations of the jurisdictional authorities.

2. ASTM: A635, A641, B633, C635, CC636, 834, E84, E90, E488, E795, E1190, E1264.
  3. Cisca: Ceiling Systems Handbook.
  4. NAAMM: Metal Finishes Manual for Architectural and Metal Products.
- B. Installer Qualifications: Engage an experienced installer who has completed acoustical panel ceilings similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.
- C. Source Limitations for Ceiling Units: Obtain each acoustical ceiling panel from one source with resources to provide products of consistent quality in appearance and physical properties without delaying the Work.
- D. Source Limitations for Suspension System: Obtain each suspension system from one source with resources to provide products of consistent quality in appearance and physical properties without delaying the Work.
- E. Fire-Test-Response Characteristics: Provide acoustical panel ceilings that comply with the following requirements:
1. Fire-response tests were performed by UL, ITS/Warnock Hersey, or another independent testing and inspecting agency that is acceptable to authorities having jurisdiction and that performs testing and follow-up services.
  2. Surface-burning characteristics of acoustical panels comply with ASTM E1264 for Class A materials as determined by testing identical products per ASTM E84.
  3. Products are identified with appropriate markings of applicable testing and inspecting agency.

#### **1.05 DELIVERY, STORAGE, AND HANDLING:**

- A. Deliver acoustical panels and suspension system components to Project site in original, unopened packages, clearly labeled with the manufacturer's name, brand designation, specification number, type, class and ratings as applicable.
- B. Store acoustical panels and suspensions system components in a fully enclosed space where they will be protected against damage from moisture, direct sunlight, surface contamination, and other causes.
- C. Before installing acoustical panels, permit them to reach room temperature and a stabilized moisture content.
- D. Handle acoustical panels carefully to avoid chipping edges or damaging units in any way.

#### **1.06 PROJECT CONDITIONS:**

- A. Environmental Limitations: Do not install acoustical panel ceilings until spaces are enclosed and weatherproof, wet-work in spaces is complete and dry, and work above ceilings is complete. Maintain temperature of 70 deg F minimum and relative humidity of 55-percent maximum in spaces in which acoustical panel work is being done.

#### **1.07 COORDINATION:**

- A. Coordinate layout and installation of acoustical panels and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

## **1.08 EXTRA MATERIALS:**

- A. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.
  - 1. Acoustical Ceiling Units: Full-size units equal to 5.0 percent of amount installed.
  - 2. Suspension System Components: Quantity of each exposed component equal to 2.0 percent of amount installed.

## **PART 2 - PRODUCTS:**

### **2.01 ACOUSTICAL PANELS, GENERAL:**

- A. Acoustical Panel Standard: Provide manufacturer's standard panels of configuration indicated that comply with ASTM E1264 classifications as designated by types, patterns, acoustical ratings, and light reflectances, unless otherwise indicated.
  - 1. Mounting Method for Measuring Noise Reduction Coefficient: Type E-400; plenum mounting in which face of test specimen is 15-3/4 inches away from test surface per ASTM E795.

### **2.02 METAL SUSPENSION SYSTEMS, GENERAL:**

- A. Metal Suspension System Standard: Provide manufacturer's standard direct-hung metal suspension systems of types, structural classifications, and finishes indicated that comply with applicable ASTM C635 requirements.
- B. Finishes and Colors, General: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes. Provide manufacturer's standard factory-applied finish for type of system indicated.
- C. Attachment Devices: Size for five times design load indicated in ASTM C635, Table 1, Direct Hung, unless otherwise indicated.
  - 1. Cast-in-Place and Post-installed Anchors in Concrete: Anchors of type and material indicated below, with holes or loops for attaching hangers of type indicated and with capability to sustain, without failure, a load equal to five times that imposed by ceiling construction, as determined by testing per ASTM E488, conducted by a qualified testing and inspecting agency.
    - a. Type: Cast-in-place anchors.
    - b. Type: Post-installed expansion anchors.
    - c. Corrosion Protection: Carbon-steel components zinc plated to comply with ASTM B633, Class Fe/Zn 5 (0.005 mm) for Class SC service condition (mild).
  - 2. Post-installed Powder-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hangers of type indicated, and with capability to sustain, without failure, a load equal to 10 times that imposed by ceiling construction, as determined by testing per ASTM E1190, conducted by a qualified testing and inspecting agency.
- D. Wire Hangers, Braces, and Ties: Provide wires complying with the following requirements:
  - 1. Zinc-Coated Carbon-Steel Wire: ASTM A641/A641M, Class 1 zinc coating, soft temper.
  - 2. Size: Select wire diameter so its stress at five times hanger design load (ASTM C635, Table 1, Direct Hung) will be less than yield stress of wire, but provide not less than 12 gauge.

- E. Sheet-Metal Edge Moldings and Trim: Type and profile indicated or, if not indicated, manufacturer's standard moldings for edges and penetrations that fit acoustical panel edge details and suspension systems indicated; formed from sheet metal of same material and finish as that used for exposed flanges of suspension system runners. Provide moldings with exposed flange of the same width as exposed runner.
- F. Metal Finish: Baked-Enamel Finish. Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-enamel finish consisting of prime coat and thermosetting topcoat, with not less than 1.0-mil dry film thickness for topcoat. Comply with paint manufacturer's written instructions for applying and baking to achieve a minimum dry film thickness of 2.0 mils.
  - 1. Color and Gloss: Matte white or as selected by the Engineer from manufacturer's full range of colors and glosses.

### **2.03 ACOUSTICAL SEALANT:**

- A. Acoustical Sealant for Exposed and Concealed Joints: Manufacturer's standard nonsag, paintable, nonstaining latex sealant complying with ASTM C834 and the following requirements:
  - 1. Product is effective in reducing airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E90.

## **PART 3 - EXECUTION**

### **3.01 EXAMINATION:**

- A. Examine substrates and structural framing to which acoustical panel ceilings attach or abut, with Installer present, for compliance with requirements specified in this and other Sections that affect ceiling installation and anchorage, and other conditions affecting performance of acoustical panel ceilings.
  - 1. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.02 PREPARATION:**

- A. Coordination: Furnish layouts for cast-in-place anchors, clips, and other ceiling anchors whose installation is specified in other Sections.
  - 1. If indicated, furnish cast-in-place anchors and similar devices to other trades for installation well in advance of time needed for coordinating other work.
- B. Measure each ceiling area and establish layout of acoustical panels to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width panels at borders, and comply with layout shown on reflected ceiling plans.

### **3.03 INSTALLATION:**

- A. General: Install acoustical panel ceilings to comply with publications referenced below per manufacturer's written instructions and CISCA's "Ceiling Systems Handbook."
  - 1. Standard for Ceiling Suspension System Installations: Comply with ASTM C636.
- B. Suspend ceiling hangers from building's structural members and as follows:
  - 1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structure or of ceiling suspension system.

2. Splay hangers only where required to miss obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
  3. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support standard suspension system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards and publications.
  4. Secure wire hangers to ceiling suspension members and to supports above with a minimum of three tight turns. Connect hangers directly either to structures or to inserts, eye screws, or other devices that are secure; that are appropriate for substrate; and that will not deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.
  5. Do not support ceilings directly from permanent metal forms or floor deck. Fasten hangers to cast-in-place hanger inserts, powder-actuated fasteners, or drilled-in anchors that extend through forms into concrete.
  6. Do not attach hangers to steel deck tabs.
  7. Do not attach hangers to steel roof deck. Attach hangers to structural members.
  8. Space hangers not more than 48 inches o.c. along each member supported directly from hangers, unless otherwise indicated; and provide hangers not more than 6 inches from ends of each member.
- C. Install edge moldings and trim of type indicated at perimeter of acoustical ceiling area and where necessary to conceal edges of acoustical panels.
1. Apply acoustical sealant in a continuous ribbon concealed on back of vertical legs of moldings before they are installed.
  2. Screw attach moldings to substrate at intervals not more than 16 inches o.c. and not more than 3 inches from ends, leveling with ceiling suspension system to a tolerance of 1/8 inch in 12 feet. Miter inside and outside corners accurately and connect securely.
  3. Do not use exposed fasteners, including pop rivets, on moldings and trim.
- D. Install suspension system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.
- E. Install acoustical panels with undamaged edges and fitted accurately into suspension system runners and edge moldings. Scribe and cut panels at borders and penetrations to provide a neat, precise fit.
1. For square-edged panels, install panels with edges fully hidden from view by flanges of suspension system runners and moldings.
  2. Install hold-down clips in areas indicated, in areas required by authorities having jurisdiction, and for fire-resistance ratings; space as recommended by panel manufacturer's written instructions, unless otherwise indicated or required.

### **3.04 FIELD QUALITY CONTROL OF POWER-ACTUATED FASTENERS AND POST-INSTALLED ANCHORS:**

- A. Testing Agency: Contractor will engage a qualified independent testing agency to perform field quality-control testing.
- B. Extent and Testing Frequency: Testing will take place in successive stages in areas described below. Proceed with installation of acoustical panel ceilings only after test results for previously installed hangers comply with requirements.
1. Extent of Each Test Area: When installation of ceiling suspension systems on each floor has reached 20 percent completion but no panels have been installed.

2. Within each test area, testing agency will select one of every 10 powder-actuated fasteners and postinstalled anchors used to attach hangers to concrete and will test them for 200 lbf of tension; it will also select one of every two postinstalled anchors used to attach bracing wires to concrete and will test them for 440 lbf of tension.
  3. When testing discovers fasteners and anchors that do not comply with requirements, testing agency will test those anchors not previously tested until 20 consecutively pass and then will resume initial testing frequency.
- C. Testing agency will report test results promptly and in writing to Contractor and Engineer.
  - D. Remove and replace those fasteners and anchors that test results indicate do not comply with specified requirements
  - E. Additional Testing: Where fasteners and anchors are removed and replaced, additional testing will be performed to determine compliance with specified requirements.

**3.05 CLEANING:**

- A. Replace damaged and broken acoustical panels.
- B. Clean exposed surfaces of acoustical panel ceilings, including trim, edge moldings, and suspension system members. Comply with manufacturer's written instructions for cleaning and touchup of minor finish damage. Remove and replace ceiling components that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.
- C. Clean up rubbish and debris and remove from site.
- D. Leave work areas in a broom clean condition.

**END OF SECTION**

## SECTION 09650

### RESILIENT FLOORING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing rubber floor covering, vinyl composition floor tile, vinyl wall base, rubber stair treads and accessories.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Product Data: For each type of product specified provide manufacturer's printed product information.
  - 2. Samples for Initial Selection: Manufacturer's color charts consisting of units or sections of units showing the full range of colors and patterns available for each type of product indicated.
  - 3. Samples for Verification: Four of each type, color and pattern of the following materials used in the Work, showing the full range of variations expected:
    - a. Floor Tile: 12 inches square.
    - b. Wall Base: 12 inches long.
    - c. Edge Strips: 12 inches long.
    - d. Adhesive: Pint container.
  - 4. Product Certificates: Signed by manufacturers of resilient products certifying that each product furnished complies with requirements.
  - 5. Maintenance Data: For each type of product specified.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ASTM: D2240, E648, E662, F710, F1066, F1344.
  - 3. FS: RR-T-650, SS-T-312, SS-W-40, UU-B-790.
- B. Installer Qualifications: Engage an experienced installer to perform work of this Section who has specialized in installing resilient products similar to those required for this Project and with a record of successful in-service performance.
- C. Source Limitations: Obtain each type, color, and pattern of product specified from one source with resources to provide products of consistent quality in appearance and physical properties without delaying the Work.
- D. Fire-Test-Response Characteristics: Provide products with the following fire-test-response characteristics as determined by testing identical products per test method indicated below by a testing and inspecting agency acceptable to authorities having jurisdiction.
  - 1. Critical Radiant Flux: 0.45 W/sq. cm or greater when tested per ASTM E648.
  - 2. Smoke Density: Maximum specific optical density of 450 or less when tested per ASTM E662.

##### 1.04 DELIVERY, STORAGE, AND HANDLING:

- A. Deliver products to Project site in manufacturer's original, unopened cartons and containers, clearly labeled with manufacturer's name and brand designation, referenced specification number, type and color, and shipping and handling instructions.
- B. Store products in dry spaces protected from the weather, with ambient temperatures maintained between 50 and 90 deg F.
- C. Store tiles on flat surfaces.
- D. Handle products to prevent breakage of containers and damage to products.
- E. Move products into spaces where they will be installed at least 48 hours before installation, unless longer conditioning period is recommended in writing by manufacturer.

**1.05 PROJECT CONDITIONS:**

- A. Maintain a temperature of not less than 70 deg F or more than 90 deg F in spaces to receive products for at least 48 hours before installation, during installation, and for at least 48 hours after installation, unless manufacturer's written recommendations specify longer time periods. After post-installation period, maintain a temperature of not less than 55 deg F or more than 95 deg F.
- B. Do not install products until they are at the same temperature as
- C. Do not install base until plaster or other backing material has thoroughly dried.
- D. Close spaces to traffic during flooring installation and for time period after installation recommended in writing by manufacturer.
- E. Install tiles and accessories after other finishing operations, including painting, have been completed. Where demountable partitions and other items are indicated for installation on top of resilient tile flooring, install tile before these items are installed.
- F. Do not install flooring over concrete slabs until slabs have cured and are sufficiently dry to bond with adhesive, as determined by flooring manufacturer's recommended bond and moisture test.

**1.06 EXTRA MATERIALS:**

- A. Furnish and store where directed extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.
  - 1. Furnish not less than one percent of the total quantity of each type, color, pattern, class, wearing surface, and size of resilient tile flooring installed, but not less than one full unopened container.
  - 2. Furnish not less than one percent of the total quantity of each type, color, and size of base material installed, but not less than one full unopened container.

**PART 2 - PRODUCTS**

**2.01 RESILIENT FLOORING:**

- A. Rubber Floor Covering: Products complying with ASTM F1344 and with requirements specified.
  - 1. Manufacturers: including but not limited to:

- a. R.C.A. Rubber Company.
    - b. Or equal.
  2. Color and Pattern: Terra Cotta.
  3. Class: I-A.
  4. Hardness: Durometer hardness not less than 85 Shore, Type A per ASTM D2240 as required according to ASTM F1344.
  5. Wearing Surface: Textured.
  6. Thickness: 3/16 inch.
  7. Fabrication: Fabricate heavy duty rubber mat with interlocking joints in five pieces to fit area shown, with edges square and true, without overlap.
- B. Vinyl Composition Floor Tile: Products complying with ASTM F1066 and with requirements specified:
1. Manufacturers: including but not limited to
    - a. Armstrong.
    - b. Azrock.
    - c. GAF.
    - d. Kentile.
    - e. Or equal.
  2. Color and Pattern: As selected by the Engineer from manufacturer's full range of colors and patterns produced for tile complying with requirements indicated.
  3. Class: Class 2 (through-pattern tile).
  4. Wearing Surface: Smooth unless otherwise indicated.
  5. Thickness: 1/8 inch.
  6. Size: 12 by 12 inches.

## 2.02 RESILIENT ACCESSORIES:

- A. Vinyl Wall Base: Products complying with FS SS-W-40, Type II and with requirements specified:
1. Color and Pattern: As selected by the Engineer from manufacturer's full range of colors and patterns produced for vinyl wall base complying with requirements indicated
  2. Style: Cove with top-set toe unless otherwise indicated.
  3. Minimum Thickness: 1/8 inch.
  4. Height: 4 inches.
  5. Lengths: Cut lengths longest practicable or coils in lengths standard with manufacturer, but not less than 96 feet.
  6. Outside Corners: Job formed.
  7. Inside Corners: Job formed.
  8. Surface: Smooth.
- B. Rubber Stair Treads: Products of style suitable for use indicated and complying with FS RR-T-650, Composition A and with requirements specified:
1. Manufacturers: including but not limited to:
    - a. R.C.A. Rubber Company.
    - b. Or equal.
  2. Color and Pattern: Terra Cotta.
  3. Design: Type 1 (smooth).
  4. Abrasive Strips: Provide abrasive strips as specified by the product designation indicated above in color selected by the Engineer from manufacturer's full range of colors.
  5. Nosing Style: Round.
  6. Nosing Height: 1/2 inch light color.
  7. Thickness: 5/16-inch tapering to 3/16-inch at back edge.

8. Size: Lengths and depths to fit each stair tread in one piece.
9. Fabrication: Fabricate nosing of stair tread to wrap around curved ends of step, to provide a uniform elevation appearance on three sides of step. Abrade at least 80 percent of the back of tread and nosing to assure adhesion to substrate. Fabricate nosing so that it will not delaminate or otherwise separate from the stair tread material.

### **2.03 INSTALLATION ACCESSORIES:**

- A. Tile Reducer Edge Strip: Products complying with FS SS-T-312, beveled, one-inch wide, 1/8-inch thick. Color to match vinyl wall base.
- B. Trowelable Leveling and Patching Compounds: Latex-modified, portland-cement-based formulation provided or approved by flooring manufacturer for applications indicated.
- C. Tile Adhesive: Waterproof asphalt cut-back cement recommended by manufacturer to suit resilient products and substrate conditions indicated.
- D. Stair Tread Adhesive: Permanent, as recommended by tread manufacturer for adhesion to galvanized steel substrate.
- E. Stair Tread Nose Filler: Two-part epoxy compound recommended by tread manufacturer to fill nosing substrates that do not conform to tread contours.
- F. Primer: As recommended by adhesive manufacturer.
- G. Base Cement: Water-resistant, type recommended by manufacturer of vinyl wall base.
- H. Building Paper: FS UU-B-790.

## **PART 3 - EXECUTION**

### **3.01 EXAMINATION:**

- A. Examine substrates, areas, and conditions where installation of resilient products will occur, with Installer present, for compliance with manufacturer's requirements. Verify that substrates and conditions are satisfactory for resilient product installation and comply with requirements specified
- B. Concrete Sub-floors: Verify that concrete slabs comply with ASTM F710 and the following:
  1. Slab substrates are dry and free of curing compounds, sealers, hardeners, and other materials that may interfere with adhesive bond. Determine adhesion and dryness characteristics by performing bond and moisture tests recommended by flooring manufacturer.
- C. Kiosk Equipment: Verify configuration of equipment in kiosk to ensure fit of flooring within 1/16-inch tolerance.

### **3.02 PREPARATION:**

- A. General: Comply with resilient product manufacturer's written installation instructions for preparing substrates indicated to receive resilient products.
- B. Use trowelable leveling and patching compounds, according to manufacturer's written instructions, to fill cracks, holes, and depressions in substrates.

- C. Remove coatings, including curing compounds, and other substances that are incompatible with flooring adhesives and that contain soap, wax, oil, or silicone, using mechanical methods recommended by manufacturer. Do not use solvents.
- D. Broom and vacuum clean substrates to be covered immediately before product installation. After cleaning, examine substrates for moisture, alkaline salts, carbonation, or dust. Do not proceed with installation until unsatisfactory conditions have been corrected.

### **3.03 RESILIENT FLOORING INSTALLATION:**

- A. General: Comply with flooring manufacturer's written installation instructions.
- B. Leveling Floor: Level floor by grinding high spots and filling low spots with leveling and patching compound following manufacturer's recommendations to ensure plane surface free of imperfections.
- C. Lay out tiles from center marks established with principal walls, discounting minor offsets, so tiles at opposite edges of room are of equal width. Adjust as necessary to avoid using cut widths that equal less than one-half of a tile at perimeter.
  - 1. Lay tiles square with room axis, unless otherwise indicated.
- D. Uniformity of Color: Use tiles alternately from at least two cartons so that pattern will be uniform and not spotty due to variation that may be found in different cartons. Match tiles for color and pattern by selecting tiles from cartons in the same sequence as manufactured and packaged, if so numbered. Cut tiles neatly around all fixtures. Discard broken, cracked, chipped, or deformed tiles.
- E. Application of Primer: Unless adhesive manufacturer recommends against priming, apply primer at rate and by method recommended.
- F. Application of Adhesive: Adhere tiles to flooring substrates using a full spread of adhesive applied to substrate to comply with tile manufacturer's written instructions, including those for trowel notching, adhesive mixing, and adhesive open and working times.
  - 1. Provide completed installation without open cracks, voids, raising and puckering at joints, telegraphing of adhesive spreader marks, and other surface imperfections.
- G. Laying of Tile:
  - 1. Scribe, cut, and fit tiles to butt neatly and tightly to vertical surfaces and permanent fixtures, including built-in furniture, cabinets, pipes, outlets, edgings, door frames, thresholds, and nosings.
  - 2. Extend tiles into toe spaces, door reveals, closets, and similar openings.
  - 3. Provide joints cut straight and true. Seal tile joints at pipes with waterproof cement.
  - 4. Embed tiles level, flush with surface and with tightly butted joints against adjoining tiles.
  - 5. Hand roll tiles according to tile manufacturer's written instructions.
- H. Maintain reference markers, holes, and openings that are in place or marked for future cutting by repeating on finish flooring as marked on subfloor. Use chalk or other nonpermanent, nonstaining marking device.

### **3.04 RESILIENT ACCESSORY INSTALLATION:**

- A. General: Install resilient accessories according to manufacturer's written installation instructions.

- B. Vinyl Wall Base: Apply resilient wall base to walls, columns, pilasters, casework and cabinets in toe spaces, and other permanent fixtures in rooms and areas where base is required. Extend wall base into closets and offsets adjoining areas to receive wall base.
  - 1. Install wall base in lengths as long as practicable without gaps at seams and with tops of adjacent pieces aligned.
  - 2. Tightly adhere wall base to substrate throughout length of each piece, with base in continuous contact with horizontal and vertical substrates.
  - 3. Do not stretch base during installation.
  - 4. On masonry surfaces or other similar irregular substrates, fill voids along top edge of resilient wall base with manufacturer's recommended adhesive filler material.
  - 5. Form outside corners on job from straight pieces of maximum lengths possible, without whitening at bends. Shave back of base at points where bends occur and remove strips perpendicular to length of base that are only deep enough to produce a snug fit without removing more than half the wall base thickness.
  - 6. Form inside corners on job, from straight pieces of maximum lengths possible, by cutting an inverted V-shaped notch in toe of wall base at the point where corner is formed. Shave back of base where necessary to produce a snug fit to substrate.
- C. Rubber Stair Tread: Adhere nosing so that it will not delaminate or otherwise separate from the stair tread material.
- D. Tile Reducer Edge Strip: Install edge strips at edges of flooring that would otherwise be exposed.
  - 1. Where tile stops at doorways without saddles or thresholds, set edge strips directly under doors.
- E. Place resilient accessories so they are butted to adjacent materials and bond to substrates with adhesive.

### **3.05 CLEANING AND PROTECTING:**

- A. Perform the following operations immediately after installing resilient products:
  - 1. Remove adhesive and other surface blemishes using cleaner recommended by resilient product manufacturers.
- B. After flooring is laid and adhesive thoroughly cured, clean and finish resilient floors as recommended by the resilient product manufacturer with approved compatible products.
- C. Keep traffic off finished floors during the remainder of construction period.
- D. Protect flooring against mars, marks, indentations, and other damage from construction operations and placement of equipment and fixtures during the remainder of construction period. Use protection methods indicated or recommended in writing by flooring manufacturer.
  - 1. Cover products installed on floor surfaces with reinforced kraft building paper and tape joints. Maintain such cover and otherwise protect floor until final acceptance.
  - 2. Do not move heavy and sharp objects directly over floor surfaces. Place plywood or hardboard panels over flooring and under objects while they are being moved. Slide or roll objects over panels without moving panels.

### **3.06 MAINTENANCE MATERIALS:**

- A. After completion of the work, furnish and store where directed at least one percent of the total quantity of tile and one percent of base material, but not less than one full unopened container of each, for future maintenance.

- B. Include proportional quantities of each type and color in original containers clearly marked to show contents and area of placement of each type and color.

**END OF SECTION**

## SECTION 09920

### FIELD PAINTING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies furnishing and applying paint at the site.
  - 1. Specific surfaces and areas which require field painting and required paint systems are listed in the schedule of painting.
  - 2. Unless an item is shown not to be field painted or specified otherwise paint it in accordance with these specifications.
- B. Definitions:
  - 1. Paint: Includes primers and undercoaters, sealers, stains, paint, varnish, enamel, epoxy and special coatings.
- C. Items Not Included In Field Painting:
  - 1. Stainless steel, ornamental metals, glass, resilient tile, ceramic tile, paving, acoustical tile, plastic laminate and similar items which are prefinished.
  - 2. Mill-, factory- and shop-applied primers and finishes.
  - 3. Corrosion-resistant structural steel, ASTM A242.
  - 4. High-strength structural corrosion-resistant steel shapes, plates and bars, ASTM A588.
  - 5. Galvanized-metal surfaces except fire stand pipes, unless exposed to public view.
  - 6. UL labels on fire-rated doors and frames.
  - 7. Precast or prestressed concrete with a sandblast finish, concrete sealer, or other special finish unless noted otherwise
- D. Related Work Specified Elsewhere:
  - 1. Mill-, factory- and shop-applied prime and finish coats: Specified with the product.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Samples:
    - a. Three each of each color and texture, with identification of materials keyed to those specified and application methods.
    - b. Samples of paint scheduled for application to smooth finishes applied to 12-inch square hardboard or metal panels.
    - c. Samples of paint scheduled for application to concrete masonry units applied to 16-inch square by two-inch thick panel of concrete masonry units, including one tooled masonry joint. Subdivide panel to define prime or filler, intermediate and finish coats.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. FS: TT-E-489, TT-E-490, TT-E-509, TT-F-336, TT-F-1098, TT-P-19, TT-P-29, TT-P-636, TT-P-641, TT-P-645, TT-P-650, TT-P-664, TT-P-1510, TT-P-001984, TT-S-71, TT-S-300, TT-V-86, TT-V-119.
  - 3. ASME: A13.1.
  - 4. ANSI: Z535.1.

5. ASTM: A242, A588, B117, C476, C920.

#### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Deliver products to the jobsite in their original unopened containers clearly labeled with the manufacturer's name and brand designation, referenced specification number and type, as applicable.
- B. Store products in an approved ventilated dry area, protect from contact with soil and from exposure to the elements. Always keep products dry. Do not allow paint to freeze.
- C. Handle products in a manner that will prevent breakage of containers and damage to products.

#### **1.05 JOB CONDITIONS:**

- A. Environmental Requirements:
  1. Do not apply paint to non-protected surfaces in wet weather or to surfaces on which ice, frost, water or dampness is visible.
  2. Do not apply exterior paint when the temperature is below 40F or expected to fall below this temperature. Do not apply interior paint when the temperature is lower than 60F or expected to fall below this temperature.
  3. Avoid painting steel which is at a temperature which can cause blistering, porosity, or otherwise be detrimental to the life of the paint. When paint is applied in hot weather or thinned in cold weather ensure that the specified thickness of paint coating is obtained.
  4. Do not apply paint in rain, wind, snow, fog or mist or when the steel surface temperature is below the dew point, resulting in condensation of moisture.
  5. Do not apply interior paint when, in the Engineer's opinion, satisfactory results cannot be obtained due to high humidity and excessive temperature; however, failure of the Engineer to notify the Contractor of the conditions will not relieve the Contractor of responsibility to produce satisfactory results.

### **PART 2 - PRODUCTS**

#### **2.01 GENERAL:**

- A. To the maximum extent practicable, use the materials of one manufacturer throughout the project. No claims as to the suitability of a material specified, or of inability to produce first-class work with these materials, will be considered unless such claims are made in writing and submitted with the Contractor's Bid Proposal.
- B. Provide a primer suitable for each substrate type and which is manufactured or recommended by the paint manufacturer as part of a complete painting system.
- C. Previously Primed Surfaces:
  1. If surfaces have been primed off-site at the mill, factory or shop, omit specified primer, but only if the off-site primer is acceptable to the paint system manufacturer for best performance of the specified paint system.
  2. For touch-up of off-site primer, use primer of the same composition as the mill, factory or shop primer.
- D. VOC Requirements: Provide products in compliance with local volatile organic compound regulations. If the listed product of a manufacturer does not comply, provide an accepted equivalent product which does comply.

- E. Colors:
1. Prior to beginning work, the Contractor will be furnished sample color chips and a Color and Material Schedule for surfaces to be painted.
  2. Match the colors of the chips and submit samples before proceeding. Label samples for surface finishes such as satin, flat or gloss as listed in the Color and Material Schedule.
  3. Tint each coat of paint slightly lighter or darker than the preceding coat or the finish coat.
  4. Final approval of colors will be made by the Engineer on samples applied on the job.
  5. Safety Colors: Items specified to be safety colors, e.g. OSHA red (safety red) and ANSI orange, to be in compliance with ANSI Z535.1, Safety Color Code.
- F. Listed materials are a guide to quality intended. Substitute materials and paint systems acceptable to the Engineer, as an equal or of superior quality for each intended use, may be used in the work at no additional cost to the Authority.
- G. Accessory Materials:
1. General: Provide miscellaneous materials and accessories, whether listed or not, as necessary to complete the work in an approved manner.
  2. Caulk: Single-component, chemically curing, synthetic rubber, non-sag, ASTM C920, Type S, NS, Class 25.
  3. Spackling compound: Ready-mixed type, U.S. Gypsum Ready-Mixed Joint Compound - Topping, ASTM C476 or equal.
  4. Thinner: As recommended by the paint manufacturer.

## 2.02 EXTERIOR PAINTING SYSTEMS:

- A. Exterior Paint Schedule: Provide the paint systems scheduled below for the various substrates, as indicated. Provide a complete paint system by one manufacturer for each substrate. Unless otherwise indicated, provide the following:
1. Concrete and masonry (except concrete masonry units): Acrylic, flat.
  2. Concrete masonry units: Acrylic, flat.
  3. Portland cement plaster (soffits): Acrylic, flat.
  4. Ferrous metal: Silicone-alkyd, semigloss.
  5. Zinc-coated metal: Silicone-alkyd, semigloss.
  6. Aluminum: Alkyd, semigloss.
  7. Wood: Acrylic-enamel, semigloss.
  8. Mechanical and electrical items (not finish painted): See substrate materials above.
- B. Concrete, Masonry (except concrete masonry units), and portland cement plaster - Acrylic, Flat: Two coats with total dry film thickness not less than 2.5 mils.
1. Undercoat: Quick-drying, flat, acrylic paint for use on the exterior over concrete, masonry, and portland cement plaster (FS TT-P-19):
    - a. Con-Lux: Mason-Plex 800 Series.
    - b. Devoe: 15XX Wonder-Shield Exterior Acrylic Latex Flat House Paint.
    - c. Moore: Moore's Flat Exterior Latex Masonry & House Paint #105.
  2. S-W:A-100 Acrylic Latex Flat Exterior Finish, A-6 Series. Finish Coat: Quick-drying, flat, acrylic paint for use on the exterior over concrete, masonry, and portland cement plaster (FS TT-P-19)
    - a. Con-Lux: Mason-Plex 800 Series.
    - b. Devoe: 15XX Wonder-Shield Exterior Acrylic Latex Flat House Paint.
    - c. Moore: Moore's Flat Exterior Latex Masonry & House Paint #105.

- d. S-W: A-100 Acrylic Latex Flat Exterior Finish, A-6 Series.
- C. Concrete Masonry Units - Acrylic, Flat: Two coats over block filler with total dry film thickness not less than 2.5 mils, excluding the block filler.
1. Block Filler: High performance latex block filler used for filling open textured concrete masonry block before application of top coats:
    - a. Con-Lux: Block-Plex 85 White.
    - b. Devoe: 52901 Bloxfil Acrylic Latex Block Filler.
    - c. Moore: Moorcraft Block Filler #145.
    - d. S-W: Heavy-Duty Block Filler B42W46.
  2. Undercoat: Quick-drying, flat, acrylic paint for use on the exterior over concrete masonry block (FS TT-P-19):
    - a. Con-Lux: Mason-Plex 800 Series.
    - b. Devoe: 15XX Wonder-Shield Exterior Acrylic Latex Flat House Paint.
    - c. Moore: Moore's Flat Exterior Latex Masonry & House Paint #105.
    - d. S-W: A-100 Acrylic Latex Flat Exterior Finish, A-6 Series.
  3. Finish Coat: Quick-drying, flat, acrylic paint for use on the exterior over concrete masonry block (FS TT-P-19):
    - a. Con-Lux: Mason-Plex 800 Series.
    - b. Devoe: 15XX Wonder-Shield Exterior Acrylic Latex Flat House Paint.
    - c. Moore: Moore's Flat Exterior Latex Masonry & House Paint #105.
    - d. S-W: A-100 Acrylic Latex Flat Exterior Finish, A-6 Series
- D. Ferrous Metal - Silicone-Alkyd, Semigloss: Two coats over primer.(Apply a second coat of primer on steel which is at grade, at slab, or passing through floor slabs. Apply to a uniform line six inches above top of grade or slab.)
1. Primer: Lead and chromate-free high solids primer which chemically inhibits rusting and is recommended by the manufacturer for application to steel which has been prepared in accordance with SSPC SP2. Rated 10 (less than 0.01% surface rusting) when tested in accordance with ASTM B117 for 500 hours. Exceeds performance requirements of FS TT-P-636:
    - a. Con-Lux: Rust Arrestor 50.
    - b. S-W: Kem Kromik Universal Metal Primer B50NZ6.
    - c. Tnemec: Series P10.
  2. Undercoat: Alkyd enamel recommended by manufacturer of finish coat as an intermediate coat over specified primer for application of silicone-alkyd finish coat:
    - a. Con-Lux: Ferrox Primer.
    - b. S-W: Silicone Alkyd Enamel B-56 Series.
    - c. Tnemec: Series 23 Enduratone.
  3. Finish Coat: Silicone-alkyd enamel with a minimum of 30% silicone content meeting the qualitative requirements of FS TT-E-490:
    - a. Con-Lux: Steel-Master 9500 Series.
    - b. S-W: Silicone Alkyd Enamel B-56 Series.
    - c. Tnemec: Series 82 Silicone-Alkyd Enamel.
- E. Ferrous Metal - Alkyd, Semigloss: Two coats over primer (primer is not required on shop-primed items):
1. Primer: Quick-drying, rust-inhibiting primer for priming ferrous metal under alkyd enamel (FS TT-P-664):
    - a. Con-Lux: Ferrox Primer, 25 Red.
    - b. Devoe: 41820 Bar-Ox Alkyd Shop/Field Primer.
    - c. Moore: Ironclad Retardo Rust-Inhibitive Paint #163.
    - d. S-W: Kem Kromik Metal Primer B50N2/B50W1.

2. Undercoat: Weather-resistant, air-drying, semigloss alkyd enamel for use on the exterior over prime-coated ferrous metal (FS TT-E-489, Class A):
    - a. Con-Lux: Enamelite Semi-Luster Series
    - b. Devoe: 70XX Mirrolac Interior/Exterior Alkyd Enamel.
    - c. Moore: Impervo Enamel #133.
    - d. S-W: Industrial Enamel, B-54Z Series.
  3. Finish Coat: Weather-resistant, air-drying, semigloss alkyd enamel for use on the exterior over prime-coated ferrous metal (FS TT-E-489, Class A):
    - a. Con-Lux: Enamelite Semi-Luster Series.
    - b. Devoe: 70XX Mirrolac Interior/Exterior Alkyd Enamel.
    - c. Moore: Impervo Enamel #133.
    - d. S-W: Industrial Enamel, B-54Z Series.
- F. Zinc-Coated Metal - Silicone-Alkyd, Semigloss: Two coats over factory-applied primer:
1. Primer: Galvanized metal primer used to prime zinc-coated (galvanized) metal surfaces (FS TT-P-641), or one of the following.
    - a. Con-Lux: Bond-Plex 46 Barrier Green.
    - b. Devoe: 13201 Mirrolac Galvanized Metal Primer.
    - c. Moore: Ironclad Galvanized Metal Latex Primer #155.
    - d. S-W: Industrial Water Based Acrylic Paint B42W110.
  2. Undercoat: Alkyd enamel recommended by manufacturer of finish coat as an intermediate coat over factory-applied primer for application of silicone-alkyd finish coat:
    - a. Con-Lux: FerroX Primer.
    - b. S-W: Silicone Alkyd Enamel B-56 Series.
    - c. Tnemec: Series 23 Enduratone.
  3. Finish Coat: Silicone-alkyd enamel with a minimum of 30% silicone content meeting the qualitative requirements of FS TT-E-490:
    - a. Con-Lux: Steel-Master 9500 Series.
    - b. S-W: Silicone Alkyd Enamel B-56 Series.
    - c. Tnemec: Series 82 Silicone-Alkyd Enamel.
- G. Zinc-Coated Metal - Alkyd, Semigloss: Two coats over primer:
1. Primer: Galvanized metal primer used to prime zinc-coated (galvanized) metal surfaces (FS TT-P-641), or one of the following:
    - a. Con-Lux: Bond-Plex 46 Barrier Green.
    - b. Devoe: 13201 Mirrolac Galvanized Metal Primer.
    - c. Moore: Ironclad Galvanized Metal Latex Primer #155.
    - d. S-W: Industrial Water Based Acrylic Paint B42W110.
  2. Undercoat: Weather-resistant, air-drying, semigloss alkyd enamel for use on the exterior over prime-coated zinc-coated (galvanized) metal (FS TT-E-489, Class A):
    - a. Con-Lux: Enamelite Semi-Luster Series.
    - b. Devoe: 70XX Mirrolac Interior/Exterior Alkyd Enamel.
    - c. Moore: Impervo Enamel #133.
    - d. S-W: Industrial Enamel, B-54Z Series.
  3. Finish Coat: Weather-resistant, air-drying, semigloss alkyd enamel for use on the exterior over prime-coated zinc-coated (galvanized) metal (FS TT-E-489, Class A):
    - a. Con-Lux: Enamelite Semi-Luster Series.
    - b. Devoe: 70XX Mirrolac Interior/Exterior Alkyd Enamel.
    - c. Moore: Impervo Enamel #133.
    - d. S-W: Industrial Enamel, B-54Z Series.
- H. Aluminum - Alkyd, Semigloss: Two coats over primer:
1. Primer: Alkyd-type zinc chromate primer used for priming aluminum under alkyd enamels (FS TT-P-645), or one of the following.
    - a. Con-Lux: Bond-Plex 46 Barrier Green.

- b. Devoe: 41839 Bar-Ox Zinc Chromate Primer.
    - c. Moore: Ironclad Retardo Rust Inhibitive Paint #163.
    - d. S-W: Zinc Chromate Primer B50Y1.
  - 2. Undercoat: Weather-resistant, air-drying, semigloss alkyd enamel for use on the exterior over prime-coated aluminum (FS TT-E-489, Class A):
    - a. Con-Lux: Enamelite Semi-Luster Series.
    - b. Devoe: 70XX Mirrolac Interior/Exterior Alkyd Enamel.
    - c. Moore: Impervo Enamel #133.
    - d. S-W: Industrial Enamel, B-54Z Series.
  - 3. Finish Coat: Weather-resistant, air-drying, semigloss alkyd enamel for use on the exterior over prime-coated aluminum (FS TT-E-489, Class A):
    - a. Con-Lux: Enamelite Semi-Luster Series
    - b. Devoe: 70XX Mirrolac Interior/Exterior Alkyd Enamel.
    - c. Moore: Impervo Enamel #133.
    - d. S-W: Industrial Enamel, B-54Z Series.
- I. Wood - Acrylic Enamel, Semigloss: Two coats over primer with total dry film thickness not less than 2.5 mils:
  - 1. Primer: Exterior alkyd or latex primer made for use on wood under an acrylic enamel (FS TT-P-001984):
    - a. Con-Lux: Wood-Plex 700 Primer.
    - b. Devoe: 1102 All-Weather Exterior Alkyd House Paint Primer.
    - c. Moore: Moorwhite Primer #100.
    - d. S-W: A-100 Exterior Latex Wood Primer
  - 2. Undercoat: Semigloss, waterborne, exterior, acrylic enamel made for use as an undercoat over a primer on wood under an acrylic enamel (FS TT-P-1510):
    - a. Con-Lux: Weather-Plex 700 Series
    - b. Devoe: 17XX Wonder-Shield Semi-Gloss Exterior Acrylic latex House and Trim Paint.
    - c. Moore: MoorGlo Latex House and Trim Paint #096.
    - d. S-W: A-100 Exterior Latex Satin.
  - 3. Finish Coat: Semigloss, waterborne, exterior, acrylic enamel made for use as a finish coat over an acrylic enamel (FS TT-P-1510):
    - a. Con-Lux: Weather-Plex 700 Series.
    - b. Devoe: 17XX Wonder-Shield Semi-Gloss Exterior Acrylic latex House and Trim Paint.
    - c. Moore: MoorGlo Latex House and Trim Paint #096.
    - d. S-W: A-100 Exterior Latex Satin.
- J. Wood - Stained-Varnish: Two coats over sealer over stain plus filler on open-grain wood. Wipe filler before applying first varnish coat.
  - 1. Stain Coat: Match interior stained-varnish finish.
  - 2. Sealer: Phenolic varnish for use on exterior natural-finished woodwork (FS TT-V-119), thinned as recommended by manufacturer:
    - a. Con-Lux: Imperial 71 Spar Varnish.
    - b. Devoe: 87 Spar Varnish.
    - c. Moore: Impervo 440 Spar Varnish.
    - d. S-W: Exterior Varnish A67V4
  - 3. Undercoat: Phenolic varnish for use on exterior natural-finished woodwork (FS TT-V-119):
    - a. Con-Lux: Imperial 71 Spar Varnish.
    - b. Devoe: 87 Spar Varnish.
    - c. Moore: Impervo 440 Spar Varnish.
    - d. S-W: Exterior Varnish A67V4.
  - 4. Finish Coat: Phenolic varnish for use on exterior natural-finished woodwork (FS TT-V-119):

- a. Con-Lux: Imperial 71 Spar Varnish.
- b. Devoe: 87 Spar Varnish.
- c. Moore: Impervo 440 Spar Varnish.
- d. S-W: Exterior Varnish A67V4.

### 2.03 INTERIOR PAINTING SYSTEMS:

- A. Interior Paint Schedule: Provide the paint systems scheduled below for the various substrates, as indicated. Provide a complete paint system by one manufacturer for each substrate. Unless otherwise indicated, provide the following:
1. Concrete and masonry (except concrete masonry units and concrete floors): Latex, flat.
  2. Concrete masonry units (except ground-faced CMU, which is to be left unpainted): Latex, flat.
  3. Concrete floors: Epoxy, gloss, with anti-slip aggregate.
  4. Gypsum plaster, veneer plaster, and GFRG: Latex, eggshell.
  5. Acoustical plaster: Unpainted.
  6. Gypsum board: Latex, flat.
  7. Woodwork: Stained-varnish finish, except alkyd, semigloss where painted is indicated.
  8. Ferrous metal:
    - a. Exposed steel structure: Silicone-alkyd, semigloss.
    - b. Other interior ferrous metal: Alkyd, semigloss.
  9. Zinc-coated metal: Alkyd, semigloss; except silicone-alkyd where part of ferrous metal assemblies painted with silicone-alkyd.
  10. Non-ferrous metal: Alkyd, semigloss.
  11. Cotton and canvass covering over insulation: Latex, flat.
  12. Mechanical and electrical items (not finish painted): See substrate materials above.
- B. Concrete and Masonry (Except concrete masonry units) - Latex, Flat: Two coats.
1. Undercoat: Flat latex-based paint made for use as an undercoat over concrete and masonry under a flat latex paint (FS TT-P-29):
    - a. Con-Lux: Jet-Plex 495 Primer.
    - b. Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
    - c. Moore: Moore's Latex Quick-Dry Prime Seal 201.
    - d. S-W: Pro-Mar 200 Latex Flat B30W200.
  2. Finish Coat: Flat latex-based paint made for use as a flat finish over concrete and masonry (FS TT-P-29):
    - a. Con-Lux: Wall-Plex 400 Series.
    - b. Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
    - c. Moore: Regal Wall Satin 215.
    - d. S-W: Pro-Mar 200 Latex Flat Wall Paint B30W200 Series.
- C. Concrete and Masonry (Except concrete masonry units) - Alkyd, Semigloss: Two coats over primer with total dry film thickness not less than 3.5 mils.
1. Primer: Flat latex-based paint made for use as a primer over concrete and masonry under an odorless alkyd enamel (FS TT-P-29):
    - a. Con-Lux: Wall-Plex 400 Series.
    - b. Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
    - c. Moore: Moore's Latex Quick-Dry Prime Seal 201.
    - d. S-W: Pro-Mar 200 Latex Flat B30W200.
  2. Undercoat: Enamel undercoat made for use on the interior as an undercoat over a primer on concrete or masonry under an odorless alkyd enamel:
    - a. Con-Lux: Enamel Underbase 54 White.
    - b. Devoe: 26XX Velour Alkyd Semigloss Enamel.

- c. Moore: Moore's Alkyd Enamel Underbody 217.
    - d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.
  - 3. Finish Coat: Semigloss odorless alkyd enamel made for use over a primer and undercoat on concrete and masonry (FS TT-E-509):
    - a. Con-Lux: Satin-Lite 900 Series
    - b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
    - c. Moore: Moore's Satin Impervo Enamel 235.
    - d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.
  
- D. Concrete and Masonry (Except concrete masonry units) - Epoxy, Semi-Gloss: Two coats over primed surface.
  - 1. Primer: Sealer made for use as a primer over masonry wall surfaces and under an epoxy enamel:
    - a. Con-Lux: Jet-Plex 495 Primer.
    - b. Duron: Acrylic Enamel Undercoater.
    - c. Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
    - d. S-W: Kem Cati-Coat Epoxy Filler/Sealer.
  - 2. Undercoat: Epoxy enamel undercoat made for use under a semi-gloss epoxy enamel:
    - a. Con-Lux: Epolon Semi-Luster Series.
    - b. Duron: Polyamide Epoxy.
    - c. Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
    - d. S-W: Heavy Duty Epoxy.
  - 3. Finish Coat: Semi-gloss epoxy enamel finish coat made for use over an epoxy enamel undercoat:
    - a. Con-Lux: Epolon Semi-Luster Series.
    - b. Duron: Polyamide Epoxy.
    - c. Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
    - d. S-W: Heavy Duty Epoxy.
  
- E. Concrete Masonry Units (Except ground-faced CMU, which is to be left unpainted) - Latex, Flat: Two coats over filled surface.
  - 1. Block Filler: High-performance latex block filler made for use for filling open textured concrete masonry block before application of top coats (FS TT-F-1098):
    - a. Con-Lux: Block-Plex 85 White.
    - b. Devoe: 52901 Bloxfil Acrylic Latex Block Filler.
    - c. Moore: Moorcraft Interior and Exterior Block Filler 173.
    - d. S-W: Heavy-Duty Block Filler B42W46.
  - 2. Undercoat: Flat latex-based paint made for use as an undercoat over filled concrete masonry block under a flat latex paint (FS TT-P-29):
    - a. Con-Lux: Wall-Plex 400 Series.
    - b. Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
    - c. Moore: Moore's Latex Quick-Dry Prime Seal 201.
    - d. S-W: Pro-Mar 200 Latex Flat B30W200.
  - 3. Finish Coat: Flat latex-based Paint made for use as a flat finish over filled concrete masonry block (FS TT-P-29):
    - a. Con-Lux: Wall-Plex 400 Series.
    - b. Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
    - c. Moore: Regal Wall Satin 215.
    - d. S-W: Pro-Mar 200 Latex Flat Wall Paint B30W200 Series.
  
- F. Concrete Masonry Units (Except ground-faced CMU, which is to have clear anti-graffiti coating over unfilled surface) - Alkyd, Semigloss: Two coats over filled surface with total dry film thickness not less than 3.5 mils, excluding filler coat
  - 1. Block Filler: High-performance latex block filler made for use for filling open textured concrete masonry block before application of top coats (FS TT-F-1098):

- a. Con-Lux: Block-Plex 85 White.
  - b. Devoe: 52901 Bloxfil Acrylic Latex Block Filler.
  - c. Moore: Moorcraft Interior and Exterior Block Filler 173.
  - d. S-W: Heavy-Duty Block Filler B42W46.
2. Undercoat: Enamel undercoat made for use on the interior as an undercoat over a block filler on concrete masonry block under an odorless alkyd enamel:
- a. Con-Lux: Enamel Underbase 54 White.
  - b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
  - c. Moore: Moore's Alkyd Enamel Underbody 217.
  - d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.
3. Finish Coat: Semigloss odorless alkyd enamel made for use over a block filler and undercoat on concrete masonry block (FS TT-E-509):
- a. Con-Lux: Satin-Lite 900 Series.
  - b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
  - c. Moore: Moore's Satin Impervo Enamel 235.
  - d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.
- G. Concrete Masonry Units (Except ground-faced CMU, which is to have clear anti-graffiti coating over unfilled surface) - Epoxy, Semi-Gloss: Two coats over filled surface.
1. Filler: Filler made for use as a primer over masonry wall surfaces and under an epoxy enamel:
- a. Con-Lux: Jet-Plex 495 Primer; or Block-Plex Block Filler.
  - b. Duron: Acrylic Enamel Undercoater; or Block Kote Latex Block Filler.
  - c. Moore: IronClad Chemical and Water Resistant Epoxy Enamel; or Moorcraft Interior and Exterior Block Filler.
  - d. S-W: Kem Cati-Coat Epoxy Filler/Sealer; or Heavy Duty Block Filler.
2. Undercoat: Epoxy enamel undercoat made for use under a semi-gloss epoxy enamel:
- a. Con-Lux: Epolon Semi-Luster Series.
  - b. Duron: Polyamide Epoxy.
  - c. Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
  - d. S-W: Heavy Duty Epoxy.
3. Finish Coat: Semi-gloss epoxy enamel finish coat made for use over an epoxy enamel undercoat:
- a. Con-Lux: Epolon Semi-Luster Series.
  - b. Duron: Polyamide Epoxy
  - c. Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
  - d. S-W: Heavy Duty Epoxy.
- H. Concrete Floor Surfaces - Epoxy, Gloss: Two coats over primer, with anti-slip aggregate in finish coat:
1. Primer: Epoxy sealer made for use as a primer over concrete floor surfaces and under an epoxy enamel:
- a. Con-Lux: None required.
  - b. Duron: Acrylic Enamel Undercoater
  - c. Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
  - d. S-W: ArmorSeal 3300LV Epoxy Primer/Sealer.
2. Undercoat: Epoxy enamel undercoat made for use over an epoxy primer and under a gloss epoxy enamel:
- a. Con-Lux: Epolon Series with Epolon 145 Reducer.
  - b. Duron: Polyamide Epoxy.
  - c. Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
  - d. S-W: ArmorSeal 1000HS.

3. Finish Coat: Epoxy enamel finish coat made for use over an epoxy enamel undercoat:
    - a. Con-Lux: Epolon Series with anti-slip aggregate.
    - b. Duron: Polyamide Epoxy with anti-slip aggregate.
    - c. Moore: IronClad Chemical and Water Resistant Epoxy Enamel with anti-slip aggregate.
    - d. S-W: ArmorSeal 1000HS with anti-slip aggregate.
- I. Gypsum Plaster, Veneer Plaster, and GFRG - Latex, Eggshell (Low-Gloss): Two coats over primer; plus sealer for GFRG.
1. Sealer for GFRG: Same as primer coat, to expose hot spots and facilitate sanding to remove "fiber bloom".
  2. Primer: Flat latex-based paint made for use as a primer on plaster under an eggshell latex paint (FS TT-P-29):
    - a. Con-Lux: Jet-Plex 495 Primer.
    - b. Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
    - c. Moore: Moore's Latex Quick-Dry Prime Seal 201.
    - d. S-W: Wall and Wood Primer B99WZ2.
  3. Undercoat: Eggshell latex paint made for use over a primer on plaster (Performance requirements of FS TT-P-29):
    - a. Con-Lux: Luster-Plex 2000 Series.
    - b. Devoe: 34XX Wonder-Tones Interior Latex Eggshell Enamel.
    - c. Moore: Regal AquaVelvet 319.
    - d. S-W: Pro-Mar 200 Latex Eggshell Enamel B20W200 Series.
  4. Finish Coat: Eggshell latex paint made for use over a primer and undercoat on plaster (Performance requirements of FS TT-P-29):
    - a. Con-Lux: Luster-Plex 2000 Series.
    - b. Devoe: 34XX Wonder-Tones Interior Latex Eggshell Enamel.
    - c. Moore: Regal AquaVelvet 319.
    - d. S-W: Pro-Mar 200 Latex Eggshell Enamel B20W200 Series.
- J. Gypsum Plaster, Veneer Plaster, and GFRG - Alkyd, Semigloss: Two coats over primer with total dry film thickness not less than 2.5 mils; plus sealer for GFRG.
1. Sealer for GFRG: Same as primer coat, to expose hot spots and facilitate sanding to remove "fiber bloom".
  2. Primer: Flat latex-based paint made for use as a primer on plaster under an odorless alkyd enamel (FS TT-P-29):
    - a. Con-Lux: Jet-Plex 495 Primer.
    - b. Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
    - c. Moore: Moore's Latex Quick-Dry Prime Seal 201.
    - d. S-W: Wall and Wood Primer B99WZ2.
  3. Undercoat: Enamel undercoat made for use as an undercoat over a primer on plaster under an odorless alkyd enamel:
    - a. Con-Lux: Enamel Underbase 54 White.
    - b. Devoe: 26XX Velour Alkyd Semigloss Enamel
    - c. Moore: Moore's Alkyd Enamel Underbody 217.
    - d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series
  4. Finish Coat: Semigloss odorless alkyd enamel made for use over a primer and undercoat on plaster (FS TT-E-509):
    - a. Con-Lux: Satin-Lite 900 Series.
    - b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
    - c. Moore: Moore's Satin Impervo Enamel 235.
    - d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.
- K. Gypsum Board - Latex, Flat: 1 coat over primer.

1. Primer: Latex-based white primer made for use on interior gypsum board under a flat latex paint (FS TT-P-650):
    - a. Con-Lux: Jet-Plex 495 Primer.
    - b. Devoe: 50801 Wonder-Tones Latex Primer and Sealer.
    - c. Moore: Moore's Latex Quick-Dry Prime Seal 201.
    - d. S-W: Pro-Mar 200 Latex Wall Primer B28W200.
  2. Finish Coat: Flat latex-based paint made for use as a flat finish over prime-coated gypsum board (FS TT-P-29):
    - a. Con-Lux: Wall-Plex 400 Series.
    - b. Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
    - c. Moore: Regal Wall Satin 215.
    - d. S-W: Pro-Mar 200 Latex Flat Wall Paint B30W200 Series.
- L. Gypsum Board - Alkyd, Semigloss: Two coats over primer with total dry film thickness not less than 2.5 mils.
1. Primer: Latex-based white primer made for use on interior gypsum board under an odorless alkyd enamel (FS TT-P-650):
    - a. Con-Lux: Jet-Plex 495 Primer.
    - b. Devoe: 50801 Wonder-Tones Latex Primer and Sealer.
    - c. Moore: Moore's Latex Quick-Dry Prime Seal 201.
    - d. S-W: Pro-Mar 200 Latex Wall Primer B28W200.
  2. Undercoat: Enamel undercoat made for use on the interior as an undercoat over a primer on interior gypsum board under an odorless alkyd enamel:
    - a. Con-Lux: Enamel Underbase 54 White.
    - b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
    - c. Moore: Moore's Alkyd Enamel Underbody 217.
    - d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.
  3. Finish Coat: Semigloss odorless alkyd enamel made for use over a primer and undercoat on interior gypsum board (FS TT-E-509):
    - a. Con-Lux: Satin-Lite 900 Series.
    - b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
    - c. Moore: Moore's Satin Impervo Enamel 235.
    - d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.
- M. Woodwork, Stained-Varnish: Two coats over sealer over stain plus filler on open-grain wood. Wipe filler before applying first varnish coat.
1. Stain Coat: Slow-penetrating oil-type wood stain made for general use on interior wood surfaces under a varnish finish (FS TT-S-71):
    - a. Devoe: 96XX Wonder Woodstain Alkyd Stain.
    - b. Moore: Moore's Interior Wood Finishes Penetrating Stain 241.
    - c. S-W: Oil Stain A-48 Series.
  2. Sealer: Quick-drying, rosin-free, clear, general-purpose shellac varnish made for use on the interior over stained-finished woodwork under a varnish finish (FS TT-S-300, Grade A):
    - a. Devoe: 4900 Wonder Woodsealer Quick-Dry Sealer.
    - b. Moore: Moore's Interior Wood Finishes, Quick-Dry Sanding Sealer 413.
    - c. S-W: Pro-Mar Varnish Sanding Sealer B26V3.
  3. Filler: Solvent-based, air-drying, paste-type wood filler made for use on open-grain wood on interior wood surfaces (FS TT-F-336):
    - a. Devoe: 4800 Wonder Woodstain Interior Paste Wood Filler.
    - b. Moore: Benwood Paste Wood Filler.
    - c. S-W: Sher-Wood Fast-Dry Filler.
  4. Undercoat: Clear varnish made for use on interior stained-finished woodwork (FS TT-V-86):
    - a. Devoe: 4600 Wonder Wood Satin Alkyd Satin Varnish.

- b. Moore: Benwood Satin Finish Varnish 404.
    - c. S-W: Oil Base Varnish, A66V91/A66F90.
  - 5. Finish Coat: Clear varnish made for use on interior stained-finished woodwork (FS TT-V-86):
    - a. Devoe: 4600 Wonder Wood Satin Alkyd Satin Varnish.
    - b. Moore: Benwood Satin Finish Varnish 404.
    - c. S-W: Oil Base Varnish, A66V91/A66F90.
  
- N. Woodwork, Painted - Alkyd, Semigloss: Two coats over primer.
  - 1. Primer: Enamel undercoat made for use as a primer over wood under an odorless alkyd enamel:
    - a. Con-Lux: Enamel Underbase 54 White.
    - b. Devoe: 50501 Interior Alkyd Primer and Vapor Barrier
    - c. Moore: Moore's Alkyd Enamel Underbody 217.
    - d. S-W: Wall and Wood Primer B49WZ2.
  - 2. Undercoat: Semigloss odorless alkyd enamel made for use over a primer on wood (FS TT-E-509):
    - a. Con-Lux: Satin-Lite 900 Series.
    - b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
    - c. Moore: Moore's Satin Impervo Enamel 235.
    - d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.
  - 3. Finish Coat: Semigloss odorless alkyd enamel made for use over a primer and undercoat on wood (FS TT-E-509):
    - a. Con-Lux: Satin-Lite 900 Series.
    - b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
    - c. Moore: Moore's Satin Impervo Enamel 235.
    - d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.
  
- O. Ferrous Metal - Silicone-Alkyd, Semigloss: Two coats over primer:
  - 1. Primer: Lead and chromate-free high solids primer which chemically inhibits rusting and is recommended by the manufacturer for application to steel which has been prepared in accordance with SSPC SP2. Rated 10 (less than 0.01% surface rusting) when tested in accordance with ASTM B117 for 500 hours. Exceeds performance requirements of FS TT-P-636:
    - a. Con-Lux: Rust Arrestor 50.
    - b. S-W: Kem Kromik Universal Metal Primer B50NZ6.
    - c. Tnemec: Series P10.
  - 2. Undercoat: Alkyd enamel recommended by manufacturer of finish coat as an intermediate coat over specified primer for application of silicone-alkyd finish coat:
    - a. Con-Lux: FerroX Primer.
    - b. S-W: Silicone Alkyd Enamel B-56 Series.
    - c. Tnemec: Series 23 Enduratone.
  - 3. Finish Coat: Silicone-alkyd enamel with a minimum of 30% silicone content meeting the qualitative requirements of FS TT-E-490:
    - a. Con-Lux: Steel-Master 9500 Series.
    - b. S-W: Silicone Alkyd Enamel B-56 Series.
    - c. Tnemec: Series 82 Silicone-Alkyd Enamel.
  
- P. Ferrous Metal - Alkyd, Semigloss: Two coats over primer with total dry film thickness not less than 2.5 mils.
  - 1. Primer: Quick-drying, rust-inhibiting primer made for priming ferrous metal under an odorless alkyd enamel (FS TT-P-664):
    - a. Con-Lux: FerroX Primer.
    - b. Devoe: 41820 Bar-Ox Alkyd Shop/Field Primer.
    - c. Moore: Ironclad Retardo Rust-Inhibitive Paint 163
    - d. S-W: Kem Kromik Metal Primer B50N2/B50W1.

2. Undercoat: Enamel undercoat made for use as an undercoat over a primer on ferrous metal under an odorless alkyd enamel:
    - a. Con-Lux: Satin-Lite 900 Series.
    - b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
    - c. Moore: Moore's Alkyd Enamel Underbody 217.
    - d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.
  3. Finish Coat: Semigloss odorless alkyd enamel made for use over a primer and undercoat on ferrous metal surfaces (FS TT-E-509):
    - a. Con-Lux: Satin-Lite 900 Series.
    - b. Devoe: 26XX Velour Alkyd Semigloss Enamel
    - c. Moore: Moore's Satin Impervo Enamel 235.
    - d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.
- Q. Ferrous Metal - Epoxy, Gloss: Two coats over primer:
1. Primer: Corrosion-inhibitive primer recommended by manufacturer for priming ferrous metal under an epoxy undercoat:
    - a. Con-Lux: Epolon Mastic 36 White.
    - b. Duron: Dura Clad Universal Phenolic Alkyd Fast Dry Metal Primer.
    - c. Moore: IronClad Epoxy Rust Inhibitive Primer
    - d. S-W: Recoatable Epoxy Primer.
  2. Undercoat: Epoxy undercoat made for use as an undercoat over a primer on metal under a gloss epoxy enamel:
    - a. Con-Lux: Epolon Series.
    - b. Duron: Dura Clad Polyamide Epoxy.
    - c. Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
    - d. S-W: ArmorSeal 100HS Series.
  3. Finish Coat:
    - a. Gloss epoxy enamel made for use over a primer and epoxy undercoat on metal surfaces.
      - 1) When the finish coat is applied to a floor surface, add anti-slip aggregate.
    - b. Con-Lux: Epolon Series.
    - c. Duron: Dura Clad Polyamide Epoxy.
    - d. Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
    - e. S-W: ArmorSeal 100HS Series.
- R. Zinc-coated Metal - Alkyd, Semigloss: Two coats over primer, with total dry film thickness not less than 2.5 mils.
1. Primer: Galvanized metal primer made for use on zinc-coated (galvanized) metal surfaces (FS TT-P-641), or one of the following:
    - a. Con-Lux: Bond-Plex 46 Barrier Green.
    - b. Devoe: 13201 Mirrolac Galvanized Metal Primer.
    - c. Moore: Ironclad Galvanized Metal Latex Primer 155.
    - d. S-W: Industrial Water Based Acrylic Paint B42W110.
  2. Undercoat: Enamel undercoat made for use as an undercoat over a primer on zinc-coated metal under an odorless alkyd enamel:
    - a. Con-Lux: Satin-Lite 900 Series.
    - b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
    - c. Moore: Moore's Alkyd Enamel Underbody 217.
    - d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.
  3. Finish Coat: Semigloss odorless alkyd enamel made for use over a primer and undercoat on zinc-coated (galvanized) metal surfaces (FS TT-E-509):
    - a. Con-Lux: Satin-Lite 900 Series.
    - b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
    - c. Moore: Moore's Satin Impervo Enamel 235.
    - d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.

- S. Zinc-Coated Metal - Silicone-Alkyd, Semigloss: Two coats over factory-applied primer:
1. Primer: Galvanized metal primer used to prime zinc-coated (galvanized) metal surfaces (FS TT-P-641), or one of the following.
    - a. Con-Lux: Bond-Plex 46 Barrier Green.
    - b. Devoe: 13201 Mirrolac Galvanized Metal Primer.
    - c. Moore: Ironclad Galvanized Metal Latex Primer #155.
    - d. S-W: Industrial Water Based Acrylic Paint B42W110.
  2. Undercoat: Alkyd enamel recommended by manufacturer of finish coat as an intermediate coat over factory-applied primer for application of silicone-alkyd finish coat:
    - a. Con-Lux: FerroX Primer.
    - b. S-W: Silicone Alkyd Enamel B-56 Series.
    - c. Tnemec: Series 23 Enduratone.
  3. Finish Coat: Silicone-alkyd enamel with a minimum of 30% silicone content meeting the qualitative requirements of FS TT-E-490:
    - a. Con-Lux: Steel-Master 9500 Series.
    - b. S-W: Silicone Alkyd Enamel B-56 Series.
    - c. Tnemec: Series 82 Silicone-Alkyd Enamel.
- T. Zinc-Coated Metal - Epoxy, Gloss: Two coats over primer:
1. Primer: Primer recommended by manufacturer for priming galvanized metal under an epoxy undercoat:
    - a. Con-Lux: Metal Bond 47 Primer.
    - b. Duron:
      - 1) Vinyl Wash Primer for surfaces subject to abrasion;
      - 2) Dura Clad Acrylic Galvanized Metal Primer for surfaces not subject to abrasion.
    - c. Moore: IronClad Galvanized Metal latex Primer.
    - d. S-W: ArmorSeal 100HS Series.
  2. Undercoat: Epoxy undercoat made for use as an undercoat over a primer on metal under a gloss epoxy enamel:
    - a. Con-Lux: Epolon Series.
    - b. Duron: Dura Clad Polyamide Epoxy.
    - c. Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
    - d. S-W: ArmorSeal 100HS Series.
  3. Finish Coat;
    - a. Gloss epoxy enamel made for use over a primer and epoxy undercoat on metal surfaces.
      - 1) When the finish coat is applied to a floor surface, add anti-slip aggregate.
    - b. Con-Lux: Epolon Series.
    - c. Duron: Dura Clad Polyamide Epoxy.
    - d. Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
    - e. S-W: ArmorSeal 100HS Series.
- U. Non-Ferrous Metal - Alkyd, Semigloss: Two coats over primer with total dry film thickness not less than 2.5 mils.
1. Primer: Corrosion inhibitive primer recommended by manufacturer for priming non-ferrous metal under an odorless alkyd enamel:
    - a. Con-Lux: Bond-Plex 46 Barrier Green.
    - b. Devoe: 13201 Mirrolac Galvanized Metal Primer.
    - c. Moore: Ironclad Retardo Rust-Inhibitive Paint 163.
    - d. S-W: Kem Kromik Metal Primer B50N2/B50W1.
  2. Undercoat: Enamel undercoat made for use as an undercoat over a primer on non-ferrous metal under an odorless alkyd enamel:

- a. Con-Lux: Satin-Lite 900 Series.
  - b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
  - c. Moore: Moore's Alkyd Enamel Underbody 217.
  - d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.
3. Finish Coat: Semigloss odorless alkyd enamel made for use over a primer and undercoat on non-ferrous metal surfaces (FS TT-E-509):
- a. Con-Lux: Satin-Lite 900 Series.
  - b. Devoe: 26XX Velour Alkyd Semigloss Enamel.
  - c. Moore: Moore's Satin Impervo Enamel 235.
  - d. S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100
- V. Cotton or Canvas Covering over Insulation - Latex, Flat: 2 coats.
1. Undercoat: Flat latex-based paint with fungicidal agent added (to render fabric mildew-proof) made for use as a sealing coat (size) on cotton or canvas covering over insulation:
- a. Con-Lux: Wall-Plex 400 Series.
  - b. Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
  - c. Moore: Regal Wall Satin 215.
  - d. S-W: Pro-Mar 200 Latex Flat Wall Paint B30W200 Series.
2. Finish Coat: Flat latex-based paint with fungicidal agent added (to render fabric mildew-proof) made for use as a sealing coat (size) on cotton or canvas covering over insulation:
- a. Con-Lux: Wall-Plex 400 Series.
  - b. Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
  - c. Moore: Regal Wall Satin 215.
  - d. S-W: Pro-Mar 200 Latex Flat Wall Paint B30W200 Series.

## **PART 3 - EXECUTION**

### **3.01 PREPARATORY WORK:**

- A. Inspect surfaces for their suitability to receive a finish. In the event that imperfections due to materials or workmanship appear on surfaces, make the appropriate corrections at no additional cost to the Authority. Correct damage to painted or decorated finishes due to carelessness or negligence of other trades.
- B. Protect hardware, hardware accessories, plates, lighting fixtures and similar items installed prior to painting; remove protection upon completion of each space. Where necessary to remove installed products to ensure their protection, arrange for removal and reinstallation by mechanics of the trade involved. Disconnect equipment adjacent to walls; where necessary, move to permit painting of wall surfaces, and following completion of painting, replace and reconnect.
- C. Clean surfaces to be painted as necessary to remove dust and dirt. Sand as necessary to properly prepare surfaces to receive paint or varnish.
- D. Wash metal surfaces with benzine or mineral spirits to remove dirt, oil or grease before applying paint. Where rust or scale is present, wire brush or sandpaper clean before painting. Apply galvanized metal primer to degreased galvanized metal before applying additional coats.
- E. Prepare masonry surfaces to be painted by removing dirt, dust, oil and grease stains and efflorescence. The method of surface preparation is at the discretion of the Contractor provided that the results are approved. Clean masonry and plaster surfaces to be painted

until they are free from alkali and thoroughly dry before applying paint. Test masonry and plaster surfaces for alkali, using red litmus paper, prior to painting.

- F. Clean concrete surfaces free from dirt, or film left from form oil or concrete curing compounds, or loose or excess mortar. Steam clean or wash the surfaces with water. Use cleaning additive with discretion, in accordance with paint manufacturer's recommendation and to the satisfaction of Engineer.
- G. Cut out cracks, scratches and other imperfections in plaster surfaces as required, fill with spackling compound and sand flush with adjacent surface. Fill voids in concrete with cement grout before painting.
- H. Fill nail holes and cracks after first coat with non-shrinking putty of a color to match that of the finish.
- I. Sand, dust and touch up scratches, abrasions or other disfigurements and remove foreign matter from prime coats before proceeding with the following coat. Featheredge spotpriming or spot coating into adjacent coatings to produce a smooth and level surface.
- J. Test concrete and plaster surfaces for moisture, using moisture meter, prior to painting. Do not apply paint to surfaces having meter reading above 15.
- K. Caulk joints between door and window frames and walls, and other joints as necessary.
- L. Coordinate the work of this section with the work of other trades.

### **3.02 APPLICATION:**

- A. Touch-up painting of structural steel, miscellaneous metal, hollow-metal doors and frames, and other materials which have been prime coated as may be required where the shop coat has been damaged by welding or abrasion during the handling and erection operations; also rivets, bolts and welds which are unpainted after assembly and erection.
- B. Apply paint by spray in accordance with the manufacturer's directions to achieve required dry film thickness (DFT). Where specifically approved by the Engineer, use rollers or brushes as best suited for material being applied. For covers on rollers use carpet with velvet back and high-pile sheep's wool or use short-hair covers, as best suited for material and texture specified. Except where otherwise noted, apply paint to a minimum dry-film thickness (DFT) of five mils, excluding filler coats, using no less than the number of coats specified in Part 2 – Products.
- C. Apply material evenly and smoothly without runs, sags or other defects with edges of paint adjoining other materials or color sharp and clean, without overlapping.
- D. Do not paint and finish while surfaces are damp. Allow sufficient time between coats, in accordance with manufacturer's directions to produce an evenly smooth finish.
- E. Do not apply final coats until after other trades, whose operations would be detrimental to finish painting, have finished their work in the areas to be painted and the areas have been approved for painting.

### **3.03 PROTECTION:**

- A. Dispose of soiled cleaning rags and waste at the close of each day's work or store such soiled rags and waste in metal containers with tight-fitting covers. Provide buckets of sand

during painting operations for use in the event of fire. Post NO SMOKING signs as necessary and as directed.

- B. Protect the work of other trades against damage or injury by use of suitable covering during the progress of the painting and finishing work. Repair damage to the satisfaction of the Engineer.

**3.04 CLEANING:**

- A. Upon completion of work, remove staging, scaffolding and containers from the site. Remove paint spots, oil or stains from glass, floors and other surfaces not to be painted, and leave job clean and acceptable to the Engineer.

**3.05 COLOR CODING OF PIPING AND EQUIPMENT:**

- A. General Requirements:
  - 1. Color coding is required for accessible piping systems and related equipment, except associated supports, brackets, hangers and similar accessories.
  - 2. Identify piping systems and related equipment which are to be color coded as follows:
    - a. Apply color to entire length of piping.
    - b. Apply lettered legends indicating the name of the contents of the system as specified.
- B. Location of Legends and Bands:
  - 1. Stencil lettered legends on the piping at the horizontal or vertical centerline. Where pipe lines are too close together and where located above the operator's normal line of vision, place the lettering below the horizontal centerline at a point which will be easily visible.
  - 2. Locate lettered legends and bands at points where pipes enter and leave rooms or spaces, at junction points and points of distribution, close to valves and equipment, at changes in direction, and at intervals along piping where necessary for identification.
  - 3. Stencil piping in accordance with ASME A13.1 and as follows to show service and direction of flow, space within sight of each other and not more than 40 feet apart on long runs.
- C. Size of Stencil Letters for Piping Identification:

Outside Diameter of Pipe Covering in Inches	Size of Letter in Inches	Width of Color Band in Inches
3/4 to 1-1/4	1/2	4
1-1/2 to 2-1/2	3/4	6
3 to 6	1-1/4	8
7 to 10	2-1/2	12
Over 10	3-1/2	12

D. Schedule of Colors and Legends:

Line	Pipe Color	Black Stenciled Legend
Hot water lines	Yellow	HW, HWR
Potable cold water lines	Blue	CW
Chilled water lines	Blue with yellow band	CHWS, CHWR
Fire lines	Red	F (use White Stencil instead of black)
Condensate lines	White	C
Condenser water lines	White with blue band	CWS, CWR
Soil and waste lines	White	S
Vent lines	Grey with white band	V
Storm Water lines	White	ST-W
Air and control air lines	Green	A

**END OF SECTION**

**DIVISION 10 - SPECIALTIES**

10155	TOILET PARTITIONS, COMPARTMENTS AND SCREENS
10180	STONE TOILET COMPARTMENT AND SCREENS
10200	METAL LOUVERS
10505	METAL LOCKERS
10605	WIRE MESH PARTITIONS
10810	TOILET ACCESSORIES

**END OF SECTION**

## SECTION 10155

### TOILET COMPARTMENTS AND SCREENS

#### PART1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing metal toilet compartments, urinal screens and metal screens for portable eye wash and body spray.
- B. Related Work Specified Elsewhere:
  - 1. Toilet Accessories: Section 10810.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Product Data: For each type and style of toilet compartment and screen specified include details of construction relative to materials, fabrication, and installation. Include details of anchors, hardware, and fastenings.
  - 2. Shop Drawings: For fabrication and installation of toilet compartment and screen assemblies. Include plans, elevations, sections, details, and attachments to other work. Submit prior to ordering materials or beginning fabrication.
    - a. Show locations of reinforcement and cutouts for compartment-mounted toilet accessories.
    - b. Samples for Verification:
      - 1) Three of each type of the following products used in the Work:
        - a) Hardware.
        - b) Sheet metal: Three inches by five inches.
      - 2) Approved full-size samples will be returned and may be used in the Work.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ADA: Americans with Disabilities Act.
  - 3. ASTM: A666.
  - 4. NAAMM: Metal Finishes Manual for Architectural and Metal Products.
- B. Manufacturer Qualifications: Provide products of an established manufacturer regularly engaged in the production of toilet accessories.

##### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver the products to the job site in original unopened containers clearly labeled with the manufacturer's name, brand designation and type as applicable.
- B. Store products in an approved dry area, protect from contact with soil and from exposure to the elements. Keep products dry.
- C. Handle products so as to prevent breakage of containers and damage to products.

##### 1.05 PROJECT CONDITIONS:

- A. Field Measurements: Verify dimensions in areas of installation by field measurements before fabrication and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work
  - 1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating units without field measurements. Coordinate supports, adjacent construction, and fixture locations to ensure actual dimensions correspond to established dimensions.

## **PART 2- PRODUCTS**

### **2.01 MANUFACTURERS:**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Ampco Products, Inc.
- C. General Partitions Mfg. Corp.
- D. Global Steel Products Corp.
- E. Knickerbocker Partition Corporation.
- F. Sanymetal
- G. Or equal.

### **2.02 MATERIALS:**

- A. General: Provide materials that have been selected for surface flatness and smoothness. Exposed surfaces that exhibit pitting, seam marks, roller marks, stains, discolorations, telegraphing of core material, or other imperfections on finished units are unacceptable.
- B. Stainless-Steel Sheet: ASTM A666, Type 302 or 304, that is leveled to stretcher-leveled flatness, finished on exposed faces as indicated in the "Stainless-Steel Sheet Finishes" Article, and of the following minimum thicknesses:
  - 1. Pilasters (Overhead Braced): 0.0375 inch.
  - 2. Pilasters (Unbraced): 0.0500 inch.
  - 3. Panels and Screens: 0.0312 inch.
  - 4. Doors: 0.0312 inch.
  - 5. Tapping Reinforcement: 0.0781 inch.
- C. Core Material for Metal-Faced Units: Manufacturer's standard sound-deadening honeycomb of resin-impregnated kraft paper in thickness required to provide finished thickness of 1 inch minimum for doors, panels, and screens and 1-1/4 inches minimum for pilasters.
- D. Pilaster Shoes and Sleeves (Caps): ASTM A666, Type 302 or 304 stainless steel, not less than 0.0312 inch thick and 3 inches high, finished to match hardware.
- E. Stirrup Brackets: Manufacturer's standard ear or U-brackets for attaching panels and screens to walls and pilasters of the following material:
  - 1. Material: Stainless steel.
  - 2. Material: Chrome-plated brass.

- F. Full-Height (Continuous) Brackets: Manufacturer's standard design for attaching panels and screens to walls and pilasters of the following material:
  - 1. Material: Stainless steel.
  - 2. Material: Chrome-plated brass.
- G. Hardware and Accessories: Manufacturer's standard design, heavy-duty operating hardware and accessories of the following material:
  - 1. Material: Stainless steel.
  - 2. Material: Chrome-plated brass.
- H. Overhead Bracing: Manufacturer's standard continuous, extruded-aluminum head rail with antigrip profile in manufacturer's standard finish.
- I. Anchorages and Fasteners: Manufacturer's standard exposed fasteners of stainless steel or chrome-plated steel or brass, finished to match hardware, with theft-resistant-type heads. Provide sex-type bolts for through-bolt applications. For concealed anchors, use hot-dip galvanized or other rust-resistant, protective-coated steel.

**2.03 COMPARTMENT AND SCREEN FABRICATION:**

- A. General: Provide standard doors, panels, screens, and pilasters fabricated for compartment system. Provide units with cutouts and drilled holes to receive compartment-mounted hardware, accessories, and grab bars, as indicated.
  - 1. Provide internal reinforcement in metal units for compartment-mounted hardware, accessories, and grab bars.
- B. Metal-Faced Toilet Compartments and Screens: Pressure laminate seamless face sheets to core material and provide continuous, interlocking molding strip or lapped and formed edges. Seal corners by welding or clips. Grind exposed welds smooth.
- C. Overhead-Braced-and-Floor-Anchored Compartments: Provide manufacturer's standard corrosion-resistant supports, leveling mechanism, fasteners, and anchors at pilasters to suit floor conditions. Make provisions for setting and securing continuous head rail at top of each pilaster. Provide shoes at pilasters to conceal supports and leveling mechanism.
- D. Floor-Anchored Compartments: Provide manufacturer's standard corrosion-resistant anchoring assemblies complete with threaded rods, lock washers, and leveling adjustment nuts at pilasters for structural connection to floor. Provide shoes at pilasters to conceal anchorage.
- E. Ceiling-Hung Compartments: Provide manufacturer's standard corrosion-resistant anchoring assemblies complete with threaded rods, lock washers, and leveling adjustment nuts at pilasters for connection to structural support above finished ceiling. Provide assemblies that support pilasters from structure without transmitting load to finished ceiling. Provide sleeves (caps) at tops of pilasters to conceal anchorage.
  - 1. Provide manufacturer's standard 4-inch-high, overhead cross bracing.
- F. Floor-and-Ceiling-Anchored Compartments: Provide manufacturer's standard corrosion-resistant anchoring assemblies complete with leveling adjustment at tops and bottoms of pilasters. Provide shoes and sleeves (caps) at pilasters to conceal anchorage.
- G. Wall-Hung Urinal Screens and Eyewash Screens: Provide units 18 inches wide by 42 inches high, nominal, or of size as indicated of same construction and finish as compartment panels, unless otherwise indicated.

1. Provide metal-faced screens with integral full-height flanges for attachment to wall.
- H. Floor-Anchored Screens: Provide pilasters and panels of same construction and finish as toilet compartments. Provide manufacturer's standard corrosion-resistant anchoring assemblies complete with threaded rods, lock washers, and leveling adjustment nuts at pilasters for structural connection to floor. Provide shoes at pilasters to conceal anchorage.
- I. Ceiling-Hung Screens: Provide pilasters and panels of same construction and finish as toilet compartments. Provide manufacturer's standard corrosion-resistant anchoring assemblies complete with threaded rods, lock washers, and leveling adjustment nuts at pilasters for connection to structural support above finished ceiling. Provide assemblies that support pilasters from structure without transmitting load to finished ceiling. Provide sleeves (caps) at tops of pilasters to conceal anchorage.
- J. Floor-and-Ceiling-Anchored Screens: Provide pilasters and panels of same construction and finish as toilet compartments. Provide manufacturer's standard corrosion-resistant anchoring assemblies complete with leveling adjustment at tops and bottoms of pilasters. Provide shoes and sleeves (caps) at pilasters to conceal anchorage.

#### **2.04 DOOR FABRICATION:**

- A. General: Unless otherwise indicated, provide 24-inch-wide in-swinging doors for standard toilet compartments and 36-inch-wide out-swinging doors with a minimum 32-inch-wide clear opening for compartments indicated to be handicapped accessible.
- B. Hardware: Provide doors with the following:
1. Hinges: Manufacturer's standard self-closing type that can be adjusted to hold door open at any angle up to 90 degrees.
  2. Latch: Concealed latch unit designed for emergency access. Provide units that comply with accessibility requirements of authorities having jurisdiction at compartments indicated to be handicapped accessible.
  3. Combination Stop/Keeper.
  4. Coat Hook: Manufacturer's standard combination hook and rubber-tipped bumper, sized to prevent door from hitting compartment-mounted accessories.
  5. Door Pull: Manufacturer's standard unit that complies with accessibility requirements of authorities having jurisdiction at out-swinging doors. Provide units on both sides of doors at compartments indicated to be handicapped accessible.

#### **2.05 STAINLESS-STEEL SHEET FINISHES:**

- A. General: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations relative to applying and designating finishes.
1. Remove or blend tool and die marks and stretch lines into finish.
  2. Grind and polish surfaces to produce uniform, directional textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.
- B. Finish: Manufacturer's standard No. 4 directional polish.
- C. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.
- D. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipment.

### **PART 3 - EXECUTION**

### **3.01 PREPARATION:**

- A. Verify dimensions before proceeding and obtain measurements at the structure for work to be accurately fitted to other construction, including wall-to-wall dimensions, floor-to-ceiling dimensions and those controlled by other trades.
- B. Examine surfaces and parts of structure to which work is to be applied. Notify the Engineer of defects or conditions detrimental to proper installation so that remedial measures may be accomplished by trades involved.
- C. Remove foreign substances from surfaces to receive specified work.

### **3.02 INSTALLATION:**

- A. General: Install units to the adjoining construction as shown on Contract Drawings and approved shop drawings.
- B. General: Comply with manufacturer's written installation instructions. Install units rigid, straight, plumb, and level. Provide clearances of not more than 1/2inch between pilasters and panels and not more than 1 inch between panels and walls. Secure units in position with manufacturer's recommended anchoring devices.
  - 1. Secure panels to walls and panels with not less than 2 stirrup brackets attached near top and bottom of panel. Locate wall brackets so holes for wall anchors occur in masonry or tile joints. Align brackets at pilasters with brackets at walls.
- C. Overhead-Braced-and-Floor-Anchored Compartments: Secure pilasters to floor and level, plumb, and tighten. Secure continuous head rail to each pilaster with not less than 2 fasteners. Hang doors level and plumb without twist or warp and adjust so tops of doors are parallel with overhead brace when doors are in closed position and with maximum clearance of 3/16-inch at vertical edges.
- D. Floor-Anchored Compartments: Set pilaster units with anchors penetrating not less than 2 inches into structural floor, unless otherwise indicated in manufacturer's written instructions. Level, plumb, and tighten pilasters. Hang doors level and plumb without twist or warp and adjust so tops of doors are parallel with overhead brace when doors are in closed position and with maximum clearance of 3/16-inch at vertical edges.
- E. Ceiling-Hung Compartments: Secure pilasters to supporting structure and level, plumb, and tighten. Hang doors level and plumb without twist or warp and adjust so tops of doors are parallel with overhead brace when doors are in closed position and with maximum clearance of 3/16-inch at vertical edges.
- F. Floor-and-Ceiling-Anchored Compartments: Secure pilasters to supporting construction and level, plumb, and tighten. Hang doors level and plumb without twist or warp and adjust so tops of doors are parallel with overhead brace when doors are in closed position and with maximum clearance of 3/16-inch at vertical edges.
- G. Screens: Attach with anchoring devices according to manufacturer's written instructions and to suit supporting structure. Set units level and plumb and to resist lateral impact.
- H. Clean finished surfaces according to manufacturer's written instructions and leave them free from imperfections. Touch up marred painted surfaces with matching materials furnished by manufacturer.

- I. After installation, Provide final protection and maintain conditions that ensure toilet compartments and screens are without damage or deterioration at the time of Substantial Completion.

**3.03 TESTING AND ADJUSTING OF COMPLETED WORK:**

- A. Hardware:
  - 1. Test proper operation of hardware by opening and closed each door through ten cycles.
  - 2. Adjust and lubricate hardware according to manufacturer's written instructions for proper operation.
  - 3. Set hinges on in-swinging doors to hold open approximately 30 degrees from closed position when unlatched. Set hinges on out-swinging doors and swing doors in entrance screens to return to fully closed position.
  - 4. Adjust, repair or replace malfunctioning hardware.

**3.04 CLEANING:**

- A. Leave areas surrounding the work in broom-clean condition.

**END OF SECTION**

## SECTION 10180

### STONE TOILET COMPARTMENTS AND SCREENS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing floor-anchored stone toilet compartments, urinal screens and accessories.
- B. Related Work Specified Elsewhere:
  - 1. Seals and Sealants: Section 07900.
  - 2. Toilet Compartments & Shields: Section 10155.
  - 3. Toilet Accessories: Section 10810.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Product Data: For each variety of stone, stone accessory, door, hardware, fitting, and other manufactured product specified.
    - a. For stone varieties, include data on physical properties required by referenced ASTM standards.
    - b. For doors, hardware, and fittings, include details of construction relative to materials, dimensions of individual components, profiles, and finishes.
  - 2. Shop Drawings: Show details of fabrication and installation of compartments and screens, including plans; elevations; sections; details of anchorages and attachments to other work; dimensions of stone units; and locations of fittings, doors, hardware, and compartment-mounted accessories.
  - 3. Door Samples for Initial Selection: Manufacturer's color charts consisting of sections of actual units showing the full range of colors, textures, and patterns available for each type of compartment door indicated.
  - 4. Sealant Samples for Initial Selection: Manufacturer's standard bead samples of actual products showing the full range of colors available for sealant.
  - 5. Samples for Verification: Three of each type of the following products used in the Work, in sizes indicated:
    - a. Stone: Sets for each color, grade, finish, and variety of stone required; not less than 12 inches square. Include two or more samples in each set showing the full range of variations in appearance characteristics expected in the completed Work.
    - b. Hardware and Fittings: Full-size samples of each hardware and fitting item required.
    - c. Sealant: Manufacturer's standard size sample for each type and color of joint sealant required.
  - 6. Maintenance Data: For stone to include precautions for cleaning materials and methods that could be detrimental to finishes and performance.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Codes and regulations of the jurisdictional authorities.
  - 2. ADA: Americans with Disabilities Act.
  - 3. ASTM: A666, C503.
  - 4. MIA: Dimension Stone-Design Manual IV.

- B. Installer Qualifications: Engage an experienced installer who has completed stone toilet compartments similar in material, design, and extent to those indicated for this Project and with a record of successful in-service performance.
- C. Fabricator Qualifications: Engage an experienced fabricator who has fabricated stone for toilet compartments similar in material, design, and extent to those indicated for this Project and with a record of successful in-service performance.
- D. Source Limitations for Stone: Obtain each variety of stone from a single quarry with resources to provide materials of consistent quality in appearance and physical properties and to cut and finish material without delaying the Work.

#### **1.04 DELIVERY, STORAGE, AND HANDLING:**

- A. Deliver materials to Project site in undamaged condition.
- B. Store and handle stone and related materials to prevent deterioration or damage due to moisture, temperature changes, contaminants, corrosion, breakage, chipping, or other causes.
- C. Stack or brace stone on edge on leveled and adequate A-frames in a manner that prevents undue stresses in stone, chipping, cracking, and breaking. If exposed to moisture, cover stone with nonstaining, waterproof membrane.

#### **1.05 PROJECT CONDITIONS:**

- A. Field Measurements: Verify dimensions in areas of installation by field measurements before stone fabrication and indicate measurements on Shop Drawings. Coordinate stone fabrication schedule with construction progress to avoid delaying the Work.
  - 1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating stone units without field measurements. Coordinate supports, adjacent construction, and fixture locations to ensure actual dimensions correspond to established dimensions.

### **PART 2 - PRODUCTS**

#### **2.01 MANUFACTURERS:**

- A. Available Product: Subject to compliance with requirements, a product that may be incorporated into the Work includes, but is not limited to, "Marblstal" by Georgia Marble Company.

#### **2.02 MATERIALS:**

- A. Stone, General: Provide stone free of cracks, defects, geological flaws, and voids. Provide material that has been selected for surface flatness, smoothness, and uniform visual quality.
- B. Marble: ASTM C503, MIA Group A soundness classification. Polished with a hardness of Ha16 and absorption of 0.09 percent.
  - 1. Color: As selected by Engineer from manufacturer's full range of colors.
- C. Dowels: Provide 1/4-inch-diameter dowels fabricated from stainless steel, ASTM A666, Type 304. Furnish templates for positioning anchoring holes in structural supporting members.

- D. Brackets: Chrome-plated forged brass 1-3/4 by 1-3/4 inch by 1-1/4-long angle brackets capable of supporting stone units in bracket configuration indicated.
- E. Hardware: Manufacturer's standard design, stainless steel or chrome plated brass, heavy-duty operating hardware and accessories. Smooth and finished wherever visible; theft-resistant, permitting removal only by special tool. Furnish two such tools.
- F. Exposed Anchorages and Fasteners: Manufacturer's standard design, stainless steel or chrome-plated brass fasteners, finished to match hardware, with theft-resistant-type heads. Provide sex-type through bolts with theft-resistant spanner heads and threaded brass rods for attachments to stone.
- G. Doors: Manufacturer's standard polyurethane varnished one-inch thick solid hardwood or solid core hardwood flush doors with 3/4-inch particle board core and hardwood edge bands bonded on all four edges.
- H. Stone Sealer: Sealer recommended by fabricator and sealer manufacturer for protecting stone from surface staining and suitable for stone finish indicated.
- I. Sealant: Nonstaining, compatible sealant recommended by stone fabricator for stone varieties and joints indicated.

### **2.03 STONE FABRICATION:**

- A. General: Provide manufacturer's standard sizes and shapes of panels, screens, and stiles.
  - 1. For marble, comply with recommendations of MIA's "Dimension Stone--Design Manual IV."
- B. Cut stone to produce sizes and shapes indicated with surfaces not varying more than 1/32-inch from true plane. Provide even (gaged) thicknesses indicated, but not less than the following actual thicknesses:
  - 1. Panels and Screens: 7/8 inch.
    - a. Stiles: 1-1/4 inches.
- C. Cut stone so that, when installed, veining will be approximately vertical.
- D. Cut and drill sinkages and holes in stone for anchors and fasteners as indicated or needed to set stone securely in place. Drill holes for compartment-mounted accessories.
- E. Finish exposed faces and edges of stone to comply with requirements indicated for finish under each type of stone required and to match approved samples. Provide stone with eased, exposed edges.
- F. Urinal Screens: Provide units 18 inches wide by 42 inches high, nominal, or of size as indicated of same construction and finish as compartment panels with floor cutout as approved from manufacturer's standard option.

### **2.04 DOOR FABRICATION:**

- A. General: Unless otherwise indicated, provide 24-inch-wide in-swinging doors for standard toilet compartments and 36-inch-wide out-swinging doors with a minimum 32-inch-wide clear opening for compartments indicated to be handicapped accessible.
- B. Hardware: Provide doors with the following:
  - 1. Hinges: Manufacturer's standard spring or gravity-type top and bottom hinges.

2. Latch: Concealed latch unit designed for emergency access. Provide units that comply with accessibility requirements of authorities having jurisdiction at compartments indicated to be handicapped accessible.
3. Combination Stop/Keeper.
4. Coat Hook: Manufacturer's standard combination hook and rubber-tipped bumper, sized to prevent door from hitting compartment-mounted accessories.
5. Door Pull: Manufacturer's standard unit that complies with accessibility requirements of authorities having jurisdiction at out-swinging doors. Provide units on both sides of doors at compartments indicated to be handicapped accessible.

### **PART 3 - EXECUTION**

#### **3.01 EXAMINATION:**

- A. Examine substrates, areas, and conditions under which stone toilet compartments and screens will be installed, with Installer present, for compliance with requirements. Do not proceed with installation until unsatisfactory conditions have been corrected.
- B. Coordinate layout and installation of supports, inserts, and anchors built into other units of work for stone toilet compartment and screen anchorage.

#### **3.02 INSTALLATION:**

- A. Set stone to comply with requirements indicated. Install anchors, fasteners, and other attachments indicated or necessary to secure stone in place. Shim and adjust anchors and supports to set stone accurately in locations indicated with uniform joints of widths indicated and with edges and faces aligned.
- B. Secure stone panels to walls and stiles with no fewer than 3 brackets. Provide back-to-back brackets at stile connections to walls and intermediate panels and at panel and screen connections to walls. Use through-bolt fasteners to attach brackets to stone. At wall connections, provide fasteners suitable for supporting construction.
- C. Do not allow stone to come in contact with plumbing sealant or putty.
- D. Floor-Anchored Units: Anchor units to floor rigid, level, and plumb. Hang doors and adjust so tops of doors are level with tops of stiles when doors are in closed position.
  1. Floor Anchorage: Set units into finished floor as indicated. Secure units with dowels epoxied into unit and structural floor in locations indicated, but not less than 2 dowels per unit. Provide minimum 1-inch dowel penetration of structural floor.
- E. Prepare joints and apply sealants at locations indicated to comply with applicable requirements of Section 07900.

#### **3.03 ADJUSTING AND CLEANING:**

- A. Hardware Adjustment: Adjust and lubricate hardware according to hardware manufacturer's written instructions for proper operation. Set hinges on in-swinging doors to hold open approximately 30 degrees from closed position when unlatched. Set hinges on out-swinging doors and swing doors in entrance screens to return to fully closed position.
- B. Clean stone using clean water and methods recommended by MIA. Do not use wire brushes, acid-type cleaning agents, cleaning compounds with caustic or harsh fillers, or other materials or methods that could damage stone.

- C. Seal stone surfaces according to sealer manufacturer's written instructions.

**3.04 PROTECTION:**

- A. Provide final protection and maintain conditions, in a manner acceptable to fabricator and Installer, that ensure stone toilet compartments and screens are without damage or deterioration at the time of Substantial Completion..

**END OF SECTION**

## SECTION 10200

### METAL LOUVERS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing fixed, extruded aluminum and formed-metal louvers, blank-off panels and accessories.
- B. Related Work Specified Elsewhere:
  - 1. Seals and Sealants: Section 07900.
  - 2. Metal Doors and Frames: Section 08110.
  - 3. Field Painting: Section 09920.

##### 1.02 DEFINITIONS:

- A. Louver Terminology: Definitions of terms for metal louvers contained in AMCA 501 apply to this Section, unless otherwise defined in this Section or in referenced standards.
- B. Standard Free Area: Free area of a louver 48 inches wide by 48 inches high, identical to that provided.
- C. Maximum Standard Airflow: Airflow at point of beginning water penetration through a louver 48 inches wide by 48 inches high, identical to that provided.
- D. Drainable-Blade Louver: Louver designed to collect and drain water to exterior at sill by means of gutters in front edges of blades and channels in jambs and mullions.

##### 1.03 PERFORMANCE REQUIREMENTS:

- A. Structural Performance: Provide exterior metal louvers capable of withstanding the effects of loads and stresses from wind and normal thermal movement without evidencing permanent deformation of louver components including blades, frames, and supports; noise or metal fatigue caused by louver blade rattle or flutter; or permanent damage to fasteners and anchors.
  - 1. Wind Load: Uniform pressure (velocity pressure) of 20 lbf/sq. ft., acting inward or outward.
  - 2. Thermal Movements: Provide louvers that allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, and other detrimental effects:
    - a. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.
- B. Air-Performance, Water-Penetration, and Air-Leakage Ratings: Provide louvers complying with performance requirements indicated, as demonstrated by testing manufacturer's stock units 48 inches wide by 48 inches high. Test units according to AMCA 500.
  - 1. Perform testing on unpainted, cleaned, degreased units.
  - 2. Perform water-penetration testing on louvers without screens.

##### 1.04 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

1. Product Data: For each type of product specified provide manufacturer's printed product information.
2. Shop Drawings: For louver units and accessories. Include plans; elevations; sections; and details showing profiles, angles, and spacing of louver blades. Show unit dimensions related to wall openings and construction; free area for each size indicated; profiles of frames at jambs, heads, and sills; and anchorage details and locations.
  - a. For installed louvers and vents indicated to comply with design loadings, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
3. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for units with factory-applied color finishes.
4. Samples for Verification: Of each type of metal finish required, prepared on Samples of same thickness and material indicated for final Work. Where finishes involve normal color and texture variations, include Sample sets showing the full range of variations expected.
5. Product Certificates: Signed by manufacturers of louvers certifying that the products furnished comply with requirements and are licensed to bear the AMCA seal based on tests made according to AMCA 500 and complying with AMCA's Certified Ratings Program.

#### **1.05 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
  1. Codes and regulations of the jurisdictional authorities.
  2. AAMA: 603.8, 605.2, 607.1.
  3. AMCA: 500, 501.
  4. ASTM: A653, a780, B26, B209, B221, C612, D1187.
  5. AWS: D1.2, D1.3.
  6. NAAMM: Metal Finishes Manual for Architectural and Metal Products.
  7. SMACNA: Architectural Sheet Metal Manual.
  8. SSPC: Paint 12.
- B. Codes, Regulations, Reference Standards and Specifications:
  9. Codes and regulations of the jurisdictional authorities.
  10. ASTM:
  11. AWS: D1.2., D1.3.
  12. NAAMM: Metal Finishes Manual for Architectural and Metal Products.SMACNA: Architectural Sheet Metal Manual.
- B. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of kind indicated. Engineering services are defined as those performed for installations of louvers that are similar to those indicated for this Project in material, design, and extent.
- C. Source Limitations: Obtain louvers and vents through one source from a single manufacturer where alike in one or more respects regarding type, design, or factory-applied color finish.
- D. Welding Standards: As follows:
  1. Comply with AWS D1.2, "Structural Welding Code--Aluminum."
  2. Comply with AWS D1.3, "Structural Welding Code--Sheet Steel." Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone re-certification.

- E. SMACNA Standard: Comply with SMACNA's "Architectural Sheet Metal Manual" recommendations for fabrication, construction details, and installation procedures.

#### **1.06 PROJECT CONDITIONS:**

- A. Field Measurements: Verify louver openings by field measurements before fabrication and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.
  - 1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish opening dimensions and proceed with fabricating louvers without field measurements. Coordinate construction to ensure that actual opening dimensions correspond to established dimensions.

### **PART 2 -PRODUCTS**

#### **2.01 MATERIALS:**

- A. Aluminum Extrusions: ASTM B221, alloy 6063-T5 or T-52
- B. Aluminum Sheet: ASTM B209, alloy 3003 or 5005 with temper as required for forming, or as otherwise recommended by metal producer for required finish
- C. Aluminum Castings: ASTM B26/B26M, alloy 319.
- D. Galvanized Sheet Steel: ASTM A653/A653M, G90 zinc coating, mill phosphatized.
- E. Fasteners: Of same basic metal and alloy as fastened metal or 300 series stainless steel, unless otherwise indicated. Do not use metals that are incompatible with joined materials.
  - 1. Use types and sizes to suit unit installation conditions.
  - 2. Use Phillips flat-head screws for exposed fasteners, unless otherwise indicated.
- F. Anchors and Inserts: Of type, size, and material required for loading and installation indicated. Use nonferrous metal or hot-dip galvanized anchors and inserts for exterior installations and elsewhere as needed for corrosion resistance. Use toothed steel or expansion bolt devices for drilled-in-place anchors.
- G. Bituminous Paint: Cold-applied asphalt mastic complying with SSPC-Paint 12 but containing no asbestos fibers, or cold-applied asphalt emulsion complying with ASTM D1187.

#### **2.02 FABRICATION, GENERAL:**

- A. Assemble louvers in factory to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.
  - 1. Continuous Vertical Assemblies: Where height of louver units exceeds fabrication and handling limitations, fabricate units to permit field-bolted assembly with close-fitting joints in jambs and mullions, reinforced with splice plates and without interrupting blade-spacing pattern.
- B. Maintain equal louver blade spacing to produce uniform appearance.
- C. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining materials' tolerances, and perimeter sealant joints.
- D. Include supports, anchorages, and accessories required for complete assembly. Provide vertical mullions of type and at spacings indicated, but not more than recommended by

manufacturer, or 72 inches o.c., whichever is less. At horizontal joints between louver units, provide horizontal mullions, unless continuous vertical assemblies are indicated.

- E. Provide sill extensions and loose sills made of same material as louvers where indicated or required for drainage to exterior and to prevent water penetrating to interior.
- F. Join frame members to one another and to fixed louver blades with fillet welds, threaded fasteners, or both, as standard with louver manufacturer, concealed from view; unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.

### **2.03 FIXED, EXTRUDED-ALUMINUM LOUVERS:**

- A. Louver Construction: Provide fixed-blade louvers with extruded-aluminum frames and blades.
- B. Horizontal Louvers: Either drainable- or nondrainable-blade (as indicated) type complying with the following:
  - 1. Louver Depth: As indicated.
  - 2. Frame Thickness: 0.125 inch, or as indicated.
  - 3. Blade Thickness: 0.125 inch, or as indicated.
  - 4. Performance Requirements: As indicated.
  - 5. AMCA Seal: Mark units with AMCA Certified Ratings Seal.
- C. Continuous, Horizontal, Drainable-Blade Louvers: Fabricated with close-fitting, field-made splice joints in blades designed to permit expansion and contraction without deforming blades or framework and with mullions recessed from front edges of blades so blades have continuous appearance.
  - 1. Louver Depth: As indicated.
  - 2. Frame Thickness: 0.125 inch, or as indicated.
  - 3. Blade Thickness: 0.125 inch, or as indicated.
  - 4. Blade Profile: As indicated.
  - 5. Blade Angle and Spacing: As indicated.

### **2.04 FIXED, FORMED-METAL LOUVERS:**

- A. Louver Construction: Provide fixed-blade louvers with frames and blades formed from metal sheet of metal indicated.
- B. Horizontal Louvers: Either drainable- or nondrainable-blade type (as indicated) complying with the following:
  - 1. Louver Depth: As indicated.
  - 2. Frame and Blade Material: Galvanized steel sheet, 0.052 inch.
  - 3. Performance Requirements: As indicated.

### **2.05 LOUVER SCREENS:**

- A. General: Provide each exterior louver with louver screens complying with the following requirements:
  - 1. Screen Location for Fixed Louvers: Interior face.
  - 2. Screening Type: Bird screening, unless otherwise indicated.
  - 3. Screening Type: Insect screening, as indicated.
- B. Secure screens to louver frames with stainless-steel machine screws, spaced a maximum of 6 inches from each corner and at 12 inches o.c.

- C. Louver Screen Frames: Fabricate screen frames with mitered corners to louver sizes indicated and to comply with the following requirements:
  - 1. Metal: Same kind and form of metal as indicated for louver to which screens are attached..
    - a. Reinforce extruded-aluminum screen frames at corners with clips.
  - 2. Finish: Same finish as louver frames to which louver screens are attached.
  - 3. Type: Rewirable frames with a driven spline or insert for securing screen mesh.
- D. Louver Screening for Aluminum Louvers: As follows:
  - 1. Bird Screening: Aluminum, ½-inch-square mesh, 0.063-inch wire
  - 2. Insect Screening: Aluminum, 18-by-16 mesh, 0.012-inch wire.
- E. Louver Screening for Galvanized Steel Louvers: As follows:
  - 1. Bird Screening: Galvanized steel, ½-inch square mesh, 0.047-inch wire.
  - 2. Insect Screening: Galvanized steel, 18-by-14 mesh, 0.011-inch wire.
  - 3. Insect Screening: Aluminum, 18-by-16 mesh, 0.012-inch wire.
- F. Louver Screening for Galvanized Steel Louvers: As follows:
  - 1. Bird Screening: Galvanized steel, 1/2-inch-square mesh, 0.047-inch wire.
  - 2. Insect Screening: Galvanized steel, 18-by-14 mesh, 0.011-inch wire.

## **2.06 BLANK-OFF PANELS:**

- A. General: Fabricate blank-off panels from materials and to sizes indicated and comply with the following requirements:
  - 1. Finish: Same as finish applied to louvers.
  - 2. Attach blank-off panels to back of louver frames with clips.
- B. Insulated, Blank-off Panels: Laminated metal-faced panels consisting of insulating core surfaced on back and front with metal sheets, complying with the following requirements:
  - 1. Thickness: 1 inch.
  - 2. Metal Facing Sheets: Aluminum sheet, 0.032 inch thick.
  - 3. Insulating Core: Unfaced, rigid, glass-fiberboard insulation complying with ASTM C612, Class 1 and 2.
  - 4. Edge Treatment: Trim perimeter edges of blank-off panels with louver manufacturer's standard extruded-aluminum-channel frames 0.081 inch -thick, with corners mitered and with same finish as panels.

## **2.07 FINISHES, GENERAL:**

- A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- B. Finish louvers after assembly.

## **2.08 ALUMINUM FINISHES:**

- A. Finish designations prefixed by AA comply with system established by the Aluminum Association for designating aluminum finishes.
- B. Class II, Clear Anodic Finish: AA-M12C22A31 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class II, clear coating 0.010 mm or thicker) complying with AAMA 607.1.

- C. Baked-Enamel Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; Organic Coating: as specified below). Apply baked enamel complying with paint manufacturer's specifications for cleaning, conversion coating, and painting.
  - 1. Organic Coating: Thermosetting, modified-acrylic enamel primer/topcoat system complying with AAMA 603.8, except with a minimum dry film thickness of 1.5 mils, medium gloss.
  - 2. Color: As selected by the Engineer from manufacturer's full range of colors.
- D. High-Performance Organic Coating Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; Organic Coating: as specified below). Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
  - 1. Fluoropolymer Three-Coat Coating System: Manufacturer's standard three-coat, thermocured system consisting of specially formulated inhibitive primer, fluoropolymer color coat, and clear fluoropolymer topcoat, with both color coat and clear topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight; complying with AAMA 605.2.
    - a. Color and Gloss: As selected by the Engineer from manufacturer's full range of colors and glosses.

## **2.09 GALVANIZED STEEL SHEET FINISHES:**

- A. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A780. Apply a conversion coating of type suited to organic coating applied over it.
- B. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-enamel finish consisting of prime coat and thermosetting topcoat, with not less than 1.0-mil dry film thickness for topcoat. Comply with paint manufacturer's written instructions for applying and baking to achieve a minimum dry film thickness of 2.0 mils.
  - 1. Color and Gloss: As selected by the Engineer from manufacturer's full range of colors and glosses.

## **PART 2 - EXECUTION**

### **3.01 PREPARATION:**

- A. Coordinate Setting Drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

### **3.02 INSTALLATION:**

- A. Locate and place louver units level, plumb, and at indicated alignment with adjacent work.
- B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.
- C. Form closely fitted joints with exposed connections accurately located and secured.
- D. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated

- E. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.
- F. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.
- G. Install concealed gaskets, flashings, joint fillers, and insulation, as louver installation progresses, where weathertight louver joints are required. Comply with Section 07900 for sealants applied during louver installation.

### **3.03 ADJUSTING, CLEANING, AND PROTECTING:**

- A. Test operation of adjustable louvers and adjust as needed to produce fully functioning units that comply with requirements.
- B. Periodically clean exposed surfaces of louvers and vents that are not protected by temporary covering to remove fingerprints and soil during construction period. Do not let soil accumulate until final cleaning.
- C. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.
- D. Protect louvers and vents from damage during construction. Use temporary protective coverings where needed and approved by louver manufacturer. Remove protective covering at the time of Substantial Completion.
- E. Restore louvers and vents damaged during installation and construction so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.
  - 1. Clean and touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.

**END OF SECTION**

## SECTION 10505

### METAL LOCKERS

#### PART 1 -GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing metal wardrobe lockers and wood benches.
- B. Related Work Specified Elsewhere:
  - 1. Cast-in-Place Structural Concrete: Section 03300.
  - 2. Concrete Unit Masonry: Section 04220.
  - 3. Rough Carpentry: Section 06100.
  - 4. Seals and Sealants: Section 07900.
  - 5. Tile: Section 09320.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Product Data: Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type of locker and bench.
  - 2. Shop Drawings: Include plans, elevations, sections, details, and attachments to other Work.
    - a. Show locker fillers, trim, base, sloping tops, and accessories. Include locker-numbering sequence.
  - 3. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for units with factory-applied color finishes.
  - 4. Samples for Verification: For the following products, in manufacturer's standard sizes, showing the full range of color, texture, and pattern variations expected. Prepare Samples from the same material to be used for the Work.
    - a. Lockers: Three samples, on metal, of each color and finish to be provided on lockers.
    - b. Locker benches: Three samples of finished wood.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ADA: Americans with Disabilities Act.
  - 3. ASTM: A366.
  - 4. NAAMM: Metal Finishes for Architectural and Metal Products.
- B. Source Limitations: Where practical, obtain locker units and accessories through one source from a single manufacturer.

##### 1.04 DELIVERY, STORAGE, AND HANDLING:

- A. Do not deliver lockers until spaces to receive them are clean, dry, and ready for locker installation
- B. Ship lockers assembled with number plates attached.
- C. Protect lockers from damage during delivery, handling, storage, and installation.

- D. Deliver master keys, control keys, and combination control charts to the Engineer.

#### **1.05 COORDINATION:**

- A. If applicable, coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified in Section 03300 "Cast-in-Place Concrete."

### **PART 2 - PRODUCTS**

#### **2.01 MATERIALS:**

- A. Cold-Rolled Steel Sheet: ASTM A366/A366M, matte finish, suitable for exposed applications, and stretcher leveled or roller leveled to stretcher-leveled flatness.
- B. Fasteners: Zinc- or nickel-plated steel, slotless-type exposed bolt heads, and self-locking nuts or lock washers for nuts on moving parts.

#### **2.02 LOCKERS:**

- A. Body: Form backs, tops, bottoms, sides and intermediate partitions from steel sheet; flanged for double thickness at back vertical corners. Comply with the following:
  - 1. Back-Material Sheet Thickness: 0.0478-inch-thick minimum.
  - 2. Side-Material Sheet Thickness: 0.0598-inch-thick minimum.
- B. Frames: Form channel frames from minimum 0.0598-inch-thick steel sheet; lapped and welded at corners. Form continuous integral door strike on vertical frame members. Provide resilient bumpers to cushion door closing.
  - 1. Latch Hooks: Form from minimum 0.1046-inch-thick steel; welded or riveted to door frames.
  - 2. Cross Frames: Form intermediate channel cross frames between tiers from minimum 0.0598-inch-thick steel sheet. Weld to vertical frame members.
- C. Solid Steel Doors: One-piece steel sheet, formed into channel shape at vertical edges and flanged at right angles at top and bottom edges. Fabricate to prevent springing when opening or closing, and to swing 180 degrees. Comply with the following:
  - 1. Sheet Thickness: 0.0598 inch minimum.
  - 2. Reinforcement: Brace or reinforce inner face of doors more than 15 inches wide.
  - 3. Louvered Vents: Stamped, louvered vents in door face, as follows:
    - a. Single-Tier Lockers: No fewer than six louver openings at top and bottom.
    - b. Double-Tier Lockers: No fewer than three louver openings at top and bottom.
- D. Shelves: Provide hat shelf in single-tier units, fabricated from minimum 0.0598-inch-thick formed-steel sheet; flanged on all edges.
- E. Hinges: Steel, full loop, five or seven knuckle; tight pin; minimum 2 inches high. Weld to inside of door frame and attach to door with at least two factory-installed fasteners that are completely concealed and tamper resistant when door is closed.
  - 1. Provide at least three hinges for each door more than 42 inches high and at least two hinges for each door 42 inches high or less.
- F. Continuous Hinges: Manufacturer's standard, steel continuous hinge mounted to door and frame.

- G. Recessed Handle and Latch: Manufacturer's standard housing, formed from 0.0359-inch-thick nickel-plated steel or stainless steel, with integral door pull, recessed for latch lifter and locking devices; nonprotruding latch lifter; and automatic, prelocking, pry-resistant latch, as follows:
  - 1. Provide minimum three-point latching for each door more than 42 inches high; minimum two-point latching for each door 42 inches high or less.
    - a. Provide strike and eye for padlock.

### **2.03 LOCKER ACCESSORIES:**

- A. Interior Equipment: Furnish each locker with the following items, unless otherwise indicated:
  - 1. Hooks: Manufacturer's standard zinc-plated, ball-pointed steel. Provide one double-prong ceiling hook, and not fewer than two single-prong wall hooks for single-, double-, and triple-tier units. Attach hooks with at least two fasteners.
  - 2. Coat Rods: Manufacturer's standard galvanized steel. Provide rod in lieu of ceiling hook for lockers 18 inches deep or greater.
- B. Number Plates: Manufacturer's standard etched, embossed, or stamped, aluminum number plates with numerals at least 3/8 inch high. Number lockers in sequence as directed by Engineer. Attach plates to each locker door, near top, centered, with at least two aluminum rivets.
- C. Continuous Metal Base: Minimum 0.0598-inch-thick steel sheet, 4 inches high or as indicated on approved shop drawings, channel or zee profiled for stiffness, fabricated in lengths as long as practicable to enclose base and base ends of lockers, and finished to match lockers.
- D. Individually Sloping Tops: Manufacturer's standard, fabricated from minimum 0.0239-inch-thick steel sheet, for installation in place of flat locker tops. Fabricate tops in width to fit one locker frame, with integral back, finished to match lockers. Provide fasteners, filler plates, supports, and wedge-shaped divider panels for each locker upright.
- E. Recess Trim: Manufacturer's standard; fabricated from minimum 0.0478-inch-thick steel sheet, minimum 2-1/2-inch face width, and finished to match lockers. Fabricate trim in lengths as long as practicable.
- F. Filler Panels: Manufacturer's standard; fabricated from minimum 0.0478-inch-thick steel sheet in an unequal leg angle shape, and finished to match lockers. Provide slip joint filler angle formed to receive filler panel.
- G. Finished End Panels: Manufacturer's standard; fabricated from minimum 0.0239-inch-thick steel sheet, finished to match lockers, and designed for concealing exposed ends of nonrecessed lockers.
  - 1. Provide one-piece panels for double-row (back-to-back) locker ends.

### **2.04 LOCKER BENCHES:**

- A. Bench Tops: Provide manufacturer's standard one-piece units, of the following material, minimum 9-1/2 inches wide by 1-1/4 inches thick, with rounded corners and edges:
  - 1. Laminated maple with one coat of clear sealer on all surfaces, and one coat of clear lacquer on top and sides.
- B. Pedestals: Provide manufacturer's standard pedestal supports, with predrilled fastener holes, complete with fasteners and anchors, and as follows:

1. Type: Tubular steel, minimum 1-1/2-inch diameter, threaded on both ends, with standard pipe flange at top and bell-shaped cast base; baked-enamel finish; floor anchored with concealed fasteners.
  - a. Color: As selected by the Engineer from manufacturer's full range.
- C. Furnish a minimum of two pedestals for each bench, with pedestal spacing not more than 72 inches o.c.

## **2.05 FABRICATION:**

- A. Unit Principle: Fabricate each locker with an individual door and frame, individual top, bottom, back, and shelves, and common intermediate uprights separating compartments.
- B. All-Welded Construction: Preassemble lockers by welding all joints, seams, and connections, with no bolts, screws, or rivets used in assembly. Grind exposed welds flush.
- C. Fabricate lockers square, rigid, and without warp, with metal faces flat and free of dents or distortion. Make exposed metal edges free of sharp edges and burrs, and safe to touch. Weld frame members together to form a rigid, one-piece assembly.
  1. Form locker-body panels, doors, shelves and accessories from one-piece steel sheet, unless otherwise indicated.

## **2.06 FINISHES, GENERAL:**

- A. Finish all steel surfaces and accessories, except prefinished stainless-steel and chrome-plated surfaces.
- B. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- C. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- D. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

## **2.07 STEEL SHEET FINISHES:**

- A. Surface Preparation: Clean surfaces of dirt, oil, grease, mill scale, rust, and other contaminants that could impair paint bond. Use manufacturer's standard methods.
- B. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard baked-enamel finish consisting of a thermosetting topcoat. Comply with paint manufacturer's written instructions for applying and baking to achieve a minimum dry film thickness of 1.4 mils on doors, frames, and legs, and 1.1 mils elsewhere.
  1. Color and Gloss: As selected by the Engineer from manufacturer's full range.

## **PART 3 - EXECUTION**

### **3.01 EXAMINATION:**

- A. Examine concrete bases for suitable conditions where metal lockers are to be installed.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.02 INSTALLATION:**

- A. Install metal lockers and accessories level, plumb, rigid, and flush according to manufacturer's written instructions.
- B. Connect groups of all-welded lockers together with standard fasteners, with no exposed fasteners on face frames.
- C. Anchor lockers to floors and walls at intervals recommended by manufacturer, but not more than 36 inches o.c. Install anchors through backup reinforcing plates where necessary to avoid metal distortion, using concealed fasteners.
- D. Fit exposed connections of trim, fillers, and closures accurately together to form tight, hairline joints, with concealed fasteners and splice plates.
  1. Attach recess trim to recessed lockers with concealed clips.
  2. Attach sloping top units to lockers, with closures at exposed ends.
- E. Attach finished end panels with fasteners only at perimeter to conceal exposed ends of nonrecessed lockers.
- F. Anchor locker benches to floors Uniformly space pedestals not more than 72 inches apart, and securely fasten to bench top and anchor to floor.

### **3.03 ADJUSTING, CLEANING, AND PROTECTION:**

- A. Adjust doors and latches to operate easily without binding. Verify that integral locking devices operate properly.
- B. Clean interior and exposed exterior surfaces and polish stainless-steel and nonferrous-metal surfaces.
- C. Protect lockers from damage, abuse, dust, dirt, stain, or paint. Do not permit locker use during construction.
- D. Touch up marred finishes, or replace locker units that cannot be restored to factory-finished appearance. Use only materials and procedures recommended or furnished by locker manufacturer.

**END OF SECTION**

## SECTION 10605

### WIRE MESH PARTITIONS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing woven wire mesh panels for the following:
  - 1. Wire mesh partitions.
  - 2. Wire mesh window guards.
  - 3. Wire mesh railing insert panels.
- B. Related Work Specified Elsewhere
  - 1. Handrails and Railings: Section 05521.
  - 2. Aluminum Entrances and Storefronts: Section 08410 for lock cylinders.

##### 1.02 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Engage a firm experienced in manufacturing wire mesh partitions similar to those indicated for this Project and that have a record of successful in-service performance.
- B. Structural Performance: As specified in Section 05521 for railing insert panels.
- C. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of wire mesh partitions and wire mesh insert panels that are similar to those indicated for this Project in material, design, and extent.

##### 1.03 DEFINITIONS

- A. The types of weaves for the wire mesh specified in this Section and defined in ASTM E 437 and its Appendix X4.2:
  - 1. Plain Weave: Wires pass over one and under the next adjacent wire in both directions.
  - 2. Lock Crimped: Deep crimps at points of intersection to lock the wires securely in place.
  - 3. Intercrimped: Similar to plain weave with extra crimps between the intersections.

##### 1.04 SUBMITTALS:

- A. Submit the following for approval in accordance with the Special Conditions and with the additional requirements as specified for each:
  - 1. Product Data for each type of product specified, consisting of manufacturer's specification, technical data, and installation instructions.
  - 2. Shop Drawings showing fabrication and installation of wire mesh partitions, window guards, railing insert panel and access panels, including plans, elevations, and large-scale details showing anchorage and accessory items. Provide location template drawings for items supported or anchored to permanent construction.
    - a) For steel channel and tube framing of wire mesh partitions and railing insert guards, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

3. Samples of a 12-by-12-inch 300-by-300-mm wire mesh panel constructed of specified frame members, wire mesh, and color charts.

#### **1.05 JOB CONDITIONS**

- A. Field Measurements: Check actual locations for wire mesh products by accurate field measurements before fabrication and show recorded measurements on Shop Drawings. Coordinate fabrication and delivery schedules with construction progress to avoid delaying the Work.
  1. Where field measurements cannot be made without delaying the Work, guarantee location dimensions and proceed with fabricating wire mesh products without field measurements. Coordinate wall, column, floor, and ceiling construction to ensure that actual location dimensions correspond to guaranteed dimensions.

### **PART 2 - PRODUCTS**

#### **2.01 MANUFACTURERS**

- A. Woven wire partitions, Window Guards and Insert Panels: Manufactured by the G - S Company, or provide systems, as approved by the Engineer, of similar quality and appearance to match construction quality and appearance of the specified manufacturer.

#### **2.02 MATERIALS**

- A. Steel Channels, Angles, Plates, and Bars: ASTM A 36 ASTM A 36M.
- B. Steel Sheet: ASTM A 568 ASTM A 568M.
- C. Cold-Rolled Steel Channels: Formed from steel sheet.
- D. Square Steel Tubing: Cold-formed structural steel tubing, ASTM A 500.
- E. Galvanized Steel Wire: ASTM A 641 ASTM A 641M.
- F. Galvanized Steel Sheet: Commercial-quality, hot-dip-coated steel sheet, ASTM A 653, with G60 or A60 ASTM A 653M, with Z180 or ZF180 coating.
- G. Bent Plate Channel: Formed from galvanized steel sheet.

#### **2.03 WIRE MESH PARTITIONS:**

- A. Mesh: 0.135-inch-3.4-mm- diameter, plain-weave, galvanized steel wire woven into 3 inch 38-mm square pattern, insert through frame members, and welded into frame square pattern, inserted through.
- B. Frames: Provide galvanized steel fasteners and other items shown or necessary for partition installation.
  1. Vertical Members: 1-1/4-by-5/8-by-0.108-inch hot dipped galvanized steel C-Section channels with 1/4-inch- diameter bolt holes approximately 18 inches 450 mm o.c.
  2. Horizontal Members: 1-by-1/2-by-1/8-inch hot dipped galvanized steel channels, mortised and tenoned to vertical members.
  3. Horizontal Reinforcing Members: 1-by-1/2-by-1/8-inch hot dipped galvanized steel channels with wire woven through or two 1-by-1/2-inch galvanized steel channels bolted or riveted toe-to-toe through mesh, and secured to vertical members. Provide number of horizontal reinforcing members to suit panel height as recommended by

partition manufacturer.

- C. Top Capping Bars: 2-1/4-by-1-inch hot dipped galvanized steel channels, secured to top framing channels with 1/4-inch- diameter, galvanized "U" bolts spaced not more than 28 inches o.c.
- D. Corner Posts: 1-1/4-by-1-1/4-by-1/8-inch hot dipped galvanized steel angles with floor shoe galvanized per ASTM A 123 and 1/4-inch- diameter bolt holes to align with bolt holes in vertical frame members.
- E. Floor Shoes: Cast aluminum or steel galvanized per ASTM A 123, sized to suit vertical framing and to provide approximately 3 inches 75 mm of clear space between finished floor and bottom horizontal frame members. Furnish units with set screws for leveling adjustment.

#### **2.04 DOORS:**

- A. Hinged Door: Door frame of 1-1/4-by-1/2-by-1/8-inch hot dipped galvanized steel c-section channels with 1-1/4-by-1/8-inch flat steel bar cover plates on 3 sides, and 1/8-inch- thick angle strike bar and cover on lock side. Provide 1-1/2 pairs of 3-by-3-inch butt hinges riveted or welded to door and frame, and mortise-type cylinder lock operated by key outside with recessed knob inside. Align bottom of door with bottom of adjacent panels.
- B. Provide manufacturer's standard cylinders for lock.

#### **2.05 WINDOW GUARDS**

- A. Mesh: 0.135-inch-diameter, lock-crimped galvanized steel wire woven into a 4-inch , 45 degree pattern, inserted through frame holes and welded into frame.
- B. Frames:
  - 1. Frames 1 1/4-by-1/2-by-1/8-inch hot dipped galvanized, cold-rolled steel channels.
  - 2. Frames at Window Guards: Hot dipped galvanized bent plate channel, sized to fit adjacent to curtainwall framing.
- C. Anchorage Devices: Furnish appropriate types and quantities of anchorage devices to provide adequate anchorage to adjacent structures.
- D. Access Panels: Provide the following at bridge walkway guards where shown:
  - 1. Jambs: Provide 1-1/4-by-1-1/4-by-1/8-inch steel angle jamb bars with bolt holes for anchorage spaced a maximum of 24 inches o.c.
  - 2. Hinging: Furnish 1 pair of 3-by-3-inch butt hinges.
  - 3. Locking Device: mortise l- type cylinder lock as specified in Section 08410.

#### **2.06 STAIRWAY PARTITIONS RAILING INSERT PANELS:**

- A. Mesh: 0.135-inch-diameter, plain-weave galvanized steel wire woven into a 3-inch square pattern, inserted through frame holes and welded into frame. Vertical wires are plumb. Horizontal wires are perpendicular to vertical wires.
- B. Frames: 1 1/4 -by-1/2-by-1/8-inch hot dipped galvanized cold-rolled steel channels.

#### **2.07 FABRICATION:**

- A. Do not use components less than sizes indicated. Use larger-size components as recommended by partition component manufacturer.

- B. Provide bolts, hardware, and accessories for complete installation.

## **2.08 FINISHES:**

- A. Wire Mesh Partitions and Doors: Manufacturer's standard shop - applied enamel finishes.
- B. Stairway Partitions and Railing insert panels:
  - 1. Manufacturer's standard shop - applied enamel finish.
- C. Window Guards:
  - 1. Manufacturer's standard polyester powder coat finish.

## **PART 3 - EXECUTION**

### **3.01 PREPARATION**

- A. Coordinate and furnish anchorages, setting drawings, diagrams, templates, instructions, and directions for installing anchorages, including concrete inserts, sleeves, anchor bolts, and miscellaneous items having integral anchors embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

### **3.02 INSTALLATION**

- A. Erect partitions plumb, rigid, properly aligned, and securely fastened in place, complying with Drawings and manufacturer's recommendations.
- B. Provide additional field bracing as shown on approved shop drawings or necessary for rigid, secure installation. Installer to provide additional clips and bracing as required.
- C. Attach window guards to inside face of aluminum curtain wall as shown on approved shop drawings. Fasten screws into pre-drilled holes with vinyl insert to prevent contact between dissimilar metals. Provide fasteners spaced evenly to screw to curtain wall system as shown on the approved shop drawings.

### **3.03 ADJUSTING AND CLEANING**

- A. Adjust moving components for smooth operation without binding.
- B. Touch up damaged finish after completing installation using field-applied paint to match color of shop-applied finish.

**END OF SECTION**

## SECTION 10810

### TOILET ACCESSORIES

#### PART 1 -GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing toilet accessories, including:
  - 1. Sanitary napkin vendors.
  - 2. Sanitary napkin disposal units.
  - 3. Framed mirrors with shelves.
  - 4. Framed mirrors without shelves.
  - 5. Liquid soap dispensers.
  - 6. Toilet paper dispensers.
  - 7. Clothes hook and bumpers.
  - 8. Paper towel dispensers.
  - 9. Waste receptacles.
  - 10. Grab bars.
  
- B. Related Work Specified Elsewhere:
  - 1. Tile: Section 09320.
  - 2. Toilet Compartments: Section 10155.
  - 3. Stone Toilet Compartments: Section 10180.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop drawings: Detailed shop drawings, including fastenings, manufacturer's installation instructions and other information. Submit prior to ordering materials or beginning installation.
  
  - 2. Samples:
    - a. For each accessory item to verify design, operation, and finish requirements. One each
    - b. Special anchors, plates or embedded items required because of the conditions in this project. One each. Submit with the related accessory samples. Delete subparagraph below if not applicable.
  
  - 3. Setting Drawings: For cutouts required in other work; include templates, substrate preparation instructions, and directions for preparing cutouts and installing anchoring devices.. Retain paragraph below for large, complicated projects. Revise to suit Project.

##### 1.03 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ADA (Americans with Disabilities Act).
  - 3. ASTM: A666, C1036, F446.
  - 4. FS: DD-M-411.
  
- B. Manufacturer Qualifications: Provide products of an established manufacturer regularly engaged in the production of toilet accessories.

- C. Source Limitations: Provide products of same manufacturer for each type of accessory unit and for units exposed to view in same areas, unless otherwise approved by the Engineer. Retain paragraph below if products are listed in schedule at the end of Part 3. See Evaluations. Retain one of three subparagraphs below, depending on Specification method selected. Correlate with Part 2 "Manufacturers" Article and schedule at the end of Part 3. See descriptions of specifying methods and examples of completed schedules in the Evaluations.

**1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Deliver products to the job site in original unopened containers clearly labeled with the manufacturer's name, brand designation and type as applicable.
- B. Store products in an approved dry area, protect from contact with soil and from exposure to the elements. Keep products dry.
- C. Handle products so as to prevent breakage of containers and damage to products.

**1.05 COORDINATION:**

- A. Coordinate accessory locations with other work to prevent interference with clearances required for access by disabled persons, proper installation, adjustment, operation, cleaning, and servicing of accessories.
- B. Deliver inserts and anchoring devices set into concrete or masonry as required to prevent delaying the Work..

**PART 2 -PRODUCTS**

**2.01 MATERIALS, GENERAL:**

- A. Provide toilet accessories of an approved manufacturer; provided complete with fasteners appropriate for surface which applied. Satin-finish stainless steel unless otherwise noted.
- B. Exposed fastenings finished to match accessories.
- C. Labels, decals and cast-in or embossed identification in conspicuous places on accessories is prohibited.
- D. Use only products which comply with barrier-free accessibility guidelines of ADA.
- E. Quantity and location are as shown.

**2.02 MATERIALS:**

- A. Stainless Steel: ASTM A666, Type 304, with No. 4 finish (satin), in 0.0312-inch minimum nominal thickness, unless otherwise indicated.
- B. Mirror Glass: ASTM C1036, Type I, Class 1, Quality q2, nominal 6.0 mm thick, with silvering, electroplated copper coating, and protective organic coating complying with FS DD-M-411.
- C. Fasteners: Screws, bolts, and other devices of same material as accessory unit, tamper and theft resistant when exposed, and of galvanized steel when concealed.

**2.03 PRODUCTS:**

- A. Sanitary Napkin Vendor: Provide stainless-steel sanitary napkin vendor complying with the following:
1. Products: Bobrick B-2800, or equal.
  2. General: Fabricate cabinet of all-welded construction. Provide seamless door with returned edges and secured by tumbler lockset. Provide identification reading "Napkins" and "Tampons"; brand-name advertising is not allowed. Capacity not less than 15 napkins and 20 tampons.
  3. Mounting: Surface-mounted type.
  4. Operation: Single-coin operation, 10 cents.
- B. Sanitary Napkin Disposal Unit: Provide stainless-steel sanitary napkin disposal unit complying with the following:
1. Products: Bobrick 270, or equal.
  2. Surface-Mounted Type: With seamless exposed walls; self-closing top cover; locking bottom panel with stainless-steel, continuous hinge; and removable, reusable receptacle.
- C. Framed Mirror with Shelf: Provide framed mirror with shelf complying with the following:
1. Products: Bobrick B-166-1836, or equal.
  2. Glass: 1/4-inch float/plate glass, No. 1 quality.
  3. Stainless-Steel, Channel-Framed Mirror: Fabricate frame from stainless-steel channels in manufacturer's standard satin finish with square corners mitered to hairline joints and mechanically interlocked. Provide concealed wall mounting bracket for theft-proof installation.
    - a. Integral Shelf: Stainless steel in thickness recommended by manufacturer, but not less than thickness of mirror frame, approximately 5 inches deep by width of mirror, with edges turned down and returned for rigidity; secure shelf to bottom of mirror frame.
- D. Framed Mirror without Shelf: Provide framed mirror without shelf complying with the following:
1. Products: Bobrick B-165-1836, or equal.
  2. Glass: 1/4-inch float/plate glass, No. 1 quality.
  3. Stainless-Steel, Channel-Framed Mirror: Fabricate frame from stainless-steel channels in manufacturer's standard satin finish with square corners mitered to hairline joints and mechanically interlocked. Provide concealed wall mounting bracket for theft-proof installation.
- E. Liquid Soap Dispenser: Provide liquid soap dispenser complying with the following:
1. Products: Bobrick B-2112, or equal.
  2. Liquid Soap Dispenser, Horizontal-Tank Type: Surface-mounted type, minimum 40-oz. capacity tank with stainless-steel piston, springs, and internal parts designed to dispense soap in measured quantity by pump action; and stainless-steel cover with unbreakable window-type refill indicator. Vandal resistant.
    - a. Soap Valve: Designed for dispensing soap in liquid form.
- F. Toilet Tissue Dispenser: Provide toilet tissue dispenser complying with the following:
1. Products: Bobrick B-274, or equal.
  2. Type: Double-roll dispenser.
  3. Mounting: Surface mounted with concealed anchorage.
  4. Material: Satin-finish aluminum bracket with plastic spindle.
  5. Operation: Eccentric-shaped, molded-plastic spindle revolves one-half revolution per dispensing operation for controlled delivery; core cannot be removed until roll is empty.
  6. Capacity: Designed for tissue rolls up to 6-inch-diameter.
- G. Clothes Hook and Bumper: Provide clothes hook and bumper complying with the following:

1. Products: Bobrick B-212, or equal.
  2. Material: Solid aluminum casting with matte finish. Rubber bumper protects wall or partition surfaces.
- H. Paper Towel Dispenser: Provide stainless-steel paper towel dispenser complying with the following:
1. Products: Bobrick B-262, or equal.
  2. Surface-Mounted Type: Sized for minimum of 400 C-fold or 525 multifold paper towels without using special adapters; with hinged front equipped with tumbler lockset; and with refill indicators that are pierced slots at sides or front.
- I. Waste Receptacle: Provide stainless-steel waste receptacle complying with the following:
1. Products: Bobrick B-275, or equal.
  2. Surface-Mounted Type: With seamless exposed walls; continuously welded bottom pan; and minimum 20-gal. capacity, reusable, vinyl liner secured at not less than four points with grommets and hooks.
- J. Grab Bar: Provide stainless-steel grab bar complying with the following:
1. Products: Bobrick B-6106, or equal. Comply with ADA.
  2. Material: Bar 18-gauge wall Type 304 stainless steel.
  3. Mounting: Exposed with manufacturer's standard flanges and anchors.
  4. Gripping Surfaces: Smooth, satin finish, unless otherwise noted.
  5. Outside Diameter: 1-1/2 inches for heavy-duty applications.
  6. At water closets for the handicapped, provide the following unless otherwise shown:
    - a. Back wall: 36-inch minimum length grab bar behind the water closet.
    - b. Side wall: 42-inch minimum length grab bar to the side of the water closet.

#### **2.04 FABRICATION:**

- A. General: Names or labels are not permitted on exposed face of accessories. On interior surface not exposed to view or back surface of each accessory, provide printed, waterproof label or stamped nameplate indicating manufacturer's name and product model number.
- B. Surface-Mounted Toilet Accessories: Unless otherwise indicated, fabricate units with tight seams and joints, and exposed edges rolled. Hang doors and access panels with continuous stainless-steel hinge. Provide concealed anchorage where possible.
- C. Framed Glass-Mirror Units: Fabricate frames for glass-mirror units to accommodate glass edge protection material. Provide mirror backing and support system that permits rigid, tamper-resistant glass installation and prevents moisture accumulation.
1. Provide galvanized steel backing sheet, not less than 0.034 inch and full mirror size, with nonabsorptive filler material. Corrugated cardboard is not an acceptable filler material.
- D. Mirror-Unit Hangers: Provide mirror-unit mounting system that permits rigid, tamper- and theft-resistant installation, as follows:
1. Heavy-duty wall brackets of galvanized steel, equipped with concealed locking devices requiring a special tool to remove
- E. Keys: Provide universal keys for internal access to accessories for servicing and resupplying. Provide minimum of six keys to the Engineer.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION:**

- A. Coordinate with other trades for concealed back plates, blocking and anchoring devices embedded or built into work of other trades.
- B. After mounting surfaces have been painted, install accessories in accordance with manufacturer's recommendations.
- C. Install accessories according to manufacturers' written instructions, using fasteners appropriate to substrate indicated and recommended by unit manufacturer. Install units level, plumb, and firmly anchored in locations and at heights recommended by the manufacturer unless otherwise shown or required by regulations. Comply with ADA.
  - 1. At water closets for the handicapped, mount grab bars as follows unless otherwise shown:
    - a. Back wall: Mount grab bar at a height between 33 and 36 inches above finish floor and to extend a minimum of 12 inches beyond the center of the water closet toward the side wall and a minimum of 24 inches toward the open side for either a left or right side approach.
    - b. Side wall: Mount grab bar at a height between 33 and 36 inches above finish floor and spaced 12 inches maximum from the back wall and extending a minimum of 54 inches from the back wall.
  - 2. At water closets for the handicapped, mount toilet paper dispenser at a minimum height of 19 inches above finish floor.
- D. Secure mirrors to walls in concealed, tamper-resistant manner with special hangers, toggle bolts, or screws. Set units level, plumb, and square at locations indicated, according to manufacturer's written instructions for substrate indicated.
- E. Install grab bars to withstand a downward load of at least 250 lbf, when tested according to method in ASTM F446.
- F. After installation, protect the toilet accessories from damage and soiling.

**3.02 TESTING AND ADJUSTING OF COMPLETED WORK:**

- A. Test accessories for unencumbered, smooth operation and verify that mechanisms function properly.
- B. Replace damaged or defective items.
- C. Test for required strength and for pull-out and pull-off of grab bars. Remove and reattach as needed.

**3.02 CLEANING:**

- A. Remove temporary labels and protective coatings.
- B. Before final acceptance, clean and polish exposed surfaces according to manufacturer's written recommendations.
- C. Leave areas surrounding the work in broom-clean condition.

**END OF SECTION**

**DIVISION 11 - EQUIPMENT**

- 11010 ROOF ANCHORS
- 11150 PARKING ACCESS AND REVENUE CONTROL
- 11155 MECHANICAL PARKING METERS
- 11156 ELECTRONIC PARKING METERS

**END OF SECTION**

## SECTION 11010

### ROOF ANCHORS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. Work of this section includes the design, supply and installation of anchors for window washing/suspended maintenance equipment.
- B. Related work specified elsewhere:
  - 1. Division 3 - Concrete
  - 2. Division 5 - Metals
  - 3. Division 7 - Thermal And Moisture Protection

##### 1.02 REFERENCES:

- A. AISC publication "Load and Resistance Factor Design Specification for Structural Steel Buildings".
- B. AISI publication "Specification for Design of Cold-Formed Steel Structural Members (1986 & 1989 Addendum)".
- C. Aluminum Association publication No.30 "Specification for Aluminum Structures" and AWS D1.2-90 Structural Welding Code - Aluminum.
- D. AWS D1.1 Structural Welding Code - Steel.

##### 1.03 DESIGN REQUIREMENTS:

- A. Design window washing/suspended maintenance system to suit building and in accordance with plans, specifications, standards, and regulations/codes contained in section 1.4 and 1.8.
- B. Locate safety and tie-back anchors to suit suspension equipment which will be used on the building with respect to items such as reach, rigging, spacing, roof edge condition and similar items.
- C. Design all anchor components to provide adequate attachment to the building and suited to current window washing/suspended maintenance practices. Ensure compatibility with industry standard equipment.
- D. Ensure all anchor components conform to proper engineering principles and have been designed by a Professional Engineer qualified in the design of window washing/suspended maintenance equipment, its application and safety requirements.
- E. Design system fall arrest safety anchors to comply with the following structural requirements:
  - 1. Designed to resist a 5,000 lb. (22.2 kN) horizontal load in any direction without detachment or fracture occurring. This load is considered to be an ultimate peak dynamic load and yielding of the anchor and structure in the event of a fall is not precluded. To avoid deformation under normal usage, anchors are to be generally designed to resist a 1,000 lb. (4.5 kN) static horizontal load in any direction without yielding.

#### **1.04 SHOP DRAWINGS AND ENGINEERING CERTIFICATION**

- A. Submit shop drawings showing complete layout and configuration of complete window washing/suspended maintenance system, including all components and accessories. Clearly indicate design and fabrication details, window "drops", hardware, and installation details.
- B. Shop drawings to include installation and rigging instructions and all necessary Restrictive and Non- Restrictive Working Usage Notes and General Safety Notes.
- C. Shop drawings complete with calculations to be reviewed by and bearstamp of a professional engineer.

#### **1.05 QUALIFICATIONS**

- A. Manufacturer: Work of this Section to be executed by manufacturer specializing in the design, fabrication and installation of window washing/suspended maintenance systems having a minimum of 5 years documented experience
- B. Loading and safety assurance: Work of this Section to meet the requirements of governing codes and jurisdiction and to comply with properly engineered loading and safety criteria for the intended use.
- C. Insurance: Manufacturer to carry specific liability insurance (products and completed operations) in the amount of \$2,000,000.00 to protect against product/system failure.
- D. Welding to be executed by welders qualified to work in the State in which the project is being completed.

#### **1.06 REGULATORY REQUIREMENTS**

- A. Comply with the following OSHA regulations:
  - 1. 1910, Subpart D (Walking and Working Surfaces).
  - 2. Appendix C to 1910 (Personal Fall Arrest Systems).
  - 3. "OSHA Ruling on Window Cleaning by Bosun's Chair" Memorandum to Regional Administrators from P. K. Clark, Director, Directorate of Compliance Program
  - 4. 1910, Subpart F (Powered Platforms).

#### **1.07 MAINTENANCE DATA**

- A. Submit 1 copy of system Equipment Manual & Inspection Log Book, with "Initial Inspection - Certification for Use" and "Inspection Sign-Off" forms completed.
- B. Submit 2 copies of a reduced plastic laminated as-built shop drawing showing equipment locations and details. This drawing is to be posted near exits onto the roof.

### **PART 2 - PRODUCTS**

#### **2.01 MANUFACTURER**

- A. This specification is generally based on systems currently being manufactured by PRO-BEL, Telephone: (905) 427-0616, Fax: 905-427-2545, Toll free: 1-800-461-0575.
- B. Other manufactured products meeting this specification may be substituted provided that manufacturers show proof of product insurance. Equipment details to be approved by The

Engineer.Companies, such as miscellaneous metal fabricators, who are not normally engaged in the design and manufacture of window washing/suspended maintenance equipment are not permitted to bid.

## **2.02 EQUIPMENT**

- A. Through bolted roof anchors as manufactured by, but not limited to:
  - 1. PRO-BEL Model EPB-73S

## **2.03 MATERIALS**

- A. U-bar, anchor bolts Type 304 stainless steel with yield strength of 42 Ksi (290 MPa). U-bar to be not less than 3/4" (19 mm) diameter material with 1-1/2" (38 mm) eye opening.
- B. Hollow steel section (HSS) piers: galvanized steel as above with yield strength of 50 Ksi (345 MPa), [with] [without] urethane foam insulation.Wall thickness to suit application.
- C. Base plate and all other sections: galvanized mild steel as above with yield strength of 43 Ksi (297 MPa). Thickness and securement to suit application.
- D. Seamless spun aluminum flashing (for steel pier anchors): Type 6061-T6 alloy to ASTM B221 with deck flange flashed in to NRCA recommendations.Seal top of aluminum flashing with conformable mastic tape and torch applied heat-shrink rubber membrane.
- E. Bolts, nuts and washers: ASTM A36, galvanized to ASTM A123.

## **2.04 FABRICATION**

- A. General:
  - 1. Fabricate work true to dimension, square, plumb, level and free from distortion or defects detrimental to appearance and performance.
  - 2. Grind off surplus welding material and ensure exposed internal corners have smooth lines.

## **PART 3 - EXECUTION**

### **3.01 EXAMINATION**

- A. Examine surfaces and areas upon which the work of this Section depends. Report to the Contractor in writing, defects of work prepared by other trades and other unsatisfactory site conditions which would cause defective installation of products, or cause latent defects in workmanship and function.
- B. Verify site dimensions.
- C. Commencement of work will imply acceptance of prepared work.

### **3.02 INSTALLATION**

- A. Install equipment in accordance with approved shop drawings and manufacturer's recommendations.
- B. Co-ordinate installation with work of related trades.
- C. Install all work true, level, tightly fitted and flush with adjacent surfaces as required.

- D. Deform threads of tail end of anchor studs after nuts have been tightened to prevent accidental removal or vandalism.
- E. Manufacturer to assist and/or supervise installation of window washing/suspended maintenance equipment installed by others.
- F. Structural steel to receive rooftop anchors equipped with 4" (100 mm) diameter HSS pier to have minimum 5" (127 mm) wide bearing surface to ensure 100% weld.

### **3.03 FINAL ADJUSTING AND INSPECTION**

- A. Adjust and leave equipment in proper working order.
- B. Complete "Initial Inspection - Certification for Use" form included in Equipment Manual & Inspection Log Book.

### **3.04 TESTING**

- A. All anchorage systems relying upon chemical adhesive fasteners to be 100% tested on site using load cell test apparatus in accordance with manufacturer's recommendations.
- B. Load cell test to apply minimum 5,000 lb. (22.2 kN) load without detachment or fracture occurring.

**END OF SECTION**

## SECTION 11150

### PARKING ACCESS AND REVENUE CONTROL SYSTEM

#### PART 1 - GENERAL

##### 1.01 Related Documents

- A. Drawings and general provision of the Contract including General and Supplementary conditions apply to this Section.
- B. Work in other Sections related to "Parking Access and Revenue Control System":
  - 1. Parking Control Booth: Section 13125

##### 1.02 DESCRIPTION

- A. SYSTEM PERFORMANCE REQUIREMENTS
  - 1. These Specifications shall be considered by the Contractor to be based primarily on system Performance Requirements. Minimum acceptable technical characteristics have also been specified for major items of equipment and certain materials and services, in order to maintain desired standards of quality, and ensure that interchangeability, maintainability, and reliability goals of the Authority are achieved.
  - 2. The specification of "Brand Name or Equal" equipment herein is intended to control the quality of system components, not to indicate that the use of the "Brand Name or Equal" will, in itself, ensure required System Performance.
  - 3. When "Brand Name or Approved Equal" proprietary products have been specified, the manufacturer's specifications attributable to the "Brand Name" product (the "approved equal" product after Owner/WMATA approval has been granted) shall apply.
  - 4. The system and equipment descriptions contained herein, are applicable to equipment, materials, selections, installation workmanship, other services, and all other Contractor work, except as otherwise stated elsewhere in these Specifications.
- B. CONTRACTOR'S TOTAL SYSTEM RESPONSIBILITY
  - 1. The Contractor shall bear total system responsibility for all specified work and for specified additions and changes to Owner/WMATA systems of any type (except Contract deliverables not requiring Contractor services, construction, testing, documentation, warranty and other areas of responsibility which are subject to periodic review and acceptance by the Owner/WMATA (specified elsewhere).The Contractor has the responsibility to integrate the various necessary elements of Contract work so that overall specification performance goals are met.
  - 2. All Contractor provided systems, equipment and services shall perform and be suitable for their intended purpose, in accordance with best commercial practices, (as a minimum), and in compliance with all applicable specification requirements.
  - 3. The Contractor shall be required to deliver complete operable parking access and revenue control systems meeting all applicable performance and availability specification requirements, notwithstanding any errors or omissions in Technical Specifications that would otherwise prevent such delivery.
  - 4. The Contractor shall assume total responsibility for the configuration of equipment, parts, interconnecting wiring, software, and other materials and services furnished. Systems provided by the Contractor that do not meet performance levels required by the Specifications shall be modified, at the Contractor's expense, until the performance levels specified in the Contract are achieved. Any modifications to approved system designs shall be subject to prior approval by the Engineer/Architect.

5. The Contractor shall assume total responsibility for the correction of any degradation of the performance of existing systems or equipment, which results from the installation of any system or equipment interface required by the Specifications.
6. Although the ultimate Owner/WMATA retains rights to review the Contractor's system and component configuration and products selected and to accept or not accept for reasons of specification compliance or noncompliance; the Contractor retains sufficient latitude to ensure compliance with all specified performance and availability requirements. The Contractor shall, therefore, present engineering data, technical documentation, test program and quality assurance program data, and product selections that will ensure compliance with the system availability standards stated in the 30-Day System Functional Accuracy Test, Specification Paragraph 3.2 "Testing Requirements", and all other technical specifications. In the event, these submissions are not accepted by the Owner/WMATA, the Contractor shall resubmit with corrections, or resubmit completely revised documentation. The Contractor shall remain responsible for bearing any additional costs associated with change necessary to affect compliance with all specified performance and availability standards, as well as compliance with all applicable "Brand Name" products and all other specifications.
7. In the event the Contractor claims relief from specified performance or availability standards due to the application of "Brand Name" proprietary or detailed specifications, Owner/WMATA directed changes, Owner/WMATA engineering or drawing reviews, or any other Owner/WMATA actions claimed to be in conflict with such performance standards; the Contractor shall furnish written notice to the Engineer/Architect within 10 days after the discovery of such action attributed to the Owner/WMATA. The Engineer/Architect will then review the Owner/WMATA action cited and Contractor problem(s) involved, in an attempt to resolve these difficulties. In the absence of such timely notice, no such specification relief will be granted. The burden of proof for such claim(s) shall rest with the Contractor. The submission of timely Contractor claim(s) for specification relief as described, shall be required as a prerequisite to the acceptance of resulting claim(s) for increased Contract cost or performance time extensions.

C. DESCRIPTION

1. The Parking Access and Revenue Collection (PARC) System for the parking facility shall be designed, furnished, installed and tested to allow Owner/WMATA to operate this facility with regard to access control and revenue collection, in the same manner as other recently opened parking facilities. The PARC System shall incorporate features to permit Owner/WMATA to add certain enhancements to the PARC system as described herein, without replacement of the system components provided under this contract.
2. PARC shall include the following:
  - a. Gate and lane control signal control console(s).
  - b. Communications support installations.
  - c. Vehicle detector loops and loop leads to operate gates, lot full signs, card readers, magnetic ticket dispensers and vehicle counting equipment.
  - d. Vehicle detector loop amplifier electronics and logic, including associated software.
  - e. Programmable vehicle counting equipment, including associated software.
  - f. Differential counter, anti-coincidence and differential logic, lane entrance/exit point and facility occupancy totaling counters (may be hardware and/or software).
  - g. Barrier/lane control gates, with articulated arms suitable for applications with limited overhead clearance, as necessary.
  - h. Barrier/lane control gate controller/microprocessors.

- i. Fee computer system for parking control booths, including associated software, entry ticket mag strip ticket reader (provide only the ability to add this hardware/software system later under separate contract), external fee display driver, patron receipt issuance printer, cashier/shift activity report generator/printer, automated cash drawer, key pad, visual display, moisture resistance and all peripherals required to make the PARC system function as specified.
  - j. Modem, or equivalent data transmission means.
  - k. Back up power supplies for system equipment, including three hour uninterruptible power supply capability for the fee computer and for vehicle counting equipment.
  - l. Controls for FULL signs and land control signals.
  - m. Bollards.
  - n. Interfaces, wiring and miscellaneous equipment required to complete the system. Parking facility central processor is to be located in the PARC Operations Center, includes associated software, network connectivity on and off-line via modem or equivalent to the management computer local area network (LAN) in the office of PARK (located at 600 Fifth Street, N.W., Washington, D.C. 20001), printer, work station and peripherals.
  - o. Integrated Logistics Support (ILS).
  - p. Provisions and full compatibility with installation and operation of magnetic ticket dispensers and card readers (including proximity smart card read/write readers).
3. System Information:
- a. The parking facility will be operated in a pay on exit mode of operation with cashiers collecting predominately fixed (daily) fees with some validation fees both higher and lower than the fixed fees. Fees are to be assumed fixed, but may be overridden prior to entering payment by pressing one of several (not less than 5) specific validation keys representing the particular rate validation structures on the fee computer. By using magnetic strip ticket dispensers and readers to be installed by separate contract later, the fee computer(s) shall be able to charge multiple day (regular rate for first and a higher fixed rate per day for subsequent days for multi-day duration parking as a validation).
  - b. Cashiering and use of barrier gates will be between the hours of 2:00 p.m. and 10:00p.m., but hours will be subject to change. The secondary parking control booth will be staffed between the hours of 4:00p.m. to 7:00p.m., but hours are subject to change. The changing of hours will be controlled by the parking facility managers from the facility central processor or via remote modem access to the central processor. No changes in software shall be required, only simple parameter changes that are described in the user manual.
  - c. During collection hours when the secondary parking control booth is not operating, the lane(s) will be obstructed from both ends by barrier gates controlled from the principal parking control booth. Only one of the three lanes will require gates at both ends.
  - d. There will be provision for future installation of magnetic stripe ticket dispensers in the entry lanes and magnetic stripe ticket readers in the cashier's booth. The fee computer as furnished under this contract shall be hardware/software compatible and ready for magnetic stripe ticket dispenser / reader operation upon installation. All software for magnetic stripe ticket operations needed in the central processor and fee computers shall be furnished under this contract.
  - e. There shall be a system installed consisting of card readers in each cashiering lane (Target Module Units) to permit processing of "smart" debit

cards (WMATA "SmarTrip" cards) to be used in payment of regular parking fees at fixed fees from the exit lanes or for payment of higher non-Metro rider fees or multiple day rates, and as permits for access.

- f. The booths will be equipped with control switches for manual operation of all barrier gates in the event of automated equipment failure. The gates shall be equipped with a manual means of raising the barrier arm in the event of a power or gate motor failure.
- g. FULL signs, activated automatically by differential vehicle counter (hardware and/or software) with anti-coincidence and directional logic and, will be installed in advance of and at each roadway entrance to the parking lot/structure complex.
- h. All payment lane gates will be operated during collection periods from both the specific parking control booth and the principal active parking control booth(s). The principal active cashier control booth(s) will be the one(s) farthest to the right upon exiting of the three lanes in the arrays.
- i. Traffic lane control signals mounted over the cashier exiting arrays above traffic lanes will be controlled from the principal control booth of the respective arrays.
- j. A fee computer shall be provided in each parking control booth and be located on the counter. The fee computers shall have a keyboard (key-pad) for cashier input and shall be capable of accepting input from magnetically encoded tickets. The fee computer key board shall be specifically designed to be protected against moisture and dirt typically encountered in a parking control booth environment.
- k. The fee computer system shall track the activity of individual cashiers who may work a whole or partial shift for each parking control booth separately. The fee computer will require each cashier to log on the fee computer before any cashier activity may occur, and log off when cashier activity is terminated. The log-on process shall be controlled by a specific security system or code unique to each cashier, supervisor or manager.
- l. The fee computer will process, monitor and control fee payment transactions in each parking control booth for each individual cashier working a whole or partial shift.
- m. The fee computers will also print basic activity reports of cashier activity and issue (print) receipts upon command.
- n. Fee computers will be directly connected to and download/upload information, data, instructions from/to an on-line parking facility central processor to be located in the PARCS Operations Center.
- o. Fee computers will drive fee display units to be included under this Contract. The fee display units shall be mounted as to be visible to drivers making cashiered transactions.
- p. The central processor will monitor the fee calculators, receive input from and monitor the functioning of the vehicle counting equipment, consolidate vehicle counting data, and create custom reports upon command either automatically or upon specific requirements. Automatic report generation shall be user controlled (on/off).
- q. Any microprocessors or other peripherals in the parking control booths will be supervised by the central processor.
- r. The Parking Facility Central Processor shall be connected via a dial up modem to an existing personal computer based local area network (LAN) in the COMP/LAND, offices located at 600 Fifth Street, N.W., Washington, D.C. 20001.
- s. The Parking Facility Central Processor shall be sized to operate the parking lot being modified and the new garage being constructed. The exiting Park-and-Ride lot is currently comprised of approximately 641 spaces. After the

construction of the new garage, the size of the lot will be approximately 410 stalls. The new garage will accommodate approximately 1,500 stalls. Therefore, the Parking Facility Central Processor shall be sized to operate a minimum of 1,910 stalls.

- t. Users entering/exiting the surface lot (from lanes outside of the garage) will be controlled by a single entrance lane and two exit lanes (one parking control booth which would include SmarTrip processing and an auxiliary payment lane with SmarTrip payment processing only).
- u. There are two entrance portals into the garage, one on the garage's Ground tier level (with two entrance lanes) and one on the Second Tier (with one entrance lane). Users may exit the garage from garage's Second tier via an array of four exit lanes. The array is located on the east side of the garage's Second Tier. Two of the exit lanes will contain a parking control booth which would include SmarTrip processing technology while the other two payment lanes will utilize SmarTrip payment processing only.
- v. Users exiting the lot may use the lot's exit lanes or may exit through the garage's exit lanes. Similarly, users exiting from the garage may exit through the lot's exit lanes.
- w. The Parking Management office LAN (PARK) shall have off line interface with the Central Processor in the parking structure, but the Central Processor shall be considered as a remote work station of the LAN for purpose of integration of transfer of data files to the LAN File Server and access to all computer files. Working from any work station on the existing LAN shall give the same degree of access and control over the central processor as working on the central processor itself. This capability shall be provided by using the latest available version of the commercial software package "PC Anywhere" or an approved function and performance equal.
- x. Any software to be licensed for use on the PARC Parking Facility Central Processor, shall also be licensed for use on the Management LAN in general.

4. Definitions:

- a. System: All elements required to manage and control the parking lot/structure. This includes all equipment, software and sub-systems for collecting and monitoring fee collection activity, counting vehicles and SmarTrip transactions by type/value, storing and transmitting parking management information, on-sight/remote, setting or changing operational parameters, operating gates and FULL signs and monitoring the arrivals, departures and occupancy of this parking lot/structure along with all other park-and ride lots and structures as independent separate facilities at this Station (new 1,500 +/- space parking structure and 410 +/- space surface lot), which may be subsequently connected to and operated by the system central processor, operation of the parking facility, as well as, associated training and documentation.
- b. Entrance/Exit Array: The installed equipment and configuration of traffic lanes and islands for one entry lane, one reversible (payment or non-payment) lane and exit (payment) lane, with two parking control booths.
- c. Entry Lane: A lane in which entering traffic is controlled by a barrier gate with an arm (used only during revenue collection hours) and overhead lane control signals.
- d. Exit/Payment Lane: A lane in which exiting traffic is controlled by a barrier gate with an arm (used only during revenue collection hours).
- e. Reversible Lane: A lane used to allow selected types of traffic past the parking control booth, from either direction, depending upon the time of day and the setting of the overhead lane control signals. Payment will be made only during revenue collection hours. The gates will be held in an up position

for the remaining hours. In the event of a system failure the cashier will operate the gate by a toggle switch(s) and buttons from the nearest primary parking control booth.

- f. Primary Booth: The parking control booth located to the right upon exiting of each three lane array used for collection of fees from vehicles exiting the parking facility.
- g. Secondary Booth: The other parking control booth(s) located at a parking fee collection array (Entrance/Exit Array) for collection of fees from vehicles exiting through the array.
- h. Failure: A physical or functional breakdown of a part or group of part or a condition or parameter that is not compatible with the software, which prevents the equipment from performing its designed functions.

### **1.03 QUALITY ASSURANCE:**

- A. The quality assurance program shall meet the following requirements in addition to those stated in the General Requirements.
- B. Qualifications: Select a manufacturer regularly engaged in production of similar parking access and revenue control equipment.
- C. Codes, Regulations and Reference Standards:
  - 1. Codes and regulations of the jurisdictional authorities.
  - 2. All traffic control devices shall conform to the FHWA Manual on Uniform Control Devices, 1988 Edition or as subsequently revised.
  - 3. NEC
  - 4. The parking control booths and PARC Operations Center islands and access paths thereto shall meet or exceed, as required herein, the minimum provisions of ADA, Accessibility Guidelines as published by the Architectural and Transportation Barriers Compliance Board (A&TBCB)
  - 5. UL
  - 6. FED STD: 595.

### **1.04 SUBMITTALS:**

- A. Submit the following for approval in accordance with the General Requirements, and with the additional requirements as specified for each.
- B. Within 120 days following NTP, a test plan for all installed equipment and systems, and the 30 Day System Functional Accuracy Test.
- C. Within 60 days following NTP, a detailed schedule of design, manufacture, installation, and testing of the equipment to be installed. Include request for modification of any drawings that may be necessary to accommodate specific equipment or space or performance requirements.
- D. Product data and drawings demonstrating that the installation design, equipment software and other system details satisfy the functional requirements and operational parameters. The equipment used in the system must be produced by a recognized firm regularly engaged in the appropriate industry and accomplish the functions intended.
- E. Shop Drawings (paper copies and CADD or Scanned CCITT Group 4 electronic media copies were available from the suppliers) for equipment and systems provided by the Contractor shall include.
  - 1. Installation details for:

- a. Gate and lane control signal control console.
  - b. Communications support installation.
  - c. Vehicle detector loops to operate gates, FULL signs card readers, magnetic strip ticket dispensers and vehicle counting. (Loops needed to operate gates and directional counting may also operate other equipment.)
  - d. SmarTrip, readers, processors and related equipment
  - e. Installation of all electronics in the system.
  - f. Traffic control barrier gates.
  - g. Fee computer, including patron's fee display, compatibility with installation of magnetic strip ticket, reader, receipt and report printer, and peripherals
  - h. PARC Parking Facility Central processor, including printer, network software installed on WMATA's Parking Management LAN - PCs or file server, communication servers and work stations; network connectivity and full operation.
  - i. Primary, backup and uninterruptible power supplies for facility parking access and revenue control equipment and processors
  - j. Control for gates and lane control signals.
  - k. Bollards
  - l. Interfaces, wiring and miscellaneous equipment required to complete the system.
  - m. Provision for installation of magnetic strip ticket dispensers and readers. Include manufacturer's recommended specification for these items as well as interface requirement to the system as furnished to ensure compatibility of equipment.
- F. Documentation shall be provided to the QC/QA Coordinator for approval as follows:
- 1. A detail schedule of design, manufacture, installation, and testing of the equipment to be installed. The QC/QA Coordinator shall submit five copies of the approved schedule to the Engineer/Architect.
  - 2. A test plan for all installed equipment and systems and performance testing. The QC/QA Coordinator shall submit one copy of all test reports within 10 days of test accomplishment to the Engineer/Architect.
  - 3. Software reference manuals and documentation to include source and code and object modules on any programs developed modified for this contract or for application templates of standard commercial software products. Source code and object modules do not need to be provided for modified commercial software products
  - 4. Operation and Maintenance Manuals and Parts Catalog.
  - 5. Training requirements.
  - 6. Certifications
    - a. Testing:
      - 1) The Contractor shall perform component or equipment level testing, system level testing and a 30-Day System Functional Accuracy Test. Certification that system is ready for operations and that the system will perform its continuing functions reliably shall be provided by the QC/QA Coordinator to the Engineer.

**1.05 PRODUCT, DELIVERY, STORAGE AND HANDLING:**

- A. Ship each unit securely packaged to avoid damage and labeled for safe handling in shipment.
- B. Store all equipment in secure and dry storage facility until ready for installation or turn over to the Owner/WMATA.

- C. The Contractor shall be responsible for receipt of all furnished equipment and supplies and for safeguarding equipment and supplies from pilferage and effects of weather until accepted by the Owner/WMATA in final installed configuration.
- D. Deliver spares to storage areas designated by the Engineer/Architect.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS AND EQUIPMENT:**

- A. Environmental Requirements: The system, with the exception of the central processor system, which shall operate in a normal office environment, all other equipment shall perform its function without degradation when operated within the following conditions:
  - 1. Temperature: Minus 29C to plus 70C.
  - 2. Humidity: To 100 percent at 35C.
  - 3. Sunlight: Full solar loading.
- B. Controls for all gates and lane control signals in the cashier lane shall be provided for each parking control booths on a panel. The control panel including all push buttons and toggle switches shall be weather and moisture proof. The control panel shall be on an incline sealed housing constructed of 16 gauge steel or aluminum with reinforced corners or framing.
  - 1. The face of the panel shall be provided with switches and buttons fully labeled as to their function and control item. The labels shall be permanent and shall not pull or wear off under normal usage. Toggle switches shall be used to either open and stop (hold) the gate in the open position or lower the gate (unless a vehicle detector loop at the gate detects a vehicle present) and allow the gate to operationally rest in the lower position. The push button will call for the gate to be opened and automatically lower once a vehicle has cleared the gate detector loop. The gate control panels in the principal booth for each three lane-cashiering array shall also have switches and buttons for all gates at the array. Each of the gate control panels for the principal parking control booths shall have a key switch to energize all gates controlling the entry drive aisle. Either principal booth shall be able to collectively open or close all entry gates and leave them in the up position when the gates are not needed for operation as after collection hours. Up and down position indicator lights, collectively for all entry gates, shall be provided on each principal parking control booth control panel. No gate shall come down on a vehicle passing through the gate, but shall lower only when all vehicles are clear.
  - 2. The control panel in each of the two principal parking control booths shall also provide for the lane control traffic signals. The principal parking control booths shall be provided with a separate key set on/off switch for each of the exit lanes. Reversible land control signals shall be provided for each lane with a key set on/off switch and a two position selector toggle switch. Toggle switch Position 1 shall provide for energizing green arrow signals with the red X signal dark for outbound. Toggle switch Position 2 shall provide for energizing a red X signal with the green arrow signal dark for the outbound direction.
  - 3. All key switches shall be keyed alike. Two such keys shall be provided for each parking control booth.
- C. The PARC Operations Center shall be provided with a two line desk phone to be installed in the counter at the middle of the end wall. This phone shall be connected to the WMATA PBAX system in station communications room. One of these phone lines shall be connected to the modem for the PARC central processor with the other line used for voice communications.

- D. Bollards: Bollards shall be six inch diameter of steel pipe construction. They shall be either filled with a rounded top for applications in poured concrete foundations or fitted with a steel top welded to the pipe and ground smooth with a flange plate or casting at the bottom for anchor bolt attachment to a concrete surface. All bollards shall be painted highway safety yellow.
- E. Parking fee and hour signs shall be located on both sides of the entrance roadway and at the leading ends of the cashier lanes at the exit point.
- F. Vehicle Counting and Telemetry:
1. A programmable vehicle counting function shall be furnished for the combined parking lot and structure facility. This function, by use of appropriate hardware and software, shall monitor all vehicles entering and exiting the facility in all lanes, store the data in the parking facility for a minimum of seven days, but transfer daily the calendar day data to the LAN computer system in the offices of PARK through the parking facility's central processor. The function shall determine and report the number of vehicles that have passed by direction through each entrance and exit lane at any given time interval during the day. It shall incrementally count by one each time a vehicle passes through a lane. It shall be capable of reading bi-directional traffic and differentiate between incoming and outgoing traffic through all entry or exit lanes, determining the direction of the vehicle from the loops set in the lanes. The detector loop amplifiers shall be self tuning.
  2. The vehicle count tabulation function shall be programmable with a real time clock in whole minutes for discrete reporting periods from one minute to one hour (1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30 and 60 minutes) yielding a maximum of 1,440 one minute tabulations during a 24 hour calendar day, 1,500 tabulations with Spring daylight savings time adjustments. Memory of sufficient size shall be provided and be addressable in the central processor to store tabulations addressable by calendar day for not less than 14 days. The data storage shall be in an ASCII file format.
    - a. The vehicle counting memory shall be provided with recharged uninterruptible power supply capable of supporting it for at least 48 hours in the event of power loss or interruption. There shall be a remote battery voltage monitoring system built into the hardware software.
    - b. An Anti-Coincidence Logic (ACL) function shall be provided by software that will decipher simultaneous counts, when more than one vehicle enters or exits the parking facility at one time. The ACL will put the counts in sequence and covers all lanes. It will take signals from the gate controllers.
    - c. The differential counting function shall, together with the ACL, monitor the total net number of vehicles in the parking structure, and shall activate the FULL signs when the parking capacity limit is reached. The parking capacity FULL sign on and off limits shall be locally set. Capability shall also be provided thru the parking structure central processor to be able to remotely set or revise the limits of the differential occupancy count from the PARK Office Management LAN computer system. The central processor shall record and store the total vehicle occupancy in the parking facility as it records the amount of vehicles counted for the unit of time. This shall be the same occupancy to be used to drive the FULL signs. Note that entering vehicles will not be required to stop to take a ticket or conduct any other type of transaction. Vehicles exiting at times either before or after collection hours will likewise not be required to stop and conduct any type of transaction. Gates will be in the up position at all times other than during revenue hours.
    - d. The count recording and differential occupancy tracking hardware and software shall be provided with all equipment and accessories including terminal capacity as necessary to activate relays, accept signals from

remote locations or from various loops or inputs, and be recorded or set locally remotely. This capability shall be provided for at least 10 channels of data and activity over and above that required to operate the count functions otherwise herein described. The 10 extra channels shall be grouped in their own matrix. The extra system shall accept count inputs at a rate up to 20 per second. Inputs shall be via Form A dry contacts.

3. An auto answer modem function shall be provided for the Central Processor which shall be full Bell compatible. The operation shall be full duplex on a two wire circuit, with a user selected 56K or higher baud rate as may be widely available at time of installation with automatic answer or switch-selected originate/answer.
  4. If necessary for system integration the Contractor shall provide a data module interface, to transfer data that has been field collected to the PARK office LAN computer system using Contractor provided software. All reports that the manufacturer's standard system provides to be printed on the on-site PC shall also be transmitted to the PARK office Management LAN computer system for printing upon command. This command shall be set by the end user manager as to be either automatic or upon specific LAN work station (remote) and/or central processor request.
  5. A combination of equipment and software shall provide a Programmable Vehicle Counting system (PVCS) for each array in the parking structure that will be resident in the on-site central processor. The PVCS shall take inputs from barrier gate controller/microprocessors and shall monitor and report with programmable summaries of vehicle activity in all lanes in each direction by array with programmable time increment sub-totals. The PVCS shall give calendar day totals. The data shall be stored on the Parking Structure central processor hard drive using ASCII text files that are addressable using standard PC based commercial software, database software, and spreadsheet software, Windows NT, are specifically included. The ASCII text files shall be organized so that each lane and direction of traffic data is consistently presented in the same location on a standard data matrix that will be used for all arrays. These data files may be retrieved by the PARK office Management LAN computer system via modem from the on-site central processor.
- G. Each parking control booth shall be equipped with cable pairs for installation of WMATA's SmarTrip proximity debit card Uniform Fare Technology Application (UFA) required for integration of automatic fare collection data. A low capacitance ( 20pF/ft) six pair, individually shielded, teflon insulated, stranded conductors for computer and instrumentation cable, Beldon 88778 or Beldon 87778 plus a 3-pair 22 AWG minimum telephone cable. For each SmarTrip card reader processor two cables shall be furnished and installed from each card reader to the Grosvenor Station kiosk through the station communications room for interface with the Automatic Fare Collection (A.F.C.) System.
- H. A parallel data file system to the above vehicle counting and recording system also on the on-site Central Processor hard drive shall provide for a file(s) listing fee computer and barrier gate controller/micro processor transactions or activity and shall contain data reporting.
1. The Fee Computer shall provide the following report files:
    - a. Transients.
    - b. SmarTrip Card users by type and transaction value amount.
    - c. Access card users
    - d. Back-out card users.
    - e. Back-out entry vehicles with or without dispenser ticket.
    - f. Total entering vehicles by array.
    - g. Total exiting vehicles by array.
    - h. Total number of validations by type.
    - i. Total cash revenue collected.

- j. Total electronic (debit) revenue collected along with detail breakdown of debit transactions.\
  - k. Any other data collected and reported which is normally furnished, advertised or listed in generally released product information for the fee computer delivered under this Contact.
  - l. Sub-totals of above by each cashier.
  - m. All related activity counts files, and transaction activity and revenue data shall have stored on the Parking Structure Central Processor hard drive for a minimum of 30 days after which files may be subject to being written over by new data the same source and subject.
  - n. All related connectors and accessories as required for the system to properly and fully operate shall be provided. All components shall be fully integrated and compatible with each other, and with the PARK office Management LAN computer system, both hardware and software. Incompatibility problems shall be resolved by the Contractor to the satisfaction of the Engineer/Architect and PARK staff.
- I. Fee Computer
1. The following parking revenue control system shall be provided and installed in the parking structure. The hardware and software furnished shall be based upon that routinely produced and furnished by the manufacturer for similar installation in parking facilities for purposes of supporting and controlling cashiering operations. The Fee Comptroller shall be a modular revenue control system that includes:
    - a. Multi-functional printer.
    - b. Fee computer terminal.
    - c. Integrated and electronically controlled cash drawer.
    - d. Power supply.
    - e. Both the printer and terminal shall be of durable corrosion and moisture resistant construction, in stainless steel or other equally durable and serviceable product.
    - f. The Fee Computer shall be user programmable and operate either through a communications network from the parking facility central processor or locally at the fee computer in the event of a communications mode failure or by a program parameter change by user.
    - g. The Fee Computer shall compute parking fees based upon time of entry, maintain a complete audit trail of transactions and revenue, display fee and Thank You, Paid, or equivalent message, on a fee display to the patron, print header programmed receipts upon command, calculate change due, have at least 3 preset fixed parking rates, accept 3 types of coupons each to be tied to a specific validation key, control cash drawer, interface with barrier gate and Fee Calculator arming loop.
    - h. The Fee Calculator shall be fully installed, operational and shall:
      - 1) Permit transaction activity only when a vehicle is over the arming detector loop.
      - 2) Provide displays to the patron of the fee amount due and Thank You or equivalent transaction-complete message.
      - 3) Print transaction receipts upon command or automatically as may be subsequently required by the Authority. The change in receipt generation shall be controlled by a simple parameter change at the Central Processor either directly or remotely from the PARK office Management LAN computer system.
      - 4) Collect data on transactions and revenue by cashier, booth and by exit lane.
      - 5) Provide reports on transaction and revenue collected by cashier, by booth, by array, total and by facility total. Permit reset to zero by supervisory personnel only. Reports shall be generated by the

central processor, but the cashier and booth reports shall also be printed in the respective parking control booth.

- 6) Collect data on vehicle activity by lane, by array total and by facility total. Permit reset to by supervisory personnel only.
  - 7) Provide alarm and trouble reports, including loss of communications with a booth loss of power at an array, failure of a peripheral, failure of communications between arrays and the central processor, failure of communications with the PARK office Management LAN computer system and software failure.
  - 8) Provide attendant log-in/log-out record by name and identification code. Prohibit fee transaction activity without a proper log-in.
  - 9) Be capable of incorporating a patron card reader debit card processing devices.
  - 10) Be capable of incorporating a patron card reader debit card processing devices.
  - 11) Be capable of incorporating a patron access card read and processing function.
  - 12) Be capable of functioning without the need of the cashier inserting a paper or magnetic strip ticket into the fee computer or peripheral devices for transactions, which are not dependent on the time of patron entry (fixed fee transactions).
- i. Parking control booth mounted displays to inform patrons of fee transaction amount and completion.
  - j. Fee Computers shall be tied to a time base generated by the Central Processor and shall all be on the same time reference. A change of the time in the Central processor shall change the time for all Fee Computers via a down load.
  - k. Fee Computers shall not operate collections for hours other than those established. The Central Processor shall be programed with the hours of collection for each of the fee computers, either as principal or as part-time secondary usage.

J. Parking Facility Central Processor

1. The contractor is to provide a Central Processor system in the PARC Parking Operations Facility, operations room. All on-site central processing software and data storage is to be done on this unit. The Contractor is responsible to fully integrate and make operational central processor. If the unit being herein specified is of sufficient capacity and or capability, the Contractor shall substitute one that is fully able to function as specified manufacturer, this unit is unable to perform required functions, the Contractor shall furnish a unit a that will efficiently perform and has at least the following features described below. This brand of the Central Processor shall be Authority standard personal computer (P.C.) Standard manufactured by Dell. No substitutions of the Dell brand of P.C. shall be allowed. The delivered unit/system shall include the latest version of the following (or approved equals):
  - a. Dell Intel Pentium 4 with 1.4 GHz minimum processor and 256 MB minimum Random Access Memory (RAM).
  - b. File System - 64 byte virtual memory
  - c. Hard Drive - 20 GB (minimum)
  - d. Diskette Drive - Generic IDEA Disk Type 55.
  - e. Diskette Drive - Generic NEC Floppy Disk 3-1/4: inch.
  - f. CD ROM Drive - Toshiba CD-ROM AM 63028.
  - g. Floppy Disk Controller - manufacturer's standard.
  - h. Hard Disk Controllers - Intel 8271, AB/BE P.I. Bus Master Controller, Primary IDEA Controller (dual FIFO) and Secondary IDEA Controller (dual FIFO).

- i. Keyboard - PC/r - T enhanced keyboard (101/102 keys).
  - j. Modem - U.S. Robotics 56K Fax Ext. (fastest option available)
  - k. Windows 98 or 2000, Windows NT 4.0 or higher
  - l. Printer - HP Laser Jet 6P
  - m. Monitor - Dell M781p 17"
  - n. Network Adapter - IBM P.I. Token Ring
  - o. Ports - Com and LPT
  - p. Controllers - Universal serial bus, sound, video and game.
  - q. Pieces of work station furniture for the Central Processor.
    - 1) 2 each - armed desk chair with adjustable seat height, swivel base and rolling casters, foam cushion seat and back with fabric covering. The chair arms shall not have fabric covering. The color shall be black or dark.
    - 2) The work station furniture shall include a 42 inch tall by 30 inch wide book shelf measuring 10 inches or greater deep. The bookshelf shall be installed in the operations room.
    - 3) Adjustable keyboard support mechanism - 6 inches wide by 30 inches deep by 29 inches high to be fastened to operations room counter top. It shall match the PARC operations room counter top in material and color.
    - 4) Free standing on rollers file drawer, to be stored under operations room counter top shall be 15 inches wide by 18 inches deep by 27 inches high.
    - 5) Product:
      - a) The basic bookshelf, keyboard support mechanism and file drawer 1 inch three-ply solid core construction with an oak or maple plastic laminate surface. Plastic laminate work surfaces shall be post-formed, top to bottom, front to back. All supports shall be constructed out of heavy gauge steel and shall be sand or beige in color. The specified components shall include brackets, panels, supports, and nuts and bolts to secure the components cohesive unitary work secure the components to the counter as required into one complete cohesive unitary work station. The work station components shall be assembled and installed by the Contractor.
      - b) The keyboard desk adjustable keyboard mechanism shall give front to back tilt of up to 15 degrees, with variable height adjustment of up to 8 inches and shall accommodate keyboards up to 21 inches wide.
- K. For integration with the PARK Office Management LAN computer system as a remote User/Server the following hardware/software shall be furnished and made fully operational:
- 1. U.S. Robotics 56K modem (furnish fastest modem available), or equal.
  - 2. 10 foot RJ-11 cable, or equal
  - 3. PC Anywhere software package or equal, latest version.
- L. The Central Processor shall be provided with a multilevel security access code system that provides for operation and printing of basic Fee Computer activity reports at level one and for total access to all central processor functions at level two. The security pass codes shall be established by the user and may be changed by the user operating at level two. Access to the Central Processor from the PARK office Management LAN will also have to go through the security code, normally level two.

- M. Management software shall be provided for monitoring the activities of the parking structure including parking facility vehicle counts and occupancy, transaction activity and revenue generation. This software shall enable the PARK OFFICE Management LAN computer system with the file server to access memory registers in the on-site Central Processor via telephone line modem 56k baud. The access shall be routinely off line. The system shall automatically dial the parking facility Central Processor to gain access, set parameters, and retrieve data. All code and custom software shall be a deliverable under this Contract. The software package shall perform the following functions:
1. Transfer and store formatted reports and data on the PARK office Management LAN file server.
  2. Generate the following reports:
    - a. Summary Reports
      - 1) Summary Entry/Exit Time Reports
      - 2) Duration of Stay Reports
    - b. Count Reports
      - 1) Totals.
      - 2) Statistics.
      - 3) Activity.
      - 4) Remote Vending.
      - 5) User Changes.
    - c. Revenue Reports
      - 1) Revenue Transactions.
      - 2) Parking Fees Collected (Value/Number).
      - 3) General Totals.
      - 4) Attendant Totals.
      - 5) Daily Revenue.
      - 6) Validations (Value/Number/Type).
      - 7) Attendant Reports.
        - a) Sign In/Sign Out.
        - b) Alarms.
  3. Raw data using the system manufacturer's standard formats. (Reports shall be generated upon user setting of a continuing automatic or special requirement report generation parameter.)
  4. Transaction and Revenue Data Reports using the manufacturer's standard formats. All transaction types and all revenue accumulations: cash, access cards and electronic debit media separately; shall be reported by cashier, booth, array and facility as a whole.
  5. From traffic count data stored in user setable time increments, report summaries covering inbound and outbound traffic resulting expected revenue from each of the respective lanes, arrays and for the total parking structure. These reports shall be in the report format system developed by WMATA staff. An example of the computer paper report is available upon request from PARK.
  6. The special software for report generation to be developed for WMATA's application shall be done so as to be Windows NT template applications or data base or spread sheet software for reading files. The Application templates shall allow the following variables to be input on a daily basis: (NOTE: Keeping these inputs for data to be entered on a daily basis separate from those done occasionally will simplify the application template use process).
    - a. Location.
    - b. Date.
    - c. Revenue Reported (for Traffic Count Data Based Revenue Report comparison with actual revenue).
  7. The software program application shall allow the following variables to be input (daily), by non-programmers with Windows NT application experience to change the format or defaults in the program as needed on an irregular basis:

- a. Location.
  - b. Facility Capacity.
  - c. Rate (hourly, daily (including various validation rates), and monthly rates).
  - d. Revenue Collection Period (2:00 p.m. to 10:00 p.m.).
8. For the Traffic Count Data Based Revenue Report comparison with actual revenue, the program will accept any time frame of raw data fee operation and tabulation (1,2,3,4,5,6,10,12,15,20,30 or 60 minutes, etc.) and automatically tabulate for the hours (including partial hours) required in the format system.
  9. All software program applications (Windows NT) or application templates shall be totally non-copy protected. The Owner/Wmata shall be fully authorized to copy, recode or modify the application template software for the Owner/Wmata's benefit.
  10. Software shall allow monitoring of traffic counts and revenue accumulations as they occur in real time.
  11. The program must archive merged (retrieved) data when given parameter dated of beginning and ending dates.
  12. Software shall provide for a parking facility time base that keeps all fee calculators and the central processors on the same time. The time base shall automatically adjust for daylight saving time adjustments twice per year.
  13. To interface with this and other facilities using the same software, the Contractor shall furnish and install a centralized management software package which shall permit communication and interface with multiple locations with the same general systems configuration in a single consolidated fashion from the parking management LAN. This central management package shall be the McGann Software Systems, Client V Web Browser or full function equal and be specifically written and developed to interface with multiple scattered sight PARC systems consisting of the Central Processor and PARC software of this contract. Multiple licensed copies ( eight) of the central management package local PARC interface software shall be furnished under this contract.
  14. Software shall be furnished under this contract which shall provide for automatic recalibration of the facility occupancy count each 24 hours. The recalibration shall consist of revising the occupancy count at 2:00AM each morning to reflect a Wmata, as end user ,entered set of occupancies (previously observed and projected) to be in the facility at 2:00 AM each of 7 days per week. The numbers will represent a seven day calendar of occupancies which the user will be entered in the central processor for each facility. Setting and changing the 7-day calendar settings shall be done as part of a menu driven exercise fully described in the user manual. Entering and changing the settings shall not require any software changes.
- N. FULL Signs: As shown and as follows:
1. FULL signs shall be activated and deactivated by the vehicle counting function.
- O. Overhead Lane Control Signals ceiling mounted, lighted signals, manually controlled from the attendant booth.
- P. Gates, Barrier Arms, Detectors, Loops and Operation.
1. Gates shall be UL approved and labeled.
  2. Each gate cabinet shall provide support for the barrier arm, and enclose and support the electro-mechanical equipment to operate the barrier arm and to protect the electrical/electronic detector and controller/microprocessor equipment, The cabinet shall protect internal components from the effects of wind, dust, rain, snow, ice and condensation. Lockable doors shall provide access for maintenance and protection against vandalism.
    - a. The weather tight, seam welded cabinet shall be constructed of galvanized steel or aluminum, measuring not more than 15 inches wide by 15 inches deep by 40 inches high. Four mounting anchor bolt holes, accessible only

from the inside cabinet, shall be provided. A weatherproof door, with flush mounted T-handle lock and two keys, shall enable easy access to components. The cabinet shall be finished with the manufacturer's standard primer system and two coats of semi-gloss finish of Federal Standard 595A, Color 20040 (Metro Brown).

b. Electrical components:

- 1) All electronic (micro-processor) controls shall be enclosed in a factory sealed plug-in controller, that shall plug into the low voltage terminal board, so that the controller shall be readily replaceable. Provide two terminal boards, one for low voltage and one for high voltage connections and operation. The high voltage terminals shall be enclosed in a galvanized connections box that will receive all high voltage wiring, and include: one 120 VAC grounded convenience outlet. Provide one 250-500 watt strip heater or 24 VAC reduced heater that shall be thermostatically controlled.
- 2) The gate arm shall be driven by a 1/3 to 1/2, single phase, instant reverse motor. The motor shall have thermal overload protection with a manual reset. All additional relays, contacts and wiring required to accomplish the proper operation shall be provided.
- 3) The gate shall be quick acting requiring less than 1-1/2 seconds to complete an opening or a closure. The gate shall automatically open upon loss of power. The gate shall be in wide use in public parking facilities with at least 200 gates in use for over 12 months. Mechanical power shall be transmitted from the motor to a gate arm drive shaft by harmonic acting crank shaft and connecting rod. Adjustable cams shall be positioned on the main shaft to activate limit switches from control of gate movement. Crank main shaft and connecting rod shall be constructed of stainless steel or steel that has been coated with zinc dichromate to prevent corrosion. All parts shall move on self lubricating bushings. There shall be provision for raising the gates in the event power loss. Limit switches shall be incorporated into the gates to control the up and down cycles. If one or both limit switches fail, the gate shall still operate in a proper manner. A signal shall be generated and sent to the on-site central processor that a failure has occurred. Once the defective limit switch has been replaced, a signal will be sent to the central processor noting the replacement of the limit switch. The gate shall incorporate a safety feature. The gate arm shall auto reverse when it strikes an object. If the gate arm strikes an object on the downward cycle, the gate arm will stop and return to the full up position. A user programmable timer will then be energized, time out, and then lower the gate arm. If the gate arm is broken, on the next cycle of the gate up or down, a signal shall be sent to the on-site central processor , which shall include the time and date of the occurrence.
- 4) The barrier gate arm shall present a physical and highly visible impediment to the passage of a vehicle. It shall be articulated (hinged) to operate within the limited overhead clearances of the parking structure as necessary. The barrier arm shall swing up on receipt of a valid control signal for the lane being controlled. After the vehicle has passed beyond the barrier, the barrier shall automatically return to its normal rest position and function. A signal shall be generated to sound an alarm located in the nearest principal parking control booth when a vehicle breaks through a remote entrance location barrier arm. Each barrier arm shall have a

one inch wide strip of rubber along the bottom edge of the arm to minimize vehicle damage in the event it strikes a vehicle. The rubber pad strip shall not permit the exposure of any metal fasteners.

3. Vehicle detector and loop installations shall be as indicated in the specifications (preformed loops in PVC conduit and installed as part of the cashier array drive aisle PCC payment pour) and as recommended by the manufacturer. The associated circuitry shall recognize vehicle movement onto the loop and an unlimited duration of vehicle presence. Detectors shall be part of the barrier gate controller/microprocessor and shall be modular. A directional logic feature shall be included that will interface two multipurpose loops in the lane and be able to distinguish the direction of traffic passing through the lane or if the vehicle backed out before passing through.
4. Gate operation:
  - a. Emergency and Owner/Wmata service vehicle egress (from Principal or Secondary Payment Lanes) during cashier operation shall be controlled by the specific cashiers using Fee Computer emergency/ service vehicle validation keys. Emergency and service from secondary lanes when there is not a cashier present in that lane will be manually controlled by the principal parking control booth during all other periods of revenue operation. The principal cashier will activate the exit gate from the gate control panel in the principal parking control booth. During non-revenue collection periods, the gates shall be left in the up position. Remote control of all gates shall be provided from the control panels in the parking control booths. The controls shall consist of toggle switches and buttons for each gate being controlled. The controls shall consist of toggle switches and buttons for each gate being controlled. The toggle switches and buttons are not to be used to operate the gates when the fee computer is operational for the particular lane being controlled. For gates to open during revenue collection periods, there must be a SmarTrip transaction or the fee computer must either process a payment or validation transaction, using one of not less than four exempt validation keys for emergency or service vehicles or for persons having insufficient funds or in protest of the fee. In the event of system failure causing shutdown of the fee computer or some element of it, and/or central processor and/or communications interface does not permit the fee computer to operate, the cashier or some fail safe operation shall permit the gate(s) to respond to actuation of a toggle switch or button by the cashier.
  - b. During periods of fee collection operation by cashiers, the exit or payment lane gate in the active lane shall be in the down (closed) position. The gate shall open upon actuation of a SmarTrip transaction, upon a fee computer/central processor command or upon the cashier logging off the fee computer and using a control panel switch. The exit payment gate(s) shall automatically return to the closed position when the vehicle clears the final loop upon completion of a fee computer, SmarTrip or manual exiting vehicle transaction. At all other times (non-revenue collection hours), the gate shall remain open (up). In a secondary payment lane cashier operated for fewer hours by a cashier than a principal payment lane, the remaining hours will have two gates remain in a closed position until the end of the collection period and no traffic will be permitted to pass. If the lane is to accommodate SmarTrip transactions, the Principal booth cashier shall activate the lane exit gate leaving the entrance gate open and allow the SmarTrip system to control the operation of the lane until the end of collection hours. At least one secondary non-cashier staffed exit lane will be used for SmarTrip transactions per array when a principal parking control booth is operating. Initiating SmarTrip control of a secondary exit lane shall occur by opening

the lane entry gates from the control panels in the principal parking control booth at the array. The entry exit lane gate controls shall be by use of toggle switches and buttons for the respective gates being controlled. In the event of system failure causing shutdown of the fee computer or some element of it, and/or central process and/or communications interface does not permit the fee computer to operate, the cashier or some fail safe operation shall permit the gate(s) to respond to actuation of a toggle switch or button by the cashier.

- c. If in the future ticket dispensers are installed automatic controls shall be provided to detect the presence of a vehicle in the entry lane, issue a control signal that will be used to arm a ticket dispenser to issue a magnetically encoded ticket, raise the barrier gate, detect the passage of the vehicle beyond the barrier and lower the gate. Controls and logic shall be provided to lower the barrier, if a vehicle backs out, with or without a ticket prior to passing beyond the final detector loop. When the barrier gate will close, controls will reset, and the lane will be ready to process another vehicle. Automatic operation of the ticket dispenser shall be disabled by the remote parking control booth mounded control panel toggle switch for the control gate in the up position.
- Q. Magnetic Coded Ticket Dispensers: These are future hardware items not to be delivered as part of this contract, but specifications are provided as the Contractor is to furnish system software for the dispensers and full compatibility.
- 1. Patron and detector loop armed/activated magnetic ticket dispensers.
  - 2. Ticket dispensers are to include a display of instructions to the patron.
  - 3. Encode and dispense magnetic strip ticket that includes magnetic codes for time and date of entry and ticket identification.
  - 4. Dispenser prints for the patron information the time date and identification data on the ticket.
  - 5. Retract and separately store tickets presented for a patron, but not taken within a set period of time.
  - 6. Ticket dispensers shall be mounted in the space reserved for them on the entrance islands for entrance and reversible lanes.
  - 7. Dispensers shall have a controller/micro-processor to control the functions of the dispenser. The controller/micro-processor shall have a real time clock, control all functions of the dispenser and communicate with the on-site central processor.
- R. Magnetic Strip Ticket Reader: These are future items not to be delivered as part of this contract, but specifications are provided as the Contractor is to furnish system software for the reader and full compatibility.
- 1. Magnetic Strip Ticket Readers shall be provided as part of the Fee Calculator console or as may be the manufacturer's standard practice.
  - 2. Parking control booth magnetic strip ticket readers shall read the magnetic coded strip on the ticket and, with the fee computer, shall display the proper fee for the patron and cashier.
  - 3. The Contractor shall furnish detailed specifications and electronic protocol for the card readers being furnished to interface with magnetic strip ticket dispensers or a combined magnetic ticket dispenser and card reader package and install the full capacity.
- S. WMATA "SmarTrip" Target Modules, Operator Displays, Parking Console Units, Target Mounting cabling, conduits & connectors.
- 1. This "SmarTrip" system is a basically stand alone smart microprocessor chip proximity debit card system which is principally components developed for WMATA and manufactured by Cubic Transportation Systems (CTS) 5650 Kearny Mesa Road,

San Diego, CA 92111 Attention: Roger Kuitie. Alternate sources of this system are not available. This CTS manufactured SmarTrip system shall include:

- a. A "Micro Tri-Reader" Target Module - includes patron display (9345-11104) for each of 6 revenue collection exit lanes: the principal and secondary cashier lanes.
- b. Parking Console Unit.
- c. Operator Display.
- d. Interconnection, cable conduit and connectors to connect "Micro Tri-Reader" Target Modules, Parking Console Unit and Operator displays with each other to achieve operation and all connectors supplementally required conduit and cable to connect with the SMADS computer in the Station kiosk, lane control gates, the fee computers and Central Processor.
- e. Target posts or brackets and connection assembly shall be bolted either the concrete island surface as an access card reader post assembly or parking control booth side wall connection bracket. Provide detailed shop drawings showing fabrication and installation details for approval. The Targets are to be mounted so that the working face of the target is 2-inches from the face of the curb and not an injury hazard to either cashiers or patrons paying for parking by cash or other means.
- f. All equipment shall be installed according to the manufacturer's instructions. In addition the following requirements shall be met:
  - 1) The parking control booth Target Module shall be installed on the outside of the parking control booth 6 inches under the opening window sill, centered on the opening.
  - 2) The Parking Console Unit shall be installed inside the parking control booth on the side wall near the window, but it shall not encroach under any circumstance into the 60 inch diameter wheel chair area required under the ADA-Accessibility Guidelines for the parking control booth. The side wall under the counter in front of the duplex AC outlet may be feasible. All cables and conduits connecting to the Parking Console Unit shall be installed in conduits which shall be run as unobtrusive as possible, tucked in under the sliding window track.
  - 3) The operator display shall be installed in a fixed position on the parking control booth counter, well to the left near the side wall and shall not interfere with reach of operation of Fee Computer or gate/lane control switches or with the working surface required to collect and process cash payments and handle coupons.
- g. The SmarTrip System shall interface with two other operating systems.
  - 1) There shall be an output of the SmarTrip system connected with appropriate lane exit control gate to operate (open) the gate upon completion of a payment transaction at the respective Target. The gate shall close immediately upon passage of the vehicle.
  - 2) The SmarTrip system manufacturer (Cubic Transportation Systems) shall provide a means to furnish an output of SmarTrip transactions by type and individual transaction completed value to the fee computer/central processor report at the close of revenue collection the electronic debit revenue to track the type and value of all transactions at the payment array and hold the cashiers accountable.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION:**

- A. Sequence and Coordination Work:
1. The Contractor shall submit a detailed schedule of design, manufacture, installation and testing of the equipment to be installed under this Contract to the Engineer/Architect for review and approval.
  2. The Contractor shall perform system integration of all components and interfaces to ensure proper functioning of the entire system to include but not to be limited to: gate operation, booth environment and control functions, fee transaction, vehicle counting, and data collection, storage transfer and transmission.
  3. The Contractor's shall install a system that utilizes the equipment of a recognized and established manufacturer of parking facility controls. The equipment and software shall be approved by the Owner/WMATA in accordance with the Contract submittals delineated above. Any modification in equipment or software must be Authority approved and functionally satisfy all requirements of the specifications. The Contractor must submit detailed installation drawings and product approval documents for approval by Owner/WMATA prior to proceeding with a modified installation. The cost for any such modification shall be contained within the original bid submitted.
- B. Installation Procedures: Install all items in accordance with approved shop drawings, or other Contract plans and submittals.
1. Parking Fee and Hours Signs: Parking rate signs shall be free standing, and bolted to structurally adequate steel supports. Signs on islands will be mounted so that the top of the sign is 46 inches above the adjacent driving surface.
  2. Wiring and Raceway: Division 16 and as follows:
    - a. Electrical equipment cabinet terminal strips shall be used in equipment cabinets and all equipment harnesses shall be wired into terminal strips.
    - b. Sufficient slack shall be left in all wiring or cables to permit easy removal of equipment from the cabinet.
  3. Load Center: Division 16, as shown and as follows:
    - a. Mount so as not to obscure signage or parking control booth view of approaching vehicles.
  4. Loops: Pre-formed vehicle detector loops are to be placed in the traffic lanes as the PCC pavement is being placed. The preformed loops in PVC conduits are to be placed centered in the drive aisle and securely tied to the reinforcing and checked for connectivity and impedance before the concrete is poured. The loops shall have not less than 1-1/2 inch of PCC cover. The contractor shall install the proper loop size, shape, placement and the number of turns in accordance with the application and equipment installed and to provide precise and efficient counting and reporting of vehicle counts. The following provides guidance on the installation of the loops, but may be modified to suit specific installations with the approval of the Engineer/Architect.
    - a. Vehicle detector loops shall be positioned in each lane as required to perform the described functions. All loops are to be centered between the vehicle curbing. The vehicle detector loops shall be rectangular in shape or as specified by the equipment manufacturer.
    - b. The loops shall be located at a fixed and constant distance below the road surface. The loop sides must not be installed parallel within two inches of any rebar or other metal item.
    - c. No splices are to be made in the vehicle detector loop cabling. There shall be a single continuous wire to and from the connection point in the gate cabinet.
    - d. Sufficient loop wiring shall be provided to lead back to a vehicle detector amplified located in the appropriate gate cabinet plus six feet of slack.

- e. When two or more loops are installed in a single lane they shall be coiled in opposite directions to the adjacent loop(s). Loops in adjacent lanes shall be coiled in opposite directions from the loops in the same relative position
  - f. The vehicle detector loop wiring shall be 14 AWG THWN single-stranded conductor cable, or as specified and recommended by the amplifier equipment manufacturer.
  - g. The coils of loop wire shall be laid and incorporated into the preformed loops so that there are no kinks or curls in the loops. Each of the three or four continuously successive turns of loop wire, which number as specified or as recommended by the detector amplifier manufacturer, shall sit on top of the loop wire already coiled, in a vertical installed reference. The two lead wires shall be twisted together in a smooth symmetrically uniform with not less than 6 twists per foot of loop lead from the corner of the loop to the end of the lead. The top of the performed detector loop (conduit) shall be not less than 1/2 inch below the finished surface. Should the detector loop amplifier manufacturer specify other installation details for performed loops, they shall be submitted to the Engineer/Architect for approval.
  - h. Before the PCC is poured to bury the loop system, each loop shall be tested for continuity and insulation resistance. All tests shall be performed in the presence of a Owner/Wmata inspector. The loop shall also be tested with a vehicle detector amplifier of the type being furnished for the project by the Contractor. This test will simulate proper operation of the loops before the PCC is poured. Vehicle detector loops not passing the tests will be removed and replaced by the Contractor at the Contractor's expense.
5. Fee Computer Peripherals: The Fee Computer shall be installed on the counters in the individual booths. Holes with plastic or rubber grommet shields installed to protect cables from chafe shall be drilled/cut into the counter top. All cables connecting the Fee Computer and peripherals shall be lead thru the grommets holes to electrical box(s) below the counter where terminal strips are to be installed.
  6. Anti-Coincidence Logic Unit Function (ACLU): the Contractor shall provide software that will provide the ACLU function capabilities.
  7. Differential Counter Function: A software and/or hardware differential counting function (automatic vehicle counting and tabulating function) shall be provided to control the functioning of the FULL signs as well as provide data to the parking facility operations management.
  8. FULL signs: The contractor shall install FULL signs.
  9. Communications Installation: The Contractor shall install cables between the parking control booths, the structure equipment, operations and equipment, operations and equipment rooms, and the Grosvenor Passenger Station communication room to utilize the Wmata PABX system. The installation and routing shall be consistent with the National Electrical Code. The security alarm circuits inside the parking control booth(s) shall be 18 AWG solid RHW or XHHW insulation. The wiring for the telephone circuits inside of the attendant booth shall be 22 AWG solid conductors (pairs), telephone cable between each booth, parking structure operations room, parking structure communications room and the station communications room shall conform ESSEX CASPIC-F+M, 18 AWG telephone cable, or approved equal, and shall be terminated in the communications room via a combined protector block and terminal assembly similar to the Reliance Comm/Tec Model R66C1-6P, or approved equal. Cable to connect Fee Computers to Central Processor shall be of the Fee Computer manufacturer's recommendation
  10. The Contractor shall furnish and install cable and all needed conduits not otherwise available for the SmarTrip readers and processors between the parking control booth and the Station kiosk thru the station communications room. The cable shall conform to 22AWG 6 - Pair individually shielded Teflon insulated stranded computer

and instrumentation cables, Beldon 88778 or Beldon 87778 and a 3-pair 22 AWG minimum telephone cable.

11. Bollards: The bollards shall be installed so as to protect the equipment on the islands from damage by misdirected vehicles.
  12. Locks: The schedule of locks must be submitted and approved prior to their installation. Locks used to secure cabinets must be such that technicians who service the equipment do not have access to the drop safe, the revenue collection personnel who service and use the safe do not have access to the wiring of the electronic equipment and cashiers do not have access to either the safe or to the electronic equipment wiring.
  13. The existing PARK Management LAN equipment shall monitor the parking facility operations, via a communications link between the LAN computer and the garage central processor for parking structure fee computers and vehicle counting devices in the parking facility. The contractor shall be responsible for complete integration and test of the system from end to end.
  14. The SmarTrip system shall be installed and interfaced as described in Part @ - Equipment.
- C. The Contractor shall provide all additional work as indicated on the drawings and specifications to complete installation of a fully functioning parking facility in accordance with the Contract schedule.
- D. Deliverable Requirements:
1. Equipment and material provided as spares shall be delivered to a Owner/WMATA facility in the Washington, D.C. Metropolitan area as directed by the Engineer/Architect.
  2. Test reports, Maintenance Manuals and as-built drawings shall be delivered to the Engineer no later than 45 days after Owner/WMATA acceptance of the Parking Access and Revenue Control System installation.

### **3.02 TESTING REQUIREMENTS:**

- A. The Contractor shall perform component or equipment level testing, system level testing and a 30 day System Functional Accuracy Test. Two overall objectives of these tests are to establish system readiness for operations and ensure that the system will perform its continuing functions reliably.
- B. The Contractor shall prepare detailed test plans, procedures, pre-test check sheets, data entry forms and test report for all testing to be performed.
- C. The test plans shall provide objectives, requirements, approach and schedule for each test.
- D. The test procedure manuals shall include, but not to be limited to:
1. Pre-test inspection check list demonstrating equipment and system readiness for testing.
  2. As-built (installed) drawings.
  3. Listing, or table, of all cable identifications and equipment tags or name plates.
  4. Detailed steps to follow to accomplish the test.
  5. Listing of expected results, pass/fail criteria or parameters for the test.
  6. A listing of test reports required to establish readiness of the equipment or system for testing.
- E. Furnish equipment required to perform all tests. Test each installation and system in accordance with the approved procedures.

- F. The Contractor shall notify the Engineer/Architect a minimum of two working days prior to commencing any tests that are to be certified by the Engineer/Architect. For test coordinated with the PARK office, a minimum of 10 working days advance notice to the Engineer/Architect shall be provided.
- G. The Contractor shall furnish personnel, tools and test equipment as required to satisfactorily complete the tests. Test equipment used in performing the tests shall be in current calibration.
- H. Prepare certified test reports for each equipment installation test. For the system level 30 day System Functional Accuracy Test, copies of the equipment level certified test report forms shall be provided to the Engineer prior to the test.
- I. Tests encompassing system level parking facility management functions shall include complete end-to-end collection and transmission of data from each parking array, receipt of the data by the LAN computer system in the Jackson Graham Building and proper operation of the software provided by the Contractor.
- J. Equipment and system level requirements shall include testing of the following:
  - 1. Single-conductor cable and multi-conductor cable: Division 16, ohms.
  - 2. Grounding: Division 16; ground resistance not to exceed 25 ohms.
  - 3. Switches and receptacles: Division 16.
  - 4. Wire connection accessories: Division 16.
  - 5. Load centers: Perform insulation resistance test of each bus section phase-to-phase ground for one (1) minute using 1,000-volt megger. Insulation resistance to be not less than manufacturer's minimum, or two (2) megohms minimum, if no manufacturer's minimum is given.
  - 6. Demonstrate that all lanes and each gate functions properly (use vehicle to demonstrate. Demonstrate an automatic (fee calculator and independently SmarTrip) system failure mode for the gates.
  - 7. Demonstrate that the programmable vehicle counter functions in accordance with specification requirements.
  - 8. Demonstrate that the SmarTrip system and peripherals function in accordance with specification requirements.
  - 9. Demonstrate that the fee computers and peripherals function in accordance with specification requirements.
  - 10. Demonstrate that the central processor and peripherals function in accordance with specification requirements. Demonstration shall include transmission of data fee computers and vehicle counters to central processor. Demonstration shall also include storage of SmarTrip generated data on central processor and transmission of all PARC data to PARK office LAN computer system.
  - 11. Demonstrate operation of uninterruptible power supplies to data memory storage devices.
  - 12. Demonstrate operation of land control traffic signals.
  - 13. Demonstrate each security alarm. Note: TPAS Central Control must be notified in advance of an alarm test.
  - 14. Demonstration operation of two line desk phone in PARC Operations Center.
  - 15. Demonstrate proper operation of all locks and keys.
- K. After completion and inspection of all work, and following opening of the facility for patron use, the Contractor shall perform a 30 day system Functional Accuracy Test. The System Functional Accuracy Test shall include an end-to-end test of all functions of the system to include parking control booth functions, fee computers, software, gates, loops, counters, differential counters, FULL signs, security alarms, two-number automatic dial telephones,

logic packages, modems, communications, data collection and transmission from the parking structure and from the arrays, and data management in the PARK offices.

- L. Acceptance Criteria for the 30 Day System Functional Accuracy Test are:
1. That all installed equipment performs its intended function as described in this Contract and in the manufacturer's product literature where not in conflict.
  2. The Fee computer and parking control booth peripherals accurately and consistently record and report all transactions, to include operation of the patron reporting signage (fee display).
  3. The Central Processor and all peripherals accurately tabulates the traffic count data and Fee Computer activity and generates, upon command, standardized reports of same.
  4. The differential counting and FULL signs shall function with no more than a one percent error. The FULL signs are initially lit only when increasing parking structure occupancies actually reach a plateau between 99 and 101 percent of designated capacity. The FULL signs are extinguished when falling occupancies actually reach 101 to 99 percent of designated capacity, with some dampening control overpaid on/off switching due to very minor changes in counted occupancy up and down being evident.
  5. Entries and exits for each lane of each array must be counted with no more than 0.5 percent error (vehicle counts for each lane, by direction of travel, with an accuracy of at least plus or minus 1 in 200).
  6. The count related functions must be established by a counting means independent of the equipment being tested (including vehicle detectors). This must include a means of recording the count event and the time frame of event for analysis and comparison with the records and reports of PARK.
  7. Management software must produce accurate reports in formats set by PARK (Revenue Expected from Traffic Counts, adjustments for permit usage, and from SmarTrip activity) or the system manufacturer (Fee Calculator reports).
  8. If the system, or any part of it, fails to meet any criteria of the Systems Functional Accuracy Test, the Contractor will be given 30 days following discovery and reporting of the failure to make corrections at no additional cost to the Authority. More than three failures during the thirty (30) day test will result in a restart of the test period.

### **3.03 INTEGRATED LOGISTICS SUPPORT (ILS)**

- A. The spares, manuals and training shall provide the Authority with the capability to support the system. The spares, manuals and training must satisfy the following requirements, in addition to those stated in the General Requirements.
- B. Maintenance Support will be on two levels as follows:
1. Line Maintenance:
    - a. This level will be first link in the corrective maintenance chain with the requisite skills, tools and test equipment to analyze trouble calls and take corrective action. Line maintenance personnel will troubleshoot and repair malfunctions in the field.
    - b. Line maintenance personnel shall perform periodic scheduled preventive maintenance in accordance with Contractor published manuals. The Contractor's recommended preventive maintenance schedule shall be based upon the number of machine actions and/or machine service time.
  2. Shop Maintenance
    - a. Shop maintenance personnel shall have the skills, tools and test equipment to adjust, replace, repair, maintain and test the system in accordance with Contractor published manuals and instructions. Detailed assembly and sub-assembly engineering shall be developed by the Contractor and reviewed

by the Owner/WMATA for approval to support shop maintenance. Those drawings must be included in the applicable technical manuals. Nothing in this section is intended to require the disclosure of certified manufacturer's proprietary information. If certified manufacturer's proprietary information is involved with any assembly, sub-assembly or system, the Contractor shall so state, identify the assembly, sub assembly or system and shall alternately cover the Authority with an expressed in writing full labor and materials equipment lifetime repair and/or replacement warranty. The Owner/WMATA only has to identify the defective system, assembly or sub-assembly to the best degree possible and ship the defective item back to the manufacturer. The manufacturer will return the repaired unit or a new or reconditioned replacement within 10 working days of receipt. Widely available consumer computer hardware purchased from other manufacturers is exempt.

C. Spare Components

1. The Contractor shall provide spare components incidental to this contract. The total value of spares provided incidental to this contract shall be five percent of the price of the equipment and materials installed under this section of the Contract.
2. Submit a recommended spare parts list, with prices, showing the spare parts necessary to support the maintenance requirements for five years of revenue collection service. The recommended spare parts list shall be based on the following guidelines.
  - a. Group the list by subsystem and equipment item for stocking identification, include ordering and procurement information for subassemblies and components.
  - b. Include component name, description, rating accuracy, manufacturer's name, part number, drawing references, and correlate with the maintenance manuals. Prepare the list in a format that can be easily adapted for entry into a computer. Provide electronic media copies of the list.
  - c. Correlate the quantities recommended with reliability requirements and lead times, and considering the following classifications:
    - 1) Wear: Components which may be expected to require regular replacement under normal maintenance schedules, such as mechanical parts subject to continuous operation.
    - 2) Consumables: Components with an expected life of less than five years, such as indicator lamps.
    - 3) One Shot: Components which normally require replacement after performing their function only one time, such as fuses.
    - 4) Long lead: Components which are not available at short notice from commercial distributors or within 48 hours from the manufacturer, such as specially made or selected components
    - 5) Exchange assemblies: Assemblies which will be exchanged with malfunctioning on the supplied equipment during maintenance and which must be inventoried as complete assemblies.
    - 6) Cross referencing: Where replacement components are common to more than one system or subsystem.
    - 7) Non-unique parts: Items which are not unique to the system and have been manufactured by others.
3. The recommended spare parts shall be identical with all corresponding items of apparatus, components, assemblies and subassemblies incorporated into the system.
4. Package and label spare parts procure under this Contract for long term Owner/WMATA storage.
5. Delivery shall be to a location in the Washington metropolitan area as directed by the Engineer/Architect.

D. Manuals:

1. Operation and Maintenance Manual: This manual shall contain all information required to operate the system and perform scheduled maintenance including inspection, lubrication, adjustment and parts removal and all schematic and system operation required to accomplish on-line trouble shooting, fault isolation and repair. It shall include drawings depicting layout and locations of controls, indicators, cranks and cut offs, and emergency procedures and safety requirements. This manual shall contain assembly exploded views and isometric drawings and detailed step-by-step instructions for the removal, repair and replacement of all subsystems and components. Off line trouble shooting shall also be covered. For software developed or modified for this contract, the manual shall include a complete annotated source code to enable trouble shooting by Owner/WMATA users/and or programmers. The manual shall include reference and documentation for any commercial software used in the system.
2. Parts Catalog: Enumerate and describe every component with its related parts, including the supplier's number, the Contractor's number and commercial equivalents. Include provisions fore entry of an Owner/WMATA part number. Use cut-away and exploded drawings to permit identification of all parts. Parts common to different components (for example bolts and nuts) shall bear the same Contractor's number with a reference to the other components in which they are found, including cross reference and indexing system in the replacement components list. Items which have been manufactured by others shall be identified by the manufacturer's name and part number as well as by the Contractors component number, if any., Each part or component shall be identified to the next larger assembly.
3. Each manual shall be organized into the following parts:
  - a. Part One - Subsystem Characteristics
    - 1) A physical description of the subsystem and pertinent technical characteristics.
    - 2) A description of the functions the subsystem is designed to perform and the general methods employed to accomplish those functions.
  - b. Part Two - Principles of Operation
    - 1) Detailed discussion of the theory of operation.
    - 2) Interface between subsystem components.
    - 3) Signal flow sequence correlated to block diagrams.
  - c. Part Three - Operating Procedures
    - 1) Turn on and turn-off procedures.
    - 2) Detailed operator instructions sufficient to operate the equipment in each available mode of operation.
  - d. Part Four - Maintenance Procedures
    - 1) Preventive maintenance procedures and schedules.
    - 2) Fault isolation and analysis procedures and schedules.
    - 3) Corrective maintenance and repair procedures.
    - 4) System calibration and test procedures.
    - 5) Parts catalog.
4. Bind each copy of the above manuals as required by the General Requirements.
5. The quantity of manuals shall be as specified below. Revisions shall be supplied in the same quantities as specified for the manuals.

ITEM	QUANTITY
Operation and Maintenance Manual	10
Parts Catalog	10

6. Delivery: Final manuals shall be delivered no later than 45 days after acceptance by the Owner/WMATA of the parking facility installation.

E. Training:

1. The Equipment Familiarization Course shall provide management, supervisory and engineering personnel with a functional understanding of the equipment (hardware and software). The functions of each item shall be covered, including the interrelationships of the equipment with vehicles and patrons.
2. A Line Maintenance Course shall provide maintenance supervisors and technicians with the knowledge and skills required in the performance of preventive maintenance of all components of the system. Additionally, the course shall cover any deliverable software, and maintenance of special test equipment provided, whether portable or stationary, including built-in test features. The course shall emphasize preventive maintenance as well location and correction of malfunctions to the system. Sufficient training in operation, theory of operation and fault isolation to isolate problems to the equipment component or software module level shall be presented.
3. The Shop Maintenance Training Course shall provide maintenance supervisors and technicians with the knowledge and skills required in the performance of preventive and corrective maintenance of the entire system. Additionally, the course shall cover any deliverable software, and the maintenance of special test equipment provided, whether portable or stationary, including built-in test features. The course shall provide in-depth training on theory of operation of the system, individual software modules, printed circuit boards (including Contractor designed, off the shelf, OEM and all other vendor supplied not covered by written expressed Contractor full labor and material lifetime warranties), any other special test equipment, shop test procedures, module and printed circuit board repair procedures, and overhaul and testing procedures to the equipment component level. Operations procedures shall also be covered.
4. Training Criteria and Instructor Qualifications:
  - a. The Contractor shall develop and provide all familiarization, line and shop level training necessary for Owner/WMATA designated personnel to support the system, and shall have fully qualified instructors presenting the instruction. Classroom instruction shall include the anatomy and functioning of the parts under discussion, the essentials of their routine care including lubrication schedules, adjustments, limits test, and inspection frequency, troubleshooting, removal and replacement. Instruction shall cover theory of operation of the system, individual modules and all printed circuit boards. Software flow diagrams shall be used to show sequence of events and timing of system operations.
  - b. Instruction shall be designed to cover, in detail, the functions of each item of equipment. Fault isolation and troubleshooting technique will be covered to the extent necessary to permit a technician to diagnose and repair faulty items of equipment. There shall be instruction designed to permit Owner/WMATA maintenance personnel with practical experience in the performance of preventive and corrective maintenance. The course shall include hands on troubleshooting and fault isolation of all subsystems using simulated faults provided for each. Students shall be allocated adequate time to perform preventive maintenance operations on the system components in addition to troubleshooting bugged system components.
  - c. Instructors shall be experienced and fully qualified to teach the course as outlined. The Contractor shall provide a resume outlining the instructor's qualifications and skills. The Contractor shall obtain approval of instructors from the Engineer/Architect 120 days prior to the beginning of the training. Qualifications will be considered adequate when:

- 1) The Contractor's designer of the system is the instructor and has the ability to communicate facts about the system in understandable terms: or
  - 2) The instructor has been trained in teaching methods and is fully familiar with the subject matter.
- d. In all cases, lesson plans shall be prepared and submitted to the Owner/WMATA at least 120 days prior to the class. These lesson plans shall outline material to be presented and list training aids to be used. The course outline and material shall be approved by the Engineer/Architect before being presented. The Contractor shall assume that Owner/WMATA employees have no knowledge of the features of the new equipment. The Owner/WMATA shall be permitted to video tape all class presentations on a non-interference basis.
5. Provide first generation reproducible training materials that meet the following requirements:
- a. An instructor's Guide for each course, which shall include:
    - 1) Table of Contents listing each topic and the time allotted.
    - 2) List of applicable documents.
    - 3) List of training materials.
    - 4) Course learning objectives including course length and recommended number of students.
    - 5) Each topic shall have a cover sheet listing the topic, objectives, time allotted and training aids required.
    - 6) Examinations, if applicable.
    - 7) Training aids shall be developed with the instructor guides.
    - 8) Student and Training Course Evaluation forms.
  - b. A Course outline with learning objectives stated for each topic, shall be provided. It shall include a topic outline for each item of equipment. Maintenance courses shall include a section devoted to system fault analysis and troubleshooting.
    - 1) Description of course including course objectives and type of training.
    - 2) Course length and recommended number of students per course.
    - 3) List of training materials required including documentation and equipment.
    - 4) Each course outline shall list all topic objectives and the time allotted to each topic.
  - c. A set of lesson plans shall be developed for each item of equipment, corresponding to the topic outline, and shall contain the following information: lesson title, time, objectives, training aids required, instructing sequence (outline), tests and summary.
  - d. Visual training aids shall be developed for each topic.
  - e. The primary source of instructional material shall be the applicable sections of the operation and maintenance manual(s), approved by the Owner/WMATA and certified by the Contractor as being correct and reflective of as-built conditions and equipment. In addition, the Contractor shall develop, for each course, notebooks containing such additional drawings, descriptive information and procedures necessary to ensure meeting all learning objectives in an orderly and timely manner. Copies of diagrams, drawings and procedures shall be produced from engineering data and manuals by the Contractor for inclusion into the notebooks. Arrange notebook material by each item of equipment and sequence according to the topic outline. This material shall be submitted for Owner/WMATA approval not later than 120 days prior to the start of training.

- f. Training shall be concluded utilizing installed equipment in the normal operating condition, except in the case of classroom or shop and maintenance training lab equipment shall be used. The Contractor shall provide the production equipment for use during conduct of the training program described herein. Any special tools or test equipment required for maintenance shall be supplied by the Contractor and delivered to the Engineer/Architect.
6. Supplemental Training: In the event the Contractor changes or performs modifications to the equipment subsequent to the training that impacts form, fit or function, the Contractor shall provide supplementary training to the Owner's/WMATA's training instructor on a one time basis.
7. Location: Training classes will be conducted at facilities provided by the Owner/WMATA.
8. Practical training on equipment shall be no less than 60 percent of the course duration. Personnel attending training sessions will be identified by Owner/WMATA.
9. Time: Class time will be at the convenience of the Owner/WMATA.
10. Scope: The following number of Owner/WMATA personnel will attend the training program:
- | Course Title | Length of Course | Number of Students per Session | Number of Course |
|--------------|------------------|--------------------------------|------------------|
| Equipment    | 4 hours          | 8                              | 1                |
| Line         | 16 hours         | 8                              | 1                |
| Shop         | 8 hours          | 4                              | 2                |
11. Schedule: The Contractor shall develop a detailed training program plan.
- a. The Contractor shall submit a final outline and schedule of classes for the training program 120 days prior to scheduled completion of the parking facility.
- b. The Contractor shall submit lesson plans course materials for students and instructors, notebooks and instructor manuals, 120 days prior to course beginning. This material will become the property of the Owner/WMATA following the conclusion of the training course. Two copies of the material for each course shall be provided 120 days in advance of this course for Owner/WMATA approval.
12. Until final delivery of the product to the Owner/WMATA, a document configuration control system approved by the Engineer/Architect shall be used to maintain all training material. All revisions shall be identified at the beginning of each manual. Revisions shall be made for all design changes and, retrofit, error corrections and as otherwise required. Include a control list for each manual produced which shall show the date and latest revision of each page in the manual. Include the list as an index in each manual, to be issued with each revision of the manual until expiration

F. The following list of equipment shall be installed and made operational:

1. Gate and lane control signal control console(s).
2. Fee Calculators.
3. SmarTrip System.
4. Communication support installations.
5. Vehicle detector loops and loop leads to operate gates, lot full signs, card readers, magnetic ticket dispensers and vehicle counting equipment.
6. Vehicle detector loop amplifier electronics and logic, including associated software
7. Programmable vehicle counting equipment, including associated software.
8. Differential counter, anti-coincidence and differential logic, lane entrance/exit point and facility totalizing counters (may be hardware and/or software).

9. Barrier/lane control gates, with articulated arms suitable for applications with limited overhead clearance, as necessary.
  10. Lane Control signals.
  11. Modem, or equivalent data transmission means.
  12. Back up power supplies for system equipment, including three hour uninterruptible power supply capability for the fee computer and for vehicle counting equipment.
  13. Controls for FULL signs and lane control signals.
  14. Bollards.
  15. Interfaces, wiring and miscellaneous equipment required to complete the system.
  16. Video cameras, recorders and monitors to be located in PARC Operations Facility operations room including associated racks, video connections and power supplies.
  17. Parking facility central processor to be located in PARC Operations Facility operations room including associated software, network connectivity on and off-line via modem or equivalent to the management computer local area network (LAN) in the office of PARK (located at 600 Fifth Street, N.W., Washington, D.C. 20001), printer, work station and peripherals.
- G. The following list of equipment shall be installed and made operational:
1. Articulated arms for Barrier Control Gates as necessary for applications with limited overhead clearance.
  2. Fee Computer for parking control booths, including associated software, interface hardware and software for future magnetic strip ticket reader, external fee display driver, patron receipt printer, cashier/shift activity report generator/printer (if not otherwise needed in support of other systems now required), automated cash drawer, key pad, visual display, moisture resistance and peripherals.
  3. Back up power supplies for system equipment, including 3 hour uninterruptible power supply capability for the fee computers unless very same equipment/system is needed for the
  4. Provisions and full compatibility for future installation and operation of magnetic ticket dispensers and card readers
  5. Full system for provision for reading / writing and processing proximity smart cards (WMATA SmarTrip system) at each parking control booth and integrated transaction data reporting to Fee Computer or Central Processor. (including proximity smart card read/write readers).
  6. Integrated Logistics Support (ILS).

**END OF SECTION**

## SECTION 11155

### MECHANICAL PARKING METERS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies mechanical parking meters, meter collection cart, collection boxes and associated features.
- B. Related Work Specified Elsewhere:
  - 1. Galvanized steel parking meter post: Section 05500.
- C. Definitions:
  - 1. Short Term spaces: Metered spaces for paid parking up to seven hours from 8:30 AM to 2:00 AM.
  - 2. Kiss and Ride spaces: Metered spaces for paid parking up to seven hours from 8:30 AM to 3:30 PM and from 7:00 PM to 2:00 AM. From 5:00 AM until 8:30 AM and from 3:30 PM to 7:00 PM these spaces are designated NO PARKING, intended to be used only for driver-attended drop-off and pick-up of Metro patrons. Long Term spaces: Metered spaces for paid parking up to 12 hours from 8:30 AM to 2:00 AM.
- D. WMATA Credit: If lock specified for the security vault doors cannot be installed due to unavailability from the lock manufacturer, a WMATA-determined credit or deduction for purchase and installation of the specified lock by WMATA will be applied and used in Bid evaluations

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Codes and regulations of the jurisdictional authorities.
- B. Qualifications of the Manufacturer: Provide products of an established manufacturer of mechanical parking meters for at least the last 10 years.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings: Details and parts list of specified products. Include manufacturer's installation, operating and maintenance instructions.
  - 2. Samples:
    - a. One meter, meter collection cart and collection box.
    - b. One of each accessory material or tool used for the work or for servicing the meters.
    - c. After approval, samples may be installed in the work.
  - 3. Certification: Document that the parking meters and support equipment are current production models, which the manufacturer has delivered to other purchasers in substantial quantities, and which are in current operational use.

##### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Follow manufacturer's instructions to protect mechanisms and finishes from damage.

- B. Deliver spare meters, meter collection carts, collection boxes and other material as directed by the Engineer.

## **PART 2 - PRODUCTS**

### **2.01 GENERAL:**

- A. Provide products and components that are new and unused.
- B. Provide parking meters and components of design and manufacture that have withstood five or more years of dependable on-street performance.
- C. Each meter consists of one mechanism with timer, enclosed in a zinc-alloy upper housing, and one coin canister, enclosed in a cast-iron security vault housing. Duplex meters include two each of the above plus one yoke.

### **2.02 MECHANISM:**

- A. Operation: After deposit of a proper coin and fully turning the operating handle, the time indicator displays the increment of time purchased. Existing time may be increased by deposit of additional proper coins until reaching the maximum time limit of the meter. Total amount of time purchased and time still available are shown after the deposit of each coin. Whenever the operating handle is turned from home position, the Violation Flag is displayed until the rotation cycle is completed.
- B. Mechanism Assembly: The meter operating mechanism is constructed as a completely assembled unit totally separate from the mechanism housing, removable from or replaced in the housing as a whole unit, for inspection or repair, without the use of special tools. The meter mechanism is to be a self-aligning, drop-in unit, that does not require locking studs, pins or screws to secure it into the housing.
- C. Coin Slot: Coin slot is to be on front of the meter next to operating handle and positioned so that coins enter the slot on edge vertically and perpendicular to face of the meter. Coin slot is to be either stainless steel or zinc alloy, sized to specific coin denomination. Meter mechanisms are to automatically close the coin slot entrance during turning of operating handle or in event of a jam, thereby preventing the insertion of additional coins until cleared. The mechanism is to be easily adjusted to maintain proper tolerance between the time winding component and the coin carrier.
- D. Washer Detector: Equip meter with a washer-sensing device to detect improper coinage or washers, passing them through without adding time.
- E. Flags: Mechanism is to have two-flags: TIME EXPIRED and VIOLATION.

### **2.03 TIMER:**

- A. Construction: Use high quality workmanship, with gears and pinions free from burrs, shock-resistant, and with gears, pinions and other components made of non-corrosive materials. Protect timer from dust, moisture and impact by using timer cover made of UV-resistant transparent thermoplastic material, so as to permit viewing of the time without requiring removal of the cover.
- B. Operation: Mechanism clock and timer is to function correctly at temperatures from minus 30F to plus 130F, with an error factor of exact run-out to plus three minutes per hour maximum.

- C. Adjustment: The front balance wheel pivot, or adjustment stud, is to be threaded so it may be used to adjust balance-wheel end play. The back, exposed end, of the arbor shaft is to be machined so that a timer key may be used to either place time on or remove it from the meter mechanism, as well as for use in winding the timer when servicing.

#### **2.04 MECHANISM HOUSING (UPPER HOUSING):**

- A. Construction: Rugged, weather-resistant zinc-alloy case constructed to resist tampering and abuse. Cap portion is to have a clear viewing window made of high-impact-resistant and UV-resistant polycarbonate material.
  - 1. Mechanism housing is to have capability of being set to at least two different housing positions by simple means from within the mechanism housing.
  - 2. Mechanism housing is to be fully interchangeable from one meter to another, or from single to duplex meter units; and vice-versa.
- B. Lock: Access to the mechanism is to be through a tumbler lock and key, but not allow access to the coin compartment
- C. Finish: Chip-and-scratch-resistant, UV-resistant, oven-cured polyester powder coating, with minimum dry film thickness of 2.5 to 3.5 mils. Color as determined by the Engineer.

#### **2.05 SECURITY VAULT (LOWER HOUSING):**

- A. Construction: One-piece cast-iron casting, rugged, weather-resistant, corrosion-resistant, and of such thickness as to resist tampering and abuse.
  - 1. Vault Door is to have same construction as the security vault. Vault door and door opening are to be machined to a tolerance of less than 1/32 inch. Door is to be hinged to the vault compartment using steel pins. Design is to prevent drilling out these steel pins to gain access to the coin compartment using a common hand-held drill and bits. Door locking mechanism is to have a latch arrangement to prevent prying open the door.
  - 2. Bottom of security vault is to fit into a nominal two-inch OD Schedule 40 (standard weight) galvanized-steel pipe, and to fasten securely to the pipe (post) with a self-adjusting three-piece wedge assembly designed so that the unit can only be removed from inside the security vault.
  - 3. Security vaults and vault doors are to be fully interchangeable from one meter to another.
- B. Lock: National KeSet High-Security Lock (part number N42002), matching the series and key combinations reserved for WMATA. Other locks are not to be furnished. See Article 1.1 paragraph entitled WMATA Credit.
- C. Keys: Keys for the lock are to be precision cut from materials ensuring long life, without damage to the lock or tumblers. Key blanks are not to be available from locksmiths. Key delivery is to be via registered letter only to the WMATA recipient designated by the Engineer.
- D. Finish: Chip-and-scratch-resistant, UV-resistant, oven-cured polyester powder coating, with minimum dry film thickness of 2.5 to 3.5 mils. Gray color as determined by the Engineer.

#### **2.06 COIN CANISTER:**

- A. Construction: Sealed box of largest-capacity-available; dent-resistant and of lightweight construction; made of corrosion-resistant metals, high-impact ABS plastic material or both. However, these containers are to be strong enough to resist entry with normal hand tools and breakage from dropping.

- B. Operation: When coin canister is removed from a meter for collection purposes, it can unlock only when inserted into a special receiving device (revenue-collection-head assembly) having an embedded key, which thereby allows coins to drop directly into the collection box mounted on a meter collection cart as specified below. The coin canister prevents coins from being removed by means of inverting or shaking the canister unless it is placed in the revenue-collection-head assembly on the collection box.
- C. Lock: Lock and keying for coin canisters are to be different from those of the mechanism housing and security vault, but are to be the same for all coin canisters and reserved for the exclusive use of WMATA.

**2.07 YOKE:**

- A. Construction: Heavy-duty cast-iron unit designed to receive two single meters as a duplex installation on a single post. Make yokes fully compatible with the parking meters. Bottom of yoke is to fit into a nominal two-inch OD Schedule 40 (standard weight) galvanized-steel pipe, and to fasten securely to the pipe (post) with a self-adjusting three-piece wedge assembly designed so that the unit can only be removed from the inside. There is to be no exposed mounting nut on the yoke or meters when assembled on the post.
- B. Finish: Chip-and-scratch-resistant, UV-resistant, oven-cured polyester powder coating, with minimum dry film thickness of 2.5 to 3.5 mils. Gray color as determined by the Engineer.
- C. Quantity: Provide yokes only where duplex meters are specifically shown.

**2.08 METER COLLECTION CART, COLLECTION BOX AND ACCESSORIES:**

- A. Meter Collection Cart is a wheeled cart designed to securely hold a collection box.
- B. Collection Box is a secure box having lock, hasp and security hinges on its access door. A revenue-collection-head assembly is on the lid of the collection box for receiving, unlocking and dumping contents from the parking meter coin canisters. Collection boxes are to be of rugged enough construction as to resist entry with normal hand tools.
- C. Revenue-Collection-Head Assembly: This is to be fully compatible with the coin canister, and includes an embedded key to unlock the sealed coin canister. The sealed coin canister thereby opens inside the revenue-collection-head assembly causing the canister's contents to empty directly into the collection box.
  - 1. Make embedded key for coin canisters different from keys for the mechanism housing and security vault, but able to open all coin canisters, and reserved for the exclusive use of WMATA.
  - 2. Head assembly is to be so constructed as to prevent unauthorized removal of coins from the collection box.
- D. Finish: Baked enamel or polyester powder coating. Color as determined by the Engineer.
- E. Quantity:
  - 1. Meter Collection Cart: One.
  - 2. Collection boxes: One for each isolated facility where meters are provided.

**2.09 DURATION, RATES, COINAGE AND RATE PLATE:**

- A. Short Term and Kiss-and-Ride Spaces: Make meters at these spaces capable of the following duration, rates and coinage, and equipped with rate plates:
  - 1. Duration: Seven hours maximum time on meter.
  - 2. Rate: \$.25 per hour to the maximum time on dial.

3. Coinage: Quarters only.
4. Short Term rate plate: Install in each meter an aluminum rate plate which lists duration, rate, coinage and periods of operation; reading as follows:

MAXIMUM SEVEN-HOUR DURATION PARKING  
EFFECTIVE FROM 8:30 A.M. TO 2:00 A.M.  
EXCEPT SATURDAYS, SUNDAYS AND HOLIDAYS  
\$0.25 PER HOUR TO MAXIMUM TIME ON DIAL  
USE QUARTERS ONLY

5. Kiss-and-Ride rate plate: Install in each meter an aluminum rate plate which lists duration, rate, coinage and periods of operation; reading as follows:

PARKING FROM 8:30 A.M. TO 3:30 P.M.  
AND 7:00 P.M. TO 2:00 A.M. ONLY  
EXCEPT SATURDAYS, SUNDAYS AND HOLIDAYS  
\$0.25 PER HOUR TO MAXIMUM TIME ON DIAL  
USE QUARTERS ONLY

- B. Long Term Spaces: Make meters at these spaces capable of the following duration, rates and coinage, and equipped with rate plates:
  1. Duration: 12-hour maximum time on meter.
  2. Rate: \$0.25 per 90 minutes to the maximum time on dial.
  3. Coinage: Quarters only.
  4. Long Term rate plate: Install in each meter an aluminum rate plate which lists duration, rate, coinage and periods of operation; reading as follows:

MAXIMUM TWELVE-HOUR DURATION PARKING  
EFFECTIVE FROM 8:30 A.M. TO 2:00 A.M.  
EXCEPT SATURDAYS, SUNDAYS AND HOLIDAYS  
\$0.25 PER 90 MINUTES TO MAXIMUM TIME ON DIAL  
USE QUARTERS ONLY

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION:**

- A. Install meters in accordance with manufacturer's instructions on posts as shown in the Contract Drawings, providing the materials required for proper installation and operation.
- B. Orient meters facing the curb against which cars park.

**END OF SECTION**

## SECTION 11156

### ELECTRONIC PARKING METERS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES:

- A. Electronic parking meters, to control and collect revenue for "Short Term" or "Kiss and Ride" parking spaces. They shall be interchangeable with electronic parking meters previously purchased by the Authority. Mounting pole installation and meter location shall be as described below. Meter requirements shall be as described below and as required by manufacturer's instructions. Signs, for patron information concerning metered parking facilities, are not specifically addressed herein. Section 02890 addresses sign requirements.
  - 1. "Short Term" spaces are those metered spaces that authorize parking for up to seven hours between the hours of 5:00 AM to 2:00 AM.<sup>\*1</sup>
  - 2. "Kiss and Ride" spaces are those metered spaces that authorize parking for up to seven hours between the hours of 8:30 AM to 3:30 PM and from 7:00 PM to 2:00 AM. From 5:00 AM until 8:30 AM and from 3:30 PM to 7:00 PM the spaces shall be for drivers dropping off and picking up Metro patrons.<sup>\*2</sup>

##### 1.02 RELATED SECTIONS:

- A. Parking Access and Revenue Control System: Section 11150.
- B. Galvanized steel parking meter post: Section 05500.
- C. Signage: Section 02890.

##### 1.03 REFERENCES:

- A. Codes and regulations of the jurisdictional authorities.

##### 1.04 DELIVERY, STORAGE AND HANDLING:

- A. Delivery of meter communications devices, software, spares, collection cart(s) and other material shall be as directed by the Engineer.
- B. Keys for the meter security vault door lock shall be delivered via registered letter only to the authorized WMATA representative designated by the Engineer.
- C. Ship each unit securely packaged to avoid damage and labeled for safe handling in shipment.
- D. Store all equipment in a secure and dry storage facility until ready for installation or turn over to the Authority.
- E. The Contractor shall be responsible for receipt of all furnished equipment and supplies and for safeguarding the equipment and supplies from pilferage and the effects of weather until accepted by the Authority in final installed configuration.
- F. Deliver spares to storage area designated by the Engineer.

##### 1.05 ENVIRONMENTAL REQUIREMENTS:

- A. The meters shall automatically compensate to ensure accurate operation and coin discrimination at all temperatures between minus 20 degrees and plus 140 degrees Fahrenheit. It shall function properly under Metropolitan D.C. conditions of solar loading, rain, snow, sleet, grime and street vibrations.

**1.06 SUBMITTALS:**

- A. Documentation shall be submitted showing that the parking meters and support equipment are current production models, which the manufacturer has delivered in substantial quantities, and which are in operational use.
- B. Integrated Logistics Support shall be provided as required by Section 11150.

**1.07 DURATION, RATES AND COINAGE:**

- A. The meters shall be programmable, using personal computers already in the offices of PARK, Contractor-provided software and a Contractor-provided remote programming device. The program capabilities of the meters shall include ability to accept from one to a minimum of five different coins and the pre-paid stored value smart card (debit card), permit variable maximum times up to 12 hours, and vary the rates for different periods of the day and different days of the week. The meters shall be capable of field programming using the remote programming device.
- B. The following duration, rates and coinage shall be used for the initial factory setting:
  - 1. Seven-hour duration.
  - 2. Rate of one hour per quarter to seven hours.
  - 3. Accept debit cards or quarters only.
- C. In "Short Term" facilities the meter shall be provided with an installed aluminum rate plate which lists duration, rate, coinage accepted and periods of operation as follows:
  - 1. MAXIMUM SEVEN HOUR DURATION PARKING EFFECTIVE
  - 2. FROM 5:00 A.M. TO 2:00 A.M.
  - 3. EXCEPT SATURDAYS, SUNDAYS AND HOLIDAYS
  - 4. \$0.25 PER HOUR TO MAXIMUM TIME ON DIAL
    - a. USE QUARTERS OR DEBIT CARDS ONLY
- D. In "Kiss and Ride" facilities the meter shall be provided with an installed aluminum rate plate which lists duration, rate, coinage accepted and periods of operation as follows:
  - 1. PARKING FROM
    - a. 8:30 A.M. TO 3:30 P.M. AND 7:00 P.M. TO 2:00 A.M. ONLY
  - 2. EXCEPT SATURDAYS, SUNDAYS AND HOLIDAYS
  - 3. \$0.25 PER HOUR TO MAXIMUM TIME ON DIAL
    - a. USE QUARTERS OR DEBIT CARDS ONLY

**PART 2 - PRODUCTS**

**2.01 ELECTRONIC MECHANISM:**

- A. The meter mechanism shall be fully electronic with solid state modular components. It shall be capable of accepting a coin, a debit card, or a combination of coins and card. The electronics shall be resistant to electromagnetic interference.
  - 1. When using coins, the meter time indicator shall display the time purchased after deposit of a proper coin. Existing time shall be incrementally increased by the deposit of additional proper coins until the maximum time limit of the meter is

- reached. Total amount of time purchased shall be shown after the deposit of each coin.
2. When using the card, the meter time indicator shall display the amount of time purchased, increasing this amount until the card is removed, the debit limit on the card is reached, or to the maximum time limit of the meter.
  3. There shall be no requirement to turn handles or push thumb slides on the meter when purchasing time.
- B. The meter operating mechanism shall be constructed as a completely assembled modular unit separate from the meter housing. The mechanism frame, coin chute, battery and card reader shall be removed from or replaced in the meter housing, as separate units, without the use of special tools.
- C. The coin and card slots shall be flush on the front of the meter and so positioned that coins and cards enter the slot at a 90-degree angle to the mechanism display face. Slots shall be metal and vandal resistant.
- D. The coin chute shall be single slot, jam resistant, and made of stainless steel or zinc alloy. It shall deposit coins in the security vault coin cannister. It shall be equipped with a detector for washers, plastic discs, slugs and other spurious coin substitutes which shall pass while not adding any time. This detector shall not have any points susceptible to grime or moisture failure. Withdrawal of a valid coin through the coin chute shall remove the time purchased by the coins insertion.
- E. The power supply for the meters shall be a six-volt lithium battery. New batteries shall be supplied for each meter in the contract. The battery shall be capable of installation and removal without tools.

## **2.02 INDICATION:**

- A. The time display shall be a four-digit liquid crystal display (LCD) with one-half inch characters. It shall be mounted on the front of the meter tilted up for maximum patron visibility. The display shall be readable in bright sunlight and low light conditions. Two characters shall indicate hours and two shall indicate minutes. The hours and minutes characters shall be separated by a colon that flashes in one second beats. The display shall function at all temperatures between minus 20 degrees and plus 140 degrees Fahrenheit. The timer LCD shall also indicate when the meter is malfunctioning by an easily understood symbol or character display.
- B. On the rear of the meter shall be a status indicator similar in concept to the time expired and violation flags used on mechanical meters. This display shall be visible from a distance of at least 70 feet in both glare and low light conditions. The display shall be green when time is registered on the meter, bright red when time is expired and yellow when there is a meter jam or failure. This status indicator shall not require power to operate and maintain visibility of a status indicator except when changing status modes.
- C. The viewing lens shall be made of high impact resistant polycarbonate materials.

## **2.03 MECHANISM HOUSING:**

- A. The entire mechanism shall be enclosed in a rugged, weather-resistant zinc alloy case constructed of such a thickness as to resist tampering or abuse. The mechanism housing shall be coated with a corrosion and ultraviolet light resistant finish.

- B. Mechanism housing compartments shall be fully interchangeable from one meter to another, or from single to double meter units; or vice-versa. Access to the mechanism shall be through a separate lock combination and key, and shall not allow access to the coin compartment housing.
- C. Mechanism housings of double meter units shall be capable of being re-positioned to at least two different orientations by simple means from within the mechanism housing.
- D. All meter housings shall be designed to fit into a standard two-inch I.D. schedule 40ST galvanized steel pipe, and fasten securely with a self-adjusting three piece wedge assembly designed so that the unit can only be removed from inside the coin compartment housing.
- E. A single meter shall consist of one operating mechanism enclosed in a zinc alloy housing and one collection canister enclosed in a cast iron security vault housing.
- F. A yoke unit shall consist of a cast iron unit on which two single meters will be installed for mounting on a single post. The yokes shall be fully compatible with the parking meters furnished in this Contract. The yoke shall be designed to fit into a standard two-inch I.D. schedule 40ST galvanized steel pipe, and fasten securely with a self-adjusting three piece wedge assembly designed so that the unit can only be removed from the inside. There shall be no exposed mounting nut on the yoke and meters once assembled on the post.
- G. All parking meters shall have a separate coin collection cannister for each operating mechanism housing. Double meters shall not share a single collection cannister.
- H. Access to the mechanism housing shall be through a lock combination and key that shall not allow access to the meter security vault housing.

**2.04 METER SECURITY VAULT:**

- A. The security vault housing shall be a one-piece cast-iron casting. The housing shall be rugged in construction, weather and corrosion-resistant, and of such thickness as to resist tampering or abuse. It shall be coated with a corrosion-resistant gray finish.
- B. Vault doors shall be of the same material as the vault housing. The vault door and door opening shall be machined to a tolerance of less than one thirty-second of an inch. They shall be hinged to the vault compartment using steel pins. It shall not be possible to drill out these steel pins to gain access to the coin compartment using a common hand-held drill and bits. The door locking mechanism shall have a latch arrangement to prevent the door from being pried open.
- C. The meter security vault door lock shall be a National KeSet High Security Lock (part number N42002), or equal, matching the series and key combinations which have been reserved for WMATA.
- D. Keys for the lock shall be precision cut and manufactured of materials which ensure long life, without damage to the lock or tumblers. Key blanks shall not be available from locksmiths.

**2.05 COIN CANISTER:**

- A. Each meter shall include a sealed, expanded-capacity or largest capacity available coin canister, which shall be dent resistant and of lightweight construction. They shall be made of corrosion-resistant metals, high-impact plastic ABS or Cyclocac materials. However, these containers shall be of strong enough construction to resist entry with normal hand tools and breakage from dropping. When the coin cannister is removed from the meter for collection

purposes, it shall then be inserted into a receptacle with an embedded key to unlock the canister in the receiving device mounted on a collection cart, causing coins to drop into the cart container. The coin cannister shall be equipped with a device which restricts the coins from being removed by means of inverting or shaking the container when it is not inserted in the revenue-collection head assembly on the collection cart container.

- B. Lock combinations of the coin canisters shall be different from either the mechanism housing or meter security vaults.

#### **2.06 PREPAID STORED VALUE SMART CARD (DEBIT CARD):**

- A. The WMATA cards are pre-programmed, micro-chip technology with the following features:
  - 1. ISO 7816-1 and ISO 7816-2 compatible.
  - 2. Dimensions of 54.0 mm high by 85.6 mm wide by 0.76 mm deep. Corners rounded with a radius of 3.18 mm. Edge burrs normal to the card face not to exceed 0.08 mm above the card surface.
  - 3. Single five-volt power supply.
  - 4. CMOS technology.
- B. Cards have a pre-programmed value of \$50. This value will decrement as it is used at the times and rates described above.
- C. Cards operate in two memory modes, an issuer mode and a count down mode. After a card has been personalized, a count down mode is generated for use.

#### **2.07 COMMUNICATIONS AND DATA TRANSFER:**

- A. Meters shall be capable of communicating with a portable, battery-powered, hand-held computer communications device supplied with this Contract.
- B. The communications device shall be used to:
  - 1. Re-program time, coinage and rate structures.
  - 2. Retrieve audit information such as currently programmed time, coinage and rate structure, serial number, transaction information, battery charge, maintenance information and programming information.
  - 3. Assign serial numbers.
  - 4. Enter maintenance information.
- C. The Contractor shall provide the communications device interface and software to upload and download of programming and data on an existing IBM-compatible personal computer in the offices of PARK.
- D. The device shall communicate with meters on an infrared band.
- E. The device shall provide an audio and visual signal when sending or receiving.
- F. Device power supply shall be a Contractor-provided nine-volt, rechargeable, NICAD battery pack and recharger.

#### **2.08 METER COLLECTION CART:**

- A. Meter Collection Cart shall consist of a cart and parking meter head assembly compatible with the collection canisters for the meters.

- B. It shall be a wheeled cart with a security lock and security hinges on its access door. A revenue- collection head assembly is to be provided for receiving and dumping the coin canisters from the parking meters. This head assembly shall include an embedded key to unlock the sealed coin canisters. The coin canister is then opened inside the head assembly emptying the contents into the collection cart. All containers and embedded keys shall be of the same lock combination and shall be reserved for the exclusive use of WMATA. The head assembly shall be constructed to prevent unauthorized removal of coins from the collection cart. The carts shall be of rugged construction to resist entry with normal hand tools.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION:**

- A. Installation at the indicated locations in accordance with manufacturer's instructions. Installed meters shall be oriented normal to the pavement marking lanes for parking space they serve. All pipe and other material required for accomplishment shall be provided by the Contractor. Mounting post pipes shall have a rainwater drain hole.

**SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.**

#### **ENDNOTES**

- \*1. Not all facilities will include both "Short Term" and "Kiss and Ride" parking. This specification section will have to be tailored as appropriate. Add 1.1 A.1. modification to all contracts that include "Short Term" parking.
- \*2. Not all facilities will include both "Short Term" and "Kiss and Ride" parking. This specification section will have to be tailored as appropriate. Add 1.1 A.2. modification to all contracts that include "Kiss and Ride" parking.

**END OF SECTION**

**DIVISION 13 - SPECIAL CONSTRUCTION**

13085	SOUND AND VIBRATION ISOLATION PADS
13110	STRAY CURRENT AND CATHODIC PROTECTION
13115	CORROSION CONTROL SYSTEM TESTING
13125	PARKING CONTROL BOOTH (NEW SECTION)
13905	FIRE PROTECTION, SUPPRESSION AND ALARM

**END OF SECTION**

## SECTION 13085

### SOUND AND VIBRATION ISOLATION PADS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing pads for sound and vibration isolation.
- B. Isolation pads for floating slabs are specified in Section 03305.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ASTM: B29, D395, D412, D573, D624, D1149, D2240, D3182, D3190.
- B. Allowable Tolerances:
  - 1. Pads:
    - a. Total thickness: Minus zero inch or plus 1/8 inch.
    - b. Length and width variation not more than 1/8 inch from dimensions shown.
- C. Testing of Pads:
  - 1. Have samples tested by an independent testing facility.
  - 2. Prepare test specimens in accordance with ASTM D3182 and ASTM D3190 and wipe with solvent before tests to remove any traces of surface impurities.
  - 3. Perform tests in accordance with the following requirements:

Original Physical Properties	ASTM Designation	Grade (Durometer)	
		60	70
Hardness, Durometer A	D2240	60 + 5	70 + 5
Tensile strength, minimum psi	D412	2,500	2,500
Elongation at break minimum percent	D412	350	350

Accelerated Test to Determine Longteristics Oven-Aged 70 Hours at 212F	ASTM Designation	Grade (Durometer)	
		60	70
Hardness, points change, maximum	D573	0 to + 15	0 to + 15
Tensile strength, percent change, maximum	D573	+ 15	+ 15
Elongation at break, percent change, maximum	D573	- 40	- 40

Ozone	ASTM Designation	Grade (Durometer)	
		60	70
One part per million (ppm) in air by volume; 20-Percent Strain, 100 Plus-or-Minus 2F, 100 Hours	D1149	No cracks	No cracks

Compression Set	ASTM Designation	Grade (Durometer)	
		60	70
22 hours at 158F; percent, maximum	D395 Method B	25	25

Low-Temperature Stiffness	ASTM Designation	Grade (Durometer)	
		60	70
At -40F, Young's Modulus, maximum psi	-	10,000	10,000
Tear test, pounds per linear inch, minimum	D624 Die C	250	250

### **1.03 SUBMITTALS:**

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Samples:
  - 1. Elastomer from each batch used, six by nine inches: Four.
  - 2. Each type of pad to be incorporated in the work, six inches by nine inches: Four.
- B. Certification.

### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Deliver products to the jobsite in original unopened containers clearly labeled with manufacturer's name and brand designation, type, and class as applicable.
- B. Store products in an approved dry area, protect from contact with soil and from exposure to the elements. Keep products dry.
- C. Handle products so as to prevent breakage of containers and damage to products.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS:**

- A. Pads: Plain elastomeric pads consisting of solid sheet of neoprene without laminations, molded individually to specified dimensions, cut from previously molded strips or slabs or extruded and cut to length.
- B. Adhesive: Epoxy, solvent-free, specifically compounded and recommended by the manufacturer as a high-quality, resilient adhesive compound, containing mildew-inhibiting agents and completely suitable for effective and permanent bonding of pads to supporting surfaces.
- C. Lead for Shims: ASTM B29, corroding-type.

### **2.02 FABRICATION:**

- A. Fabrication includes adaptation or assembly of components into complete pads of the type specified.
- B. Exterior surfaces, corners and edges of pads finished so as to present a smooth workmanlike appearance, as approved.
- C. Corners and edges may be rounded in accordance with the following:
  - 1. Corner radius: 3/8-inch maximum.
  - 2. Edge radius: 1/8-inch maximum.
- D. Pads fabricated to shapes shown.

## **PART 3 - EXECUTION**

### **3.01 PREPARATION:**

- A. Examine locations where pads are to be placed and correct unsatisfactory supporting areas as approved.

- B. Do not place upon areas which are improperly finished, deformed, irregular or soiled by paint, oil, grease or other substances that might induce sliding or otherwise prevent full, firm and stable adhesion to supporting areas. Thoroughly clean supporting areas immediately before placing pads.

**3.02 INSTALLATION:**

- A. Place pads to conform to lines, grades and other requirements of construction as shown.
- B. Where necessary, construct concrete surfaces intended as supporting areas slightly higher than specified elevation and grind surface down to exact elevation.
- C. Provide shims where directed and where necessary to secure even support.
- D. Use shims of necessary thickness, same size as pads, made of lead or manufactured from same material as specified pads.
- E. Where necessary, provide shims as follows:
  - 1. 1/4 inch or more in thickness: Same material as pads.
  - 2. 1/16-inch to 3/16-inch thick: Lead.
- F. Coat contact surfaces of shims, except top surface under bearing member, with epoxy resin before installing pads. Eliminate air bubbles.
- G. When supporting areas have been prepared in an approved manner, install pads in designated locations and hold securely in place as shown.

**3.03 CLEAN-UP:**

- A. Remove rubbish and debris caused by this work from site.
- B. Leave areas surrounding sound and vibration-isolation work in broom-clean condition.

**END OF SECTION**

## SECTION 13110

### STRAY CURRENT AND CATHODIC PROTECTION

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing and connecting stray-current and cathodic-protection equipment.
- B. Related Work Specified Elsewhere:
  - 1. Grading, excavation and backfilling: Section 02320.
  - 2. Corrosion control system testing: Section 13115.
  - 3. Grounding and bonding: Section 16060.
  - 4. Wire, cable and busways: Section 16120.
  - 5. Wire connection accessories: Section 16125.
  - 6. Raceways, boxes and cabinets: Section 16130.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of jurisdictional authorities.
  - 2. ICEA: S-61-402.
  - 3. ASTM: B418, D256, D570, D638, D693, D1248, E11.
  - 4. MS: MIL-A-18001.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings.
  - 2. Certification:
    - a. Certified test reports of field quality-control testing.

##### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Mark each item with manufacturer's name, brand designation, referenced standard, type, class and rating, as applicable.
- B. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.
- C. Store equipment in secure and dry storage facility.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. Cast-Iron Anodes:
  - 1. Size and type: As shown.
  - 2. Chemical composition:

Element	Percent
Silicon	14.33
Chromium	4.5
Carbon	0.85
Manganese	0.65
Iron	Remainder

3. Physical properties:
  - a. Tensile strength: 15,000 psi.
  - b. Compressive strength: 100,000 psi.
  - c. Brinell hardness: 520.
  - d. Density: 7.0 grams per cubic centimeter.
  - e. Melting point: 2,300F.
  - f. Specific resistance: 72 microhms per centimeter cube at 20C.
  - g. Coefficient of expansion:  $7.33 \times 10^{-6}$  per degree F from 32F to 212F.
4. Lead wire: Single-conductor insulated cable, 8AWG minimum, factory-connected to anode with connection sealed with cast epoxy-resin encapsulation.
5. Anode packaged as follows:
  - a. Stove pipe: Galvanized steel, 30-gauge minimum, in accordance with the one of the following:
    - 1) Diameter: Eight inches; Length: Eight feet.
    - 2) Diameter: Five inches; Length: Six feet.
  - b. Ends of pipe crimped to end seal of ½-inch interior-grade plywood.
  - c. Containing compacted backfill of coke breeze of graded coal or recalcined petroleum coke, with the following additional requirements:
    - 1) Resistivity on dry basis: 60 ohms per centimeter cube, maximum.
    - 2) Chemical composition:

Material	Percent
Fixed carbon	78.22 - 78.40
Ash	18.6 maximum
Moisture	9.50 - 14.70
Volatile matter	3.00 - 3.14
Sulphur	1.2 maximum

- 3) Gradation:
  - a) Sieve size in accordance with ASTM E11.
  - b) Requirements:

Percent Passing	Sieve Size
½ inch	100
3/8 inch	85
No. 6	65

B. Magnesium Anodes:

1. Packaged anodes, type and size as shown.
2. Chemical composition for high-potential type anodes:

Element	Percent
Aluminum	0.010 maximum
Manganese	0.50 - 1.30
Zinc	0.050 maximum
Silicon	0.050 maximum
Copper	0.020 maximum
Nickel	0.001 maximum
Iron	0.030 maximum

Element (Cont.)	Percent (Cont.)
Other metallic elements	0.050 each or 0.300 maximum total
Magnesium	Remainder

3. Lead wire: Single-conductor insulated cable, 12AWG minimum, factory-connected to anode with connection sealed with cast epoxy-resin encapsulation.
4. Anode packaged in permeable cloth sack containing compacted backfill of mixture with the following requirements:

Material	Percent
Gypsum	75
Bentonite	20
Sodium sulphate	5

- C. Zinc Anodes: MS MIL-A-18001, bare-ribbon 5/8 by 7/8-inch section or packaged anode, type and size as shown, with the following additional requirements:
  1. Lead wire: Single-conductor insulated cable, 12AWG minimum, factory-connected to the anode with connection sealed with cast epoxy-resin encapsulation.
  2. Anode packaged in permeable cloth sack containing compacted backfill of mixture consisting of 50-percent hydrated gypsum and 50-percent bentonite.
- D. Reference Electrode: ASTM B418, Type II, one galvanized-steel rod, factory-connected to electrode and equipped with two bolted connectors suitable for 12AWG single-conductor insulated cable.
- E. Test Boxes:
  1. Cathodic-protection test boxes: Plastic, each five inches inside diameter by 18 inches long, with cast-iron lid, collar and terminal board.
  2. Stray-current test boxes: Six inches cubical, galvanized cast-iron box with watertight cover.

- F. Wire and Cable:
1. Header cable, bond wire and cast-iron anode lead wire in accordance with the following:
    - a. Single-conductor.
    - b. Size: As shown.
    - c. Insulation: HMWPE, 600 volt, in accordance with the following:
      - 1) ASTM D1248, Type I, Class C, Grade 5.
      - 2) ICEA S-61-402.
  2. Magnesium or zinc anode lead and test wire:
    - a. Single-conductor.
    - b. Size: 12AWG unless otherwise shown.
    - c. Color: As shown; anode lead as furnished.
    - d. Insulation: TW, 600-volt, moisture-resistant thermoplastic in accordance with UL 83.

- G. Pipeline-Casing Spacers:
1. Virgin polyethylene, molded.
  2. Runner height: Sufficient to provide ½-inch clearance between pipe, couplings and hubs as well as internal casing wall.
  3. Color: Natural.
  4. In accordance with the following:

Characteristic	Reference	Requirement
Compressive strength	ASTM D693	3,200 psi
Tensile strength	ASTM D638,	3,100 - 5,500 psi
Impact strength	ASTM D256	1.5 - 2.0 foot-pound per inch notch
Water absorption	ASTM D570	0.1 percent
Temperature	-	180F (80C) maximum

5. Bolts:
    - a. Steel, cadmium-plated.
    - b. Sizes: As standard with the manufacturer.
  6. Nuts:
    - a. Steel, cadmium-plated, square.
    - b. Sizes: To match bolts.
- H. Pipeline-Casing End Seals:
1. Type L:
    - a. Modular mechanical-type.
    - b. Consisting of interlocking synthetic-rubber links with cadmium-plated steel nuts and bolts.
    - c. Depth limitations: As shown.
  2. Type H:
    - a. Compression-ring seals.
    - b. Nonconductive sleeve: Fiberglass reinforced epoxy (FRE), Adyl Type D or equal, with cadmium-plated steel nuts and bolts.

- c. Depth limitations: As shown.
- I. Insulating Gasket:
  - 1. Asbestos, all-temperature.
  - 2. Full-face.
  - 3. Thickness: 1/8 inch.
  - 4. Johns-Mansville 71 or equal.
- J. Insulating Sleeves and Washers:
  - 1. Up to 300F:
    - a. Sleeve: Mylar tube, 1/32-inch thick.
    - b. Washer: Phenolic, 1/8-inch thick.
  - 2. 300F and above:
    - a. Sleeve: Klingerit or equal, 1/32-inch thick.
    - b. Washer: Johns-Mansville 71 or equal, Teflon.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION:**

- A. Bury anodes or electrodes of type and at location shown. Excavate and backfill holes in accordance with Section 02320, with the following additional requirements:
  - 1. Wet packaged anode thoroughly before backfilling hole.
  - 2. Use fine clay soil, free from stones and bricks, for backfilling.
- B. Install header cable of size and at location shown, in accordance with Section 16120.
- C. Install test boxes of type and at location shown.
- D. Connect anode lead wires to header cable or test boxes as shown.
- E. Isolate pipes of different metals and Authority pipes from utility-company pipes using insulated union, compression insulating couplings, or insulated flange and bolt connections. Connect each side of insulated joints to test box using conductors as shown.
- F. Where Authority pipes cross utility-company pipes, connect Authority pipes to test boxes using two 12AWG and one 4AWG conductors as shown.
- G. Bond joints in buried metallic pipe and structure in accordance with Section 16060. Connect buried metallic pipe and structure to test boxes using single-conductor insulated cable of size shown.
- H. Install conduit of type shown, in accordance with Section 16130.
- I. Install single-conductor insulated cable in accordance with Section 16120. Leave one foot of slack in test boxes.
- J. Use thermit weld sealed with cast epoxy-resin encapsulation for splices made in direct-burial cable.
- K. Use compression-type connectors in accordance with Section 16125.
- L. Install casing spacers in accordance with manufacturer's recommendation, except maximum spacer distance not to exceed 10 feet.

**3.02 IDENTIFICATION:**

- A. Identify wire and cable in each test box using nonmetallic fiberboard or plastic tags or pressure-sensitive labels.

**3.03 FIELD QUALITY CONTROL:**

- A. Provide necessary equipment and perform testing in the presence of the Engineer in accordance with Section 13115.

**END OF SECTION**

## SECTION 13115

### CORROSION CONTROL SYSTEM TESTING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies test procedures for corrosion-control systems.
- B. Related Work Specified Elsewhere:
  - 1. Wire, cable and busways: Section 16120.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of jurisdictional authorities.
- B. Instrument Calibration:
  - 1. Calibrate test instruments within six months prior to use on this project.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Working Drawings:
    - a. Layout of system being tested, showing location of system components, including test stations.
    - b. Instrument hook-up for each test.
  - 2. Certification:
    - a. Certified test report for each test conducted including the following:
      - 1) Types, models, serial numbers, and dates of calibration of all instruments.
      - 2) Data resulting from specified test procedures, in approved format.
    - b. Certificates of inspection.

#### PART 2 - PRODUCTS

##### 2.01 MATERIALS:

- A. Wire and Cable: Section 16120.

#### PART 3 - EXECUTION

##### 3.01 TEST EQUIPMENT:

- A. DC Voltmeter: Multi-scale, center zero, minimum sensitivity 50,000 ohm/volt, accurate to within one percent of full scale, covering the following full-scale ranges: 0-10 and 0-100 millivolts; 0-1, 0-10, 0-100 volts.
- B. DC Ammeter: Multi-scale, maximum shunt drop of 20-mV sensitivity, or millivolt meter and shunts, accurate to within one percent of full scale, covering the following full-scale ranges: 0-1, 0-10, 0-100 amperes.

- C. Resistivity Meter: Self-contained, synchronous-vibrator, battery-powered unit. Instrument readings unaffected by resistance of leads or probes.
- D. DC-Power Sources: Automotive wet-cell batteries, six or 12 volts. For circuits with high internal resistance use two or more batteries, a dc generator or cathodic-protection rectifier.
- E. Test Cable: Single-conductor cable, stranded copper, assorted sizes and lengths to suit test conditions.
- F. Steel probes for making electrical contact to buried structures in absence of test stations.
- G. Slide-Wire Resistors: 0-400 ohm, 15-ampere capacity over full-range of adjustment.
- H. Reference Half-Cell: 7/8-inch diameter by eight inches long, saturated copper-copper sulfate.

### 3.02 TEST PROCEDURES:

- A. Electrical Continuity:
  - 1. Test the following items for continuity:
    - a. Mechanical and bell-and-spigot pipe joints: Test after backfilling is completed. Test individual and multiple bonds.
    - b. Metallic tunnel-liner joints: Test after invert has been cast. Test longitudinal bonds individually or in sections not to exceed 150-linear feet.
    - c. Concrete reinforcement in tunnel, station, retaining wall, reinforced-concrete pipe, aerial, floating slab and building structures: Test after concrete has been cast. Test bonded joints individually or in sections not to exceed 150 feet for tunnel and station structures, not to exceed 500-linear feet for other structures.
    - d. Underpinning, soldier and structural piles: Test prior to backfilling or use leads in structure after backfilling. Test bonded piles individually or in longitudinal sections not exceeding 600-linear feet.
  - 2. Test Procedure:
    - a. Single bond: Connect instruments across bond to be tested as shown. Use separate set of wires and contact points to structures for voltage and current circuits. Beginning with highest scales on voltmeter and ammeter, close switch and observe meter readings. Reduce meter ranges until lowest possible scale is reached. Adjust current level to less than five amperes. Read ON values of voltage and current, break circuit and immediately read OFF values. Record ON and OFF readings on data sheet and determine incremental change for current and voltage. Obtain minimum of three readings to ensure accuracy. Determine and record bond resistance for each reading. Resistance of bond not to exceed calculated theoretical resistance by more than 10 percent.
    - b. Multiple bonds in parallel: Where two structures are bonded by multiple bonds in parallel, test as specified for single bond. Record resistance readings obtained. Actual resistance not to exceed 10 percent of calculated theoretical resistance of bonds.
    - c. Multiple bonds in series: Connect instruments as shown. Determine and record resistance between points A and B, including bonds in series as specified for single-bond test. Total resistance measured between points A and B not to exceed 10 percent of theoretical resistance of sum of bonds plus theoretical resistance of structure between points A and B.

- d. Multiple bonds in parallel on reinforcing steel: Connect instruments as shown. Determine and record resistance between points A and B, including bonds in parallel as specified for single-bond test.
- B. Insulating Joints:
- 1. Test the following for zero-percentage leakage through insulation.
    - a. Insulated flanges and unions: Test buried flanges and fittings after backfilling is completed. Test exposed flanges and fittings after installation is completed. Test each flange or union individually, using existing test wires.
    - b. Casing and sleeve insulation: Test prior to backfilling. Test each casing or sleeve individually.
  - 2. Test Procedures:
    - a. Set up instrumentation as shown. If pipe length is too short for proper test-connection spacing, use maximum possible spacing for L-value. With switches open, read and record value of  $E_0$ . Close switch in I1 circuit. Read and record current, I1, and voltage, E1. Calculate calibration factor (K) for millivolt shunt using equation shown.
    - b. With switches open, read and record value of  $E_0$ . Close switch in I2 circuit. Read and record current, I2, and voltage, E2. Determine difference between  $E_0$  and E2.
    - c. Calculate and record percentage of leakage by equation shown.
- C. Cathodic-Protection Systems Using Cast-Iron Anode:
- 1. Test the following:
    - a. Hydraulic-elevator well casing: Test casing having cathodic-protection system after pit invert has been constructed. Test each system individually using test stations in elevator pit.
    - b. Buried chilled-water, steam and condensate piping: Test after backfilling is complete. Test each system individually, using existing test stations along pipeline.
  - 2. Procedures: Perform tests in the following order:
    - a. Electrical-continuity and insulating-joint tests as specified.
    - b. Anode tests:
      - 1) Structure-to-anode resistance:
        - a) Connect instruments as shown.
        - b) With switch open, record voltage reading 1 on E.
        - c) Close switch and record voltage and current readings.
        - d) Reduce current level to less than five amperes by adjusting power source. Record voltage and current readings.
        - e) Open switch and immediately record voltage as current-off value for potential.
        - f) Using different values of current and voltage, determine and record resistance using formula shown. Obtain a minimum of three sets of readings to ensure accuracy.
        - g) Take necessary corrective measures to ensure that resistance is not less than 0.3 ohms.
      - 2) Anode-to-earth resistance:
        - a) Procedure:
          - (1) Place copper-copper sulfate reference half-cell at least 50 feet away from anode location and connect voltmeter to read anode-to-earth voltage as shown.
          - (2) Perform test as specified for structure-to-anode resistance.

- b) Acceptance criteria: Actual anode-to-earth resistance not to exceed 20 percent of design soil resistance.
- c) Design resistance: As specified in Exhibit 13115-1.
- d) Soil resistivity:
  - (1) If anode-to-earth resistance exceeds 20 percent of design resistance, obtain average soil resistivity in anode-location area.
  - (2) Make measurements by four-pin method as shown.
  - (3) Make measurements using suitable resistivity instrument or by battery, voltmeter and ammeter.
  - (4) Place pins at least 1.5-times pin spacing horizontally from underground metallic structures.

D. Cathodic-Protection Systems Using Magnesium Anode:

- 1. Test galvanic-anode cathodic-protection system for the following structures and utilities:
  - a. Buried potable-water, chilled-water and fire piping; sewage-ejector piping; and sewage-pump piping using test stations.
  - b. Piling: Test structures having cathodic-protection systems. Test each structure individually. Test electrical continuity between piles.
- 2. Procedures: Perform tests in the following order:
  - a. Electrical-continuity and insulating-joint tests as specified.
  - b. Anode tests:
    - 1) Structure-to-anode resistance: Perform test as specified for cathodic-protection systems using cast-iron anode.
    - 2) Anode-to-earth resistance test and soil resistivity: Perform tests as specified for cathodic-protection systems using cast-iron anode.

E. Wire and Cable: Install in accordance with Section 16120.

F. Coal-Tar Epoxy Coating:

- 1. Subject final coating to spark test for capability of maintaining dielectric integrity at 5,000 volts minimum.
- 2. Visually inspect coating prior to installation; repair damaged areas in accordance with field-correction recommendations of the coating manufacturer.
- 3. Backfilling prior to approval of coating is prohibited.

**Exhibit 13115-1**

G. Design Resistance:

Structure	Soil Resistance	Anodes	Anode-to-Earth Resistance

**Exhibit 13115-1 (Cont.)**

H. Evaluation:

1. When anode-to-earth resistance exceeds 20 percent of design value, use data from soil-resistivity test to recalculate design resistance.
2. If actual anode-to-earth resistance exceeds recalculated design resistance, install additional anodes as directed.

I. Recalculation: Resistance is calculated by use of the following formulae:

1. Single horizontal anode:

$$a. \quad R_{H(N=1)} = \frac{0.00521e}{L} \left\{ 2.3 \log \frac{4L^2 + 4L(S^2 + L^2)^{0.5}}{dS} + \frac{S}{L} - \frac{(S^2 + L^2)^{0.5}}{L} - 1 \right\}$$

b. Where:

$R_{H(N=1)}$  = Resistance to earth of the horizontal-ground anode (ohms).

e = Effective soil resistivity (ohm-cm).

L = Horizontal-anode length (feet).

d = Anode diameter (feet).

S = Twice anode depth (feet).

2. Single vertical anode:

$$a. \quad R_{V(N=1)} = \frac{eK}{L}$$

b. Where:

$R_{V(N=1)}$  = Resistance of single vertical anode-to-earth (ohms).

e = Effective soil resistivity (ohm-cm).

L = Length of anode (feet).

K = Shape function (anode length/anode diameter) from Table 1.

**Exhibit 13115-1 (Cont.)**

c. Table 1: The Shape Function:

L/d	K	L/d	K
1	.0056	16	.0201
2	.0092	18	.0207
3	.0113	20	.0213
4	.0128	25	.0224
5	.0140	30	.0234
6	.0150	35	.0242
7	.0158	40	.0249
8	.0165	45	.0255
9	.0171	50	.0261
10	.0177	55	.0266
12	.0186	60	.0270
14	.0194	-	-

3. Multiple vertical anodes in parallel:

a.  $R_{V(N,S)} = \frac{R_{V(N=1)}}{N} + \frac{eP}{S}$

b. Where:

$R_{V(N,S)}$  = Resistance-to-earth of vertical anodes in parallel (ohms).

$R_{V(N=1)}$  = Resistance-to-earth of single anode (ohms).

e = Effective soil resistivity (ohm-cm).

N = Number of vertical anodes in parallel.

S = Spacing between anodes (feet).

P = Parallel factor from Table 2.

**Exhibit 13115-1 (Cont.)**

c. Table 2: Parallel Factor:

n	P	n	P
2	.00261	14	.00168
3	.00289	16	.00155
4	.00283	18	.00145
5	.00268	20	.00135
6	.00252	22	.00128
7	.00237	24	.00121
8	.00224	26	.00114
9	.00212	28	.00109
10	.00201	30	.00101
12	.00182	-	-

4. Resistance-to-earth of the horizontal ground bed:

a.  $R_{H(N,S)} = \frac{R_{V(N,S)}}{R_{V(N=1)}/N} \times \frac{R_{H(N=1)}}{N}$

b. Where:

$R_{H(N,S)}$  = Resistance-to-earth of the horizontal ground bed (ohms).

$R_{V(N,S)}$  = Resistance-to-earth of N anodes, at spacing S, installed vertically (ohms).

$R_{V(N=1)}$  = Resistance-to-earth of single vertical anode (ohms).

$R_{H(N=1)}$  = Resistance-to-earth of single horizontal anode (ohms)

N = Number of anodes.

**END OF SECTION**

## SECTION 13125

### PARKING CONTROL BOOTH

#### PART1 - GENERAL

##### 1.01 DESCRIPTION

- A. This section specifies prefabricated factory assembled parking cashier's booths including equipment and related services. Related work specified elsewhere:
  - 1. Cast-in-Place Concrete: Section 03300; for concrete islands, concrete foundations and anchor bolt installation.
  - 2. Parking Access and Revenue Control System: Section 11150.

##### 1.02 SUBMITTALS

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
- B. Product Data: For each item of parking control booths. Include manufacturer's standard details and installation and maintenance instructions.
- C. Shop Drawings: Include plans, elevations, and details of typical members and other components. Show layout and installation details, including anchorage details.
  - 1. Anchor-Bolt Plans: Include location, diameter, and projection of anchor bolts required to attach parking control booth to foundation or concrete pad.
  - 2. Wiring Diagrams: Detail wiring for parking control booth system and differentiate between manufacturer-installed and field-installed wiring.
    - a. Show locations of connections to electrical service provided in other Sections.
- D. Lock Schedule: For all keyed locks to safe, cashier's drawer, electrical equipment cabinet, and entrance door.
- E. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for the following finishes:
  - 1. Wall panels with factory-applied color finishes.
  - 2. Floor covering material and wall base.
- F. Samples for Verification: Provide 4-inch x 4-inch samples with finishes initially selected in manufacturer's standard sizes, showing the full range of color, texture, and pattern variations expected. Prepare Samples from same material to be used for the Work.
- G. Maintenance Data: For parking control booth components to include in the maintenance manuals specified in the General Requirements.
- H. Maintenance Instructions: Manufacturer's written instructions for maintenance of parking control booths.
  - 1. Include precautions against materials and methods that may be detrimental to finishes and performance.

##### 1.03 QUALITY ASSURANCE

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. FHWA Manual on Uniform Traffic Control Devices, Latest Edition.

2. NEC.
  3. ADA, ADAAG.
  4. UL 752, Level 3.
  5. NFPA.
  6. OSHA.
  7. ASTM: A60, A123, A336, A500, A513, A653, A666, C578, C1048, E331, E774, E1646, F1344.
  8. FS SS-W-40.
- B. Installer Qualifications: Engage an experienced installer who is an authorized representative of the parking control booth manufacturer for installation of the type of units required for this Project, and whose installations have resulted in construction with a record of successful in-service performance.
- C. Source Limitations: Obtain parking control booths through one source from a single manufacturer.
- D. Product Options: Drawings indicate size, profiles, and dimensional requirements of each parking control booth components and are based on the specific type and model indicated. Other manufacturers' individual components with equal performance characteristics may be considered provided deviations in dimensions and profiles are minor and do not change design concept.
1. Do not modify intended design concept, as judged solely by the Engineer, except with Engineers approval and only to extent needed to comply with performance requirements. Where modifications are proposed, submit comprehensive explanatory data to Engineer for review.
- E. Listing and Labeling: Provide internal electrical components required as part of parking control booth specified in this Section that are listed and labeled.
1. The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100.
  2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" as defined in OSHA Regulation 1910.7.
- F. Accessible Booths: All components of parking control booths shall be designed, fabricated and installed to meet ADA guidelines for accessibility.

#### **1.04 PERFORMANCE REQUIREMENTS**

- A. General: Provide a complete, integrated set of parking control booths system manufacturer's standard mutually dependent components and assemblies that form a metal building system capable of withstanding structural and other loads, thermally induced movement, and exposure to weather without failure or infiltration of water into building interior. Include primary and secondary framing, roof and wall panels, and accessories complying with requirements indicated, including those in this Section.
- B. Thermal Movements: Provide metal building roof and wall panel systems that allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.
- C. Water Penetration for Roof Panels: Provide roof panel assemblies with no water penetration as defined in the test method when tested according to ASTM E 1646 at a minimum

differential pressure of 20 percent of inward-acting, wind-load design pressure of not less than 6.24 lbf/sq. ft.300 and not more than 12 lbf/sq. ft.

- D. Water Penetration for Wall Panels: Provide wall panel assemblies with no water penetration as defined in the test method when tested according to ASTM E 331 at a minimum differential pressure of 20 percent of inward-acting, wind-load design pressure of not less than 6.24 lbf/sq. ft. and not more than 12 lbf/sq. ft..
- E. Structural Performance: Provide parking control booth systems capable of withstanding the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
  - 1. Design Loads: 50 psf live load.
  - 2. Wind Load: 30 psf.
- F. Thermal Performance: Provide metal building assemblies with the following thermal-resistance values (R-value):
  - 1. Roof Assemblies: R-17 or greater.
  - 2. Wall Assemblies: R-12 or greater.
  - 3. Floor Assemblies: R-11 or greater.
- G. Ballistic Design: Provide bullet resistant windows, wall panels and door assemblies complying with UL 752 specification for Level III protection. Bullet Resistant and insulated glazing assemblies for all fixed and operable window units. Confirm glass thicknesses by analyzing Project loads and in-service conditions.
- H. Mechanical System Performance: Provide HVAC and heating system performance meeting the temperature range requirements indicated:
  - 1. A/C Output: Maintain 75 degree F inside temperature, plus or minus 4 degree F in 100 degree F outside temperature in full sun exposure.
  - 2. Heat Output: Maintain 65 degree F inside temperature with 10 degree below zero F outside temperature in darkness.

#### **1.05 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Deliver booths and equipment in good conditions.
- B. Store booths so as to prevent corrosion, deterioration, and damage
- C. Handle booths and equipment so as to prevent damage.
- D. Protect products according to manufacturer's recommendations. Specifically, avoid damage to glass edges, and prevent damage from temperature changes, sunlight, and moisture.
- E. Deliver equipment to the site individually wrapped and packed to avoid damage. Protect from water, dirt, and other potentially harmful substances.

#### **1.06 PROJECT CONDITIONS:**

- A. Field Survey: Verify existing conditions prior to installation for coordination of anchor bolt locations, power stubs, clear dimensions of concrete islands and recessed box-out for booths, and headroom clearance for parking control booths roof and roof mounted equipment.

#### **1.07 COORDINATION:**

- A. Coordinate installation of anchorages for parking control booths. Furnish setting drawings, templates, and directions for installing electrical work, anchorages, including concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete. Deliver such items to the Project site in time for installation.

## **PART 2 - PRODUCTS**

### **2.01 MANUFACTURERS**

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering parking control booths that may be incorporated into the Work include, but are not limited to, the following: Retain above for nonproprietary or below for semiproprietary Specification. Refer to Division 1 Section "Materials and Equipment."
  - 1. B.I.G. Enterprises, Inc.
  - 2. Mardan Fabricators, Inc.
  - 3. Par-Kut International.
  - 4. Porta-King.

### **2.02 MATERIALS**

- A. Cold-Rolled Steel Sheet: ASTM A 366/A 366M.
- B. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, CS (Commercial Steel), Type B; with G60 zinc (galvanized) or A60 zinc-iron-alloy (galvannealed) coating designation.
- C. Steel Structural Tubing: ASTM A 500, cold-formed steel structural tubing, Grade B.
- D. Steel Mechanical Tubing: ASTM A 513, welded steel mechanical tubing.
  - 1. Hot-Dip Galvanized: According to ASTM A 123.
- E. Stainless-Steel Sheet: ASTM A 666, Type 302 or 304.
- F. Sealed Insulating Glazing Units: Factory-assembled multiple lites, separated by and sealed to spacers forming air-tight, dehydrated air spaces(s), complying with ASTM E 774, Class CBA:
  - 1. Outer Lite: Laminated polycarbonate sheet, with mar-resistant coating; 1.3 inches thick. Ballistics Resistance: UL 752, Super-Power Small Arms (SPSA), .44 Magnum.
  - 2. Air Space: 1/4 inch.
  - 3. Inner Lite: Clear Tempered Float Glass: ASTM C 1048, Condition A (uncoated surfaces), Class 1 (clear), Kind FT (fully tempered), 1/4 inch thick.
- G. Extruded-Polystyrene Board Insulation: Rigid, cellular, thermal insulation formed from polystyrene base resin by an extrusion process, complying with ASTM C 578, Type IV, 1.60-lb/cu. ft. minimum density.

### **2.03 BASE AND FLOOR ASSEMBLY**

- A. Structural: 4-inch-high assemblies consisting of a perimeter frame fabricated from 2-by-4-by-0.079-inch galvanized steel tubing with corners mitered and welded. Floor framing members consisting of 3-inch x 3-inch, 2-inch x 2-inch, and 2-inch x 4-inch x .079-inch galvanized steel tubing with spacing not to exceed 24-inch o.c.. Provide 2-inch x 3-inch x 1/4-inch galvanized steel exterior mounting brackets welded to base and extending outside the structure with a 5/8-inch pre-drilled hole to accept anchor bolt.

- B. Flooring: 0.108-inch thick galvanized steel floor plate over 3/4-inch thick, oriented strand board (OSB) sub-floor.
- C. Rubber Floor Covering: ASTM F1344; 3/16 inch thick heavy duty rubber mat with interlocking joints in five pieces to fit area shown, with edges square and true, without overlap.
  - 1. Textured wearing surface; terra cotta color.
- D. Vinyl Wall Base: FS SS-W-40, Type II; 1/8 inch thick, 4 inch high, cove profile with top-set toe.
  - 1. Color: As selected from manufacturer's full range of colors.

#### **2.04 WALL ASSEMBLY**

- A. General: Fabricate panels weathertight and in a manner that will prevent condensation on interior face.
- B. Wall Framing: 12 gauge, steel tubes, 2-inch x 2-inch, 2-inch x 4-inch, 3-inch x 3-inch minimum *structural steel tubing*.
- C. Wall Panels: Fabricate for bullet resistant assembly meeting UL Test 752, Level 3. Exterior panels: 14 gauge metallic coated sheet steel; interior panels: 18 gauge sheet steel, and rigid Insulation; R-12 between sheet steel.

#### **2.05 ROOF AND CANOPY ASSEMBLY:**

- A. Structural Framing: Galvanized steel shapes, not less than 16 gauge thickness.
- B. Roof Panels: Fabricated from 0.064-inch thick, galvanized steel sheet with continuously welded seams. Furnish canopy with 3-inch overhang, 8-inch high fascia, 1-inch high drip edge and two drains with downspouts. Provide four removable lifting ring on each corner of roof where shown.
- C. Fabricated from 0.079-inch-thick, galvanized steel ceiling panels. Provide manufacturer's standard insulation, R-17 or greater, in cavity between ceiling and roof.

#### **2.06 DOORS**

- A. General: Provide flush-design heavy-duty out-swinging doors, 2 inches thick. Construct doors with smooth, flush surfaces without visible joints or seams on exposed faces or stile edges. Provide door assembly and operation complying with UL 752 specification for Level III protection for ballistic protection and ADA for accessibility.
- B. Door Lite: Sealed Insulating Glazing Units as indicated.
- C. Hardware and Accessories: Lever type lockset and double lockset dead bolt, with weather protected finish of Satin Chrome, US 26D. Provide 32-inch x 16-inch stainless steel kickplate on each side of door. Aluminum threshold, 1/2-inch high. Provide manufacturer's standard weatherstripping.

#### **2.07 SECURITY WINDOWS**

- A. Framing: Fabricate perimeter framing, mullions, and glazing stops from metal sheet as follows:

1. Material: Cold-rolled steel sheet, factory primed with manufacturer's standard finish to match finish and color of wall panels.
- B. Bullet resistant and Insulating Sealed Glazing Units. Comply with UL 752 specification for Level III protection.
- C. Horizontal-Sliding Transaction Window: ADA compliant; one fixed glazed panel and one horizontal-sliding glazed panel:
  1. Sliding Window Hardware: Provide roller track designed for overhead support of two or four wheel carriage supporting horizontal-sliding glazed panel. Provide manufacturer's standard pull and laminated hook-bolt deadlock for each horizontal-sliding glazed panel. Provide weather stripping.
  2. Sill: Stainless-steel channel frame, designed for glazing.

## **2.08 ELECTRICAL**

- A. General: All electrical fixtures; lights, plugmolds, switches, etc., shall bear the Underwriter Laboratories label verifying that all of the electrical work conforms to the National Electric Code (NEC). The contractor shall certify that all electrical work in the booth conforms to the NEC.
- B. Electrical Service: Prewired booth ready for connection to service at site. Provide 3-wire, 125-A, 120/240-V, single-phase service; and electrical equipment box. Minimum wire size shall be 12 AWG.
- C. All wiring shall be concealed in water (fluid) tight flexible metal conduit or electrical metallic tubing (EMT) inside of walls.
- D. Terminate and label all conduits at 12-inch x 12-inch x 4-inch splice box. Feed to splice box is through 12-inch x 6-inch cutout in floor (front right side beneath counter) of booth.
- E. Provide a 5 foot long plug mold mounted to backsplash with standard 115 VAC electrical outlets, 6-inch maximum spacing
- F. Fasten all electrical connections with tamperproof screws and/or bolts.
- G. Provide minimum of two 115 VAC duplex outlets each side of walls.
- H. Provide control switch for manual operation of barrier gates.
- I. Electrical Equipment Cabinet: 12-circuit breaker box with keyed locks, mount to wall underside counter opposite cashier's window

## **2.09 LIGHTING**

- A. Provide two surface mounted 80-watt low temperature ballast fluorescent light fixtures, 4-feet long with 2 tubes, 40 foot candles minimum.
- B. Locate switch in wall frame adjacent to door.

## **2.10 MECHANICAL**

- A. Manufacturer: Provide self-contained thermostatically controlled heating units as manufactured by Chromalox Industrial, catalog number H1801, part number 261948, or approved equal.
- B. Heating Units: Provided two industrial application wall mounted heaters, mount units below counter one unit to side wall adjacent to cashiers window and one unit to end wall in front of cashier.
- C. Roof Mounted HVAC Unit: Provide roof mounted, thermostatically controlled 13,500 B.T.U. combination HVAC unit, . The heat strip shall be approximately 1500 watts. Mount to roof on a 3-inch to 4-inch high curb, with positive water dams fabricated with continuous welded metal lip to prevent water infiltration around the air conditioning unit. Provide continuous flexible seals and sealants around the unit. Controls: Provide thermostat(s) to control operation of the heating and air conditioning units such that the temperature of the booth will remain within limits indicated.

## 2.11 EQUIPMENT

- A. Drop Safe: Provide a rotary hopper type drop-safe, approximately 12-inches long x 12-inches wide x 18-inches high conforming to the Standard Safe Classification for fire resistance, burglary protection and tamper resistance. Install as indicated.
  - 1. Lock System: Protect safe door with a jimmy-proof, punch-proof and puncture proof dual lock system with changeable keys. Provide one local and one supervisory key for each control booth. Supervisory key shall open all safes in each control booth on the Project.
- B. Alarm System: Provide silent alarm system as manufactured by Ademco Security Group; model 219 or approved equal, with recessed push-button mechanism, locking type by key with open contact and compatible with existing WMATA system. Install as indicated.
  - 1. Reporting: Silent alarm shall report to and trigger an alarm in the Transit Police and Security Communications Room located in the Jackson Graham Building, 600 Fifth Street, N.W. Washington, D.C. via the Authority's telephone lines. The alarm dialer shall be key pad programmable. Reporting signal shall be number coded to identify the booth where signal originated from.
  - 2. Request from the Engineer, the appropriate WMATA numbers and PABX actuation 45 days prior to activation of the alarm system.
- C. Telephone System: Provide three-number, automatic dial, wall mounted telephone system as manufactured by GAI-Tronics Corp., model 187007, latest version, or approved equal with maximum overall dimensions of 8 1/2-inch height x 8 1/2-inches width x 2 1/2-inches depth.
  - 1. Provide three external push button controls, one for each location to which the telephone may call, mechanically interlocked so that the telephone cannot be in a no dial mode or neutral position.
  - 2. Provide two gong ringer and a noise canceling microphone.
  - 3. Provide handset cord, minimum 4-feet long, with flexible metal shielding, non-modular, directly wired to connections at ends of booth. The station line cord shall be of modular-to-spade lug configuration.
  - 4. Provide programmable automatic dialing circuitry via a touch tone key-pad contained within the telephone assembly and with the following automatic dialing functions from the booth:
    - a. Position One: to Communication Room in the Jackson Graham Building.
    - b. Position Two: to the WMATA phone mail system.
    - c. Position Three: to WMATA System Maintenance.
    - d. Telephone shall prohibit originating any other outgoing calls, but shall permit receipt of incoming calls.

- D. Lightning and Surge Arrestors: Provide lightning and surge arrestors for protecting equipment to cover voltages from 5 to 170V peak (AC and DC) and maximum surge current rating of 15,000 amperes for a typical wave shape.
- E. Transaction Display: Provide manufacturer's standard, booth mounted, digital display
- F. SmartCard Targets: Provide booth mounted Smartcard targets as specified in Section 11150.

## **2.12 FABRICATION, GENERAL**

- A. Fabricate parking control booth assemblies to meet the requirements of the ADA for accessibility and shall be equipped with an accessible workstation complying with the requirements of ADAAG 4.2 through 4.35.
- B. Provide manufacturer's standard, completely assembled, prefabricated parking control booth, ready for installation on Project site. Booth consists of a structural frame and pre-finished, insulated, wall and roof panels, door, and operable windows. Provide built-in cashier's work counter with storage drawer below. Equip booth with interior electric lighting, service outlets, and an electric heating and cooling units.
  - 1. Overall dimensions: 68-inches x 92-inches x 91-inches high, excluding height of HVAC unit. Fabricate base to install in a 4-inch deep recess in concrete curb. Floor of the booth to align flush with the elevation of the top of curb.

## **2.13 FABRICATION, WINDOWS**

- A. General: Fabricate security windows to comply with indicated standards. Include a complete system for assembly of components and anchorage of security windows.
  - 1. Provide security windows that are re-glazable from the secure side without dismantling the non-secure side of framing.
- B. Provide weep holes and internal water passages for exterior security windows to conduct infiltrating water to the exterior.
- C. Framing: Miter or cope corners the full depth of framing; weld, and dress smooth.
  - 1. Fabricate framing with manufacturer's standard, internal opaque armoring in thicknesses required for security windows to comply with ballistics-resistance performance indicated.
- D. Glazing Stops: Finish glazing stops to match security window framing.
  - 1. Secure-Side (Exterior) Glazing Stops: Welded or integral to framing.
  - 2. Non-secure-Side (Interior) Glazing Stops: Removable, coordinated with glazing indicated.
- E. Welding: Weld components to comply with referenced AWS standard. To greatest extent possible weld before finishing and in concealed locations to minimize distortion or discoloration of finish. Remove weld spatter and welding oxides from exposed surfaces by descaling or grinding.
- F. Metal Protection: Separate dissimilar metals to protect against galvanic action by painting contact surfaces with primer or by applying sealant or tape recommended by manufacturer for this purpose.

- G. Pre-glazed Fabrication: Pre-glaze security windows at the factory where possible and practical for applications indicated.
- H. Weather Stripping: Factory applied.
- I. Security Fasteners: Fabricate security windows using security fasteners with head style appropriate for fabrication requirements, strength, and finish of adjacent materials, except that a maximum of two different sets of tools shall be required to operate security fasteners for Project. Provide stainless-steel security fasteners in stainless-steel materials.

## **2.14 FABRICATION, WORK SURFACES**

- A. Work Counters: 24-inch deep, full-width, 14 gauge thickness, reinforced, stainless-steel work counter with hemmed edges and 4-inch integral backsplash. Mount top of counter 30-inches above floor. Include integral cash drawer below counter.
  - 1. Provide 3-inch wide clear space between back of backsplash and face of front wall for air circulation
- B. Integral Cash Drawer: 17-inch wide x 10-inch deep, 18 gauge steel drawer with high grade disc tumbler spring bolt lock, two keys, and chrome finished steel pull. Mount to underside of counter with exposed fasteners. Locate drawer adjacent to sliding window.

## **2.15 FINISHES**

- A. Exposed Finish for Wall Panels, Doors, Countertops, Ceilings and Roof: Prime coat all exposed steel surfaces, excluding aluminum, chrome and stainless steel surfaces, with manufacturer's standard two-part, rust-inhibitive epoxy primer.
  - 1. Polyurethane Two Coat System: Electrostatically applied catalyst polyurethane paint over undercoat application. Apply to all interior and exterior steel surfaces with finish coat of manufacturer's standard industrial polyurethane paint in colors as selected by the Engineer from manufacturer's full range of colors.

## **PART 3 - EXECUTION**

### **3.01 EXAMINATION**

- A. Before installation, examine areas to receive parking control booths. Verify that critical dimensions are correct and conditions are acceptable.
  - 1. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.02 PREPARATION**

- A. Provide templates for anchor bolts and other items encased in concrete or below finished surfaces so as not to delay the Work.

### **3.03 INSTALLATION**

- A. General: Install parking control booths according to manufacturer's written instructions and placement drawings.
  - 1. Coordinate placement of anchors and accessories encased in concrete with Section 03300.
- B. Prefabricated Cashier's Booth: Unload cashier's booth with forklift or crane. Set booth level, plumb, and aligned with the elevation of the top of the concrete curb slab.

- C. Install drop safe to floor under countertop adjacent to the service window. Bolt to steel floor plate with J bolts.
- D. Installation of alarm system to include, but not to be limited to, the installation of the following:
  - 1. Control Unit: alarm processor, transmitter with auto-dialer, power supply, back-up battery, and the interconnecting cable between the cashier booths, the parking structure Communications Room and the designated terminal in the Station Communications Room.
  - 2. Telephone lines: Connect PABX telephone lines to the WMATA Transit Police Communications Room in the Jackson Graham Building.
- E. Electrical Load Center: Section 16440.

### **3.04 CLEANING AND PROTECTING**

- A. After installing clean finished surfaces, touch up shop-applied finishes as required to restore damaged areas.
- B. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure parking control equipment is without damage or deterioration at the time of Substantial Completion.

### **3.05 DEMONSTRATION**

- A. Instruct WMATA's maintenance personnel on proper operation and maintenance of parking control booth equipment. Train personnel on procedures to follow if operation fails or malfunctions.
- B. Coordinate testing of the alarm system with the Engineer.
- C. Demonstrate operation of all keyed locks.

**END OF SECTION**

## SECTION 13905

### FIRE PROTECTION, SUPPRESSION AND ALARM

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing dry standpipe, wet standpipe, sprinkler, exterior fire protection and clean agent fire-suppression systems.
- B. Related Work Specified Elsewhere:
  - 1. Water distribution system: Section 02515.
  - 2. Storm and sanitary system: Section 02535
  - 3. Firestopping: Section 07841.
  - 4. Field painting: Section 09920.
  - 5. Corrosion control system: Section 13115.
  - 6. Identification of mechanical equipment and piping: Section 15075.
  - 7. Piping system: Section 15205.
  - 8. Control equipment: Section 15900.
  - 9. Grounding and bonding: Section 16060.
  - 10. Wire and cable: Section 16120.
  - 11. Raceways, boxes and cabinets: Section 16130.
- C. Description of System:
  - 1. Dry standpipe system: Consists of siamese fire-department connection, dry fire line, check valves, automatic air vents, drain valves and angle hose valves.
  - 2. Wet standpipe system: Consists of siamese fire-department connection, wet fire line, check valves, drain valves, fire water-line surveillance valve, angle hose valves and capped branch connections for sprinkler systems where shown.
  - 3. Fire-suppression system for entrance escalators: Consists of fire line to point inside entrance escalator pit/machine room capped for future extension by escalator contractor, supplied from wet standpipe system.
  - 4. Sprinkler system, other than escalator: Consists of sprinkler lines, fire water-line surveillance valve, flow-alarm check valve, drain valve, and sprinkler heads as well as heating tracers in areas subject to freezing temperatures, supplied from wet standpipe system or from domestic water line as shown.
  - 5. Exterior fire-protection system: Consists of lead-ins to wet standpipe system, valves and accessories, supplied from the city water main.
  - 6. Automatic, total-flooding clean agent suppression system: Consists of smoke detectors, agent storage containers, nozzles, clean agent suppression system control and detection panel, manual pull station, alarm bell, evacuation horn, clean agent suppression system discharge visual alarm and necessary interface boxes for signals from and to HVAC and communications. Each room or hazard area to have its own system designed to provide a concentration of 7 percent by volume.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. AWS: A5.13
  - 3. FM Approval Guide.
  - 4. NFPA: 12A, 13, 14, 15, 24, 2001.
  - 5. UL: 262, 312, 1479, Fire Protection Directory.
  - 6. ANSI/ASME: B16.1, B16.5, B16.9, B31.1.

7. ANSI: Z535.1.
8. NEMA: 250.
9. FS: A-A-1992 SS-C-153, WW-P-421, WW-P-501, WW-U-516, WW-U-531.
10. MSS: SP-58.
11. ASTM: A36, A47, A53, A135, A183, A234, A 240, A276, B766, D1752, D2000.

B. Qualification of Welding Personnel: Section 05120.

C. Design Criteria:

1. NFPA 12A, 13, 14, 15 and 2001 as applicable.

### **1.03 SUBMITTALS:**

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

1. Shop Drawings:
  - a. Methods of joining, welding, fastenings, and anchoring.
  - b. Materials and locations for wet standpipe, dry standpipe, sprinkler, clean agent suppression and external systems.
  - c. Pipes and piping layout, including pipe hangers and supports.
  - d. Pipe hangers and supports.
  - e. Valves.
  - f. Escutcheons.
  - g. Gauges.
  - h. Automatic air vents.
  - i. Pipe sleeves.
  - j. Mechanical couplings.
  - k. Layout of sprinkler and clean agent suppression systems and detail drawings approved by Fire Marshal of jurisdiction in which work is to be performed.
  - l. Reports covering test materials.
2. Certification:
  - a. Fire line test results.
  - b. Manufacturer's certification that pipe-joint gaskets and lubricants are satisfactory for use with pipe and fittings specified and that couplings are designed and tested as specified.
3. Samples: Paint, Section 09920.
4. Operation and Maintenance Manuals.

### **1.04 JOB CONDITIONS:**

- A. Do not perform welding when the temperature of the base metal is less than zero degree F.
- B. Do not perform welding when surfaces are wet or during periods of high winds unless operator and work are properly protected.
- C. Environmental Requirements: Paint, Section 09920.

### **1.05 OPERATION AND MAINTENANCE TRAINING:**

- A. Upon completion of installation and in accordance with the General Requirements furnish for a period of not less than two consecutive man-days services of a manufacturer's field engineer with specialized experience in the components of the system to instruct Authority personnel in the proper operation and maintenance of the systems.

## PART 2 - PRODUCTS

### 2.01 MATERIALS:

- A. General Requirements:
  - 1. In design and purchase of equipment, provide for interchangeability of items of piping and electrical equipment sub-assemblies, parts and relays.
- B. Pipe and Fittings:
  - 1. Exterior fire-protection system:
    - a. Ductile-iron pipe and fittings:
      - 1) Piping embedded or otherwise inaccessible: FS WW-P-421, Type III, Grade C, 250-pound pressure class.
      - 2) Piping from point of connection to inside of structure: FS WW-P-421, Grade C, 250-pound pressure class, flanged. Flanges: ANSI B16.1.
      - 3) Pipe coated on outside with bituminous coating and lined with cement mortar of twice standard thickness specified for pipe size used.
        - a) Cement-mortar lining having seal coat of nontoxic, tasteless and odor-free bituminous material.
      - 4) Neoprene gaskets furnished for joints.
    - 2. Interior fire-protection system:
      - a. Fire lines, embedded or otherwise inaccessible:
        - 1) Pipe: Galvanized steel, ASTM A53, Type E, Grade B, with the following additional requirements:
          - a) Fire-protection piping: Extra-strong weight, Schedule 80.
        - 2) Fittings and flanges: Galvanized, furnished with wall thickness equal to or greater than that of adjacent pipe, with the following additional requirements:
          - a) Fire lines: ASTM A234, Grade B, and ANSI B16.9 for dimensions and tolerances.
            - (1) Flanges: ASTM A234 and ANSI B16.5 for dimensions and tolerances.
      - b. Fire lines, exposed or otherwise accessible:
        - 1) Pipe:
          - a) Galvanized steel: One of the following:
            - (1) ASTM A53: One of the following:
              - (a) Type E, Grade B.
              - (b) Type F, Grade A.
            - (2) ASTM A13
          - b) Welded or seamless.
          - c) Standard weight, Schedule 40, with grooved ends. Use of Schedule 10 pipe is not allowed.
        - 2) Mechanical joint couplings: Keyed for joining grooved-end piping.
          - a) Coupling housing: Malleable iron in accordance with ASTM A47, Grade 32510, galvanized, fabricated in two or more parts enclosing resilient gasket seal, with keys to fit machined grooves on pipe ends. Rated at 300-psig minimum pressure and factory-finished with manufacturer's standard paint coating.
          - b) Coupling gasket: Chlorinated butyl, ASTM D2000, specification 3-BA-615-A14-B13, with following additional requirements:
            - (1) Molded grooves.

- (2) Pressure-responsive seal, integrity increasing with internal pressure.
    - c) Coupling bolts and nuts: Oval-neck track-type bolts with hexagonal nuts conforming to ASTM A183 permitting single-wrench assembly, having minimum tensile strength of 110,000 psi, with cadmium-plated finish ASTM B766, Type III.
  - 3) Fittings:
    - a) Grooved-end, fabricated of malleable-iron casting in accordance with ASTM A47, Grade 32510, galvanized; nonstandard fittings fabricated from Schedule 40 steel pipe.
    - b) Mechanical branch outlets:
      - (1) Victaulic 920 or equal.
      - (2) Victaulic Style 72 or equal.
    - c) Threaded pipe fittings: FS WW-P-501, Type 1, Class B.
    - d) Welding fittings made of same wall thickness as pipe.
      - (1) Factory-made welding fittings.
      - (2) Mitered-joint elbows and field-made reducers are prohibited.
    - e) Butt-welded fittings larger than 1-1/2 inches: ANSI B16.9.
    - f) Flanges for welded piping system: ANSI B16.5, galvanized forged steel, welded-neck type, 175 pressure class for stations and 250 pressure class for tunnels.
  - 4) Paint, Primer, and Undercoat: Alkyd Semigloss System as specified in Section 09920, Color: OSHA Red (Safety Red) in compliance with ANSI Z535.1 for piping, White for stenciling.
- c. Unions: WP 175 psig.
  - 1) 1-1/2 inches and smaller: Threaded, FS WW-U-531, Type B to match piping.
  - 2) Two inches and larger: Flanged.
    - a) Two union flanges, 2-1/2 and three inches: Steel, FSA WW-U-531, or cast iron, ANSI B16.1.
  - 3) Four inches and larger: Forged steel, slip-on weld neck flanges, ANSI B16.5.
  - 4) Nonferrous piping unions: Brass, FS WW-U-516.

C. Valves:

1. Fire-line valves, outside stem and yoke (OS&Y), UL Fire Protection Directory listed or FM Approval Guide listed for 175-psig minimum, meeting requirements of listed NFPA Standards, with UL or FM symbol cast or stamped on valve body.
2. Gate valves: UL 262 or FM Approval Guide listed, 175-psig WP
3. Check valves: UL 312 or FM Approval Guide listed, 175-psig WP, flanged-end connections, swing-type, metal-to-metal, rubber-faced or equivalent, valve seat 15 degrees from perpendicular to direction of flow.
4. Sprinkler flow-alarm check valves: Designed to operate on 10 gpm or more with restriction bypass which allows restricted flow of water to pass from supply to system side of alarm-valve clapper, to decrease possibility of false alarms resulting from increase in supply water pressure or from water hammer.
  - a. Furnished with retarding chamber, test and drain connections and electric contact unit.
  - b. Cast-iron bodies with nonferrous-metal seat, rings, bearings and renewable clapper facing.
  - c. Contacts: Section 15900.
5. Fire water-line surveillance valve:

- a. Double-disc, solid-wedge gate-type with outside stem and yoke (OS&Y) and renewable ring seats.
  - b. Designed for position indicator contact:
    - 1) Contacts open with valve fully open.
    - 2) Contacts close and alarm condition is initiated with two turns of hand wheel or when valve stem has moved one-fifth of distance from normal fully open position.
  - 6. Sprinkler alarm check-valve surveillance: Contact closes on flow amounting to 10 gpm or greater.
  - 7. Ball drip valves: 3/4 inch, threaded both ends and rated at 175-psig minimum.
  - 8. Air and vacuum valves:
    - a. Automatic.
    - b. High-capacity; minimum flow, 3.0 cfs; pressure differential, 5.0-psig maximum.
    - c. Designed for maximum system working pressure; 175-psig minimum; suitable for working pressures from zero psig to maximum capacity.
  - 9. Angle hose valves:
    - a. Cast bronze, male outlet, replaceable rubber disc and rising stem.
    - b. Rough-bronze body, polished-finish bonnet, nut and stem, complete with cap and chain.
    - c. Cast-iron or aluminum hand wheel, red-enameled.
    - d. Working pressure: 200 psig.
    - e. UL Fire Protection Directory listed with symbol cast or stamped on valve body.
    - f. American National Standard Fire Hose threads.
  - 10. In-line cut-off valves:
    - a. Flanged gate valve, with outside stem and yoke
    - b. Comply with UL 262, UL Fire Protection Directory listed or FM Approval Guide listed with symbol cast or stamped on valve body.
    - c. Working pressure, 175 psig.
    - d. Cast-iron or aluminum hand wheel, red-enameled.
- D. Fire Department Siamese Connection:
- 1. Free standing:
    - a. Paved areas: Double clapper, with sidewalk sleeve, sidewalk plate, two rocker-lug plugs and chains, polished brass, two female inlets with 2-1/2 inch American National Standard Fire Hose Threads, UL Fire Protection Directory listed or FM Approval Guide listed, working pressure of 200 psig and with cast recessed Type B Metro logo and inscription, as shown, except inside fenced Authority property.
    - b. Landscaped areas: As specified for paved areas, except no sidewalk sleeve or plate.
    - c. Paint, Primer, and Undercoat: Alkyd Semigloss System as specified in Section 09920, Color: OSHA Red (Safety Red) in compliance with ANSI Z535.1 for piping, White for stenciling.
  - 2. Wall-mounted: Double clapper rectangular wall plate for flush mounting, two rocker-lug plugs and chains, polished brass, two female inlets with 2-1/2 inch American National Standard Fire Hose Threads, UL Fire Protection Directory listed or FM Approval Guide listed, working pressure of 200 psig, and with cast raised Type B Metro logo and inscription as shown. Provide sill cock where necessary for drainage.
- E. Sprinkler Heads:
- 1. Standard fusible-link type.
  - 2. Bronze finish, exposed and temperature rating of 165F in accordance with listed NFPA Standards.

- F. Sprinkler Test Connections:
  - 1. Drain piping, valves and fittings necessary for testing in accordance with listed NFPA Standards.
- G. Control System: Except as specified for clean agent suppression systems: Provided by others.
- H. Supporting Devices:
  - 1. Pipe hangers and supports:
    - a. Adjustable, stainless steel, clevis-type, threaded full length, with diameter consistent with pipe size and the load imposed: MSS SP-58.
    - b. Hanger rods: 3/8-inch minimum diameter, stainless steel, ASTM A276, Type 304, threaded full length, with diameter consistent with pipe size and the load imposed: MSS SP-58.
    - c. Nuts and washers: Stainless steel.
    - d. Supported from stainless steel inserts in concrete slab: MSS SP-58.
  - 2. Adjustable U-bolt type:
    - a. U-Bolt: Fabricated from stainless steel, MSS SP-58.
    - b. Nuts and washers: Stainless steel..
    - c. Chair: Cast iron or fabricated from stainless steel.
  - 3. Z-bar: Fabricated from stainless steel: ASTM A240, Type 304.
  - 4. Pipe anchors:
    - a. Designed to withstand a minimum of five times anchor load.
    - b. Vertical pipes anchored by means of clamps welded around pipes and secured to wall or floor construction.
  - 5. Expansion-bolt anchors:
    - a. Consisting of bolt, expander, star lock washer and nut.
    - b. Fabricated of stainless steel, Alloy S30300 in accordance with ASTM E527, including expander and star lock washer.
    - c. Anchor assemblies: FS A-A-1992, Group II, Type 4, Class 1.
  - 6. Self-drilling anchors:
    - a. Self-drilling, expansion anchors with self-cutting annular broaching grooves.
    - b. Anchor and expander plug: Double-plated, FS A-A-1992, Group III, Type 1.
  - 7. Pipe sleeves:
    - a. Through interior masonry-unit walls: PVC, as shown, large enough to accommodate pipe but minimum two sizes larger than pipe size.
    - b. Through cast-in-place concrete interior walls and concrete ceilings: Factory-made cast iron with anchor flange and cast-iron plate collar screw-fastened to slab and pipe.
      - 1) Sleeves minimum two sizes larger than pipe; for floors and ceilings projecting four inches above finish floor.
    - c. Through exterior structural elements: Minimum two sizes larger than pipe and as shown.
    - d. Sleeves designed for pipe-movement allowance due to expansion and contraction.
  - 8. Escutcheon plates:
    - a. Polished brass or stainless steel, screw-fastened to wall or ceiling.
    - b. Plate collars caulked with silicone sealant or intumescent putty.
    - c. Sealant: UL-1479.
- I. Pressure Gauges: Spring pressure-type, 3-1/2 inch dial, in accordance with NFPA 14.
- J. Bonding Strap: 2AWG single-conductor cable: Section 16060.
- K. Preformed Joint Filler: ASTM D1752.

- L. Coal-Tar Epoxy: Section 02535.
  - 1. Thinner of type recommended by manufacturer of coating and used only when approved.
  
- M. Water-Flow Indicator: Vane-type water flow switch, UL Fire Protection Directory listed, FM Approval Guide listed. Electrical rating: 24 volts dc, 1.5 amperes, normally open contacts to actuate with flow of 10 gpm or more.
  
- N. Clean agent suppression system:
  - 1. Smoke detectors: Products of combustion, dual-chamber, ionization-type, operating voltage of 22 to 28 volts dc, 30 milli-amperes (ma) standby current drain at 24 volts dc and alarm current drain of 60 ma at 24 volts dc. Three amperes minimum alarm contact rating at 24 volts dc. Detector will activate alarm approximately five seconds after product of combustion particulate enters ionization chamber. Detectors equipped with indicator lamp which will remain lighted until reset. Unit listed by UL Fire Protection Directory and FM Approval Guide as signal and release device.
  - 2. Manual pull station: Contained in cast-metal housing for mounting on standard four-inch junction box unit to have dual-action release configuration such as discharge lever protected by lift cover, to prevent accidental discharge, and tamper-resistant screw to prevent unauthorized access to reset procedure. For operation at 24 volts dc. Listed by UL Fire Protection Directory as release device.
  - 3. Abort switch: A momentary, normally closed push-button switch. Time delay to restart at designated setting when abort switch is released. Switch to be accessible and labeled 'CLEAN AGENT ABORT.' Activation of the abort switch to silence discharge warning horn.
  - 4. Clean agent suppression system control equipment:
    - a. Control panel: Multizone for operation by smoke detectors and manual pull station, singly or in combination, to activate prealarm or release of agent as required. Power source for operating extinguishing system as well as specified auxiliary functions.
      - 1) Panel enclosure: NEMA 250, Type 1 surface-mounted, dead front; indicators and control switches visible, mounted on panel behind hinged, locked glass-paneled door, complete with relays, trouble and alarm bell, silencing switch with ring-back feature, LED indicating lamps, nameplates, switches and terminals to provide relays for fire-alarm system tie-in, for HVAC systems fan shut-down, HVAC-damper closing, for test delay switch with automatic reset to permit testing fire-alarm system without activating auxiliary control functions.
      - 2) Operating circuitry: Solid-state electronics with plug-in circuit modules for detection and release circuits; 120-volt ac, 60-Hertz supply; 24 volts dc signal and release circuits including power for operating extinguishing sub-system and other functions. Power consumption 10 watts steady state, 200 watts peak.
      - 3) Functional circuitry: Provide two detection zones and two output circuits for signal and release, all Class B supervised. Detection circuits to accommodate smoke detectors and manual stations intermixed. Signal output circuit of the polarity-reversal type. Release circuit to include supervised abort switch and adjustable time delay. Provide separate relay output for each zone alarm, general alarm, trouble, predischarge and system-fired circuit; utilize 10-ampere contact.
      - 4) Operation: Activation of detector, circuit to light zone alarm lamp on indication panel, sound audible local alarm, activate the extinguisher system and energize auxiliary relays for remote alarm

or equipment shut-down. Loss of dc power or discontinuity in detection circuits to light trouble lamp on indicator panel and actuate bell alarm; provide trouble bell silence switch with ring-back circuit to silence trouble bell alarm. Receipt of zone alarm to override trouble alarm. A single switch to reset control unit.

- 5) Indicator lights, as follows:
- a) POWER ON: Green.
  - b) TROUBLE: Yellow.
  - c) ALARM ZONE 1: Red.
  - d) ALARM ZONE 2: Red.
  - e) PRE-DISCHARGE: Red.
  - f) SYSTEM FIRED: Red.

b. Extinguishing system:

- 1) Provide system designed to discharge seven-percent volume concentration of extinguishing agent with discharge not to exceed 10 seconds. The system to comply with NFPA 2001. Each extinguishing system to include the following
- a) Agent storage container: Container fabricated of high-strength alloy steel with burst-disc actuator valve assembly, safety plug, cable assembly, 0 - 600-psig pressure gauge, pressure switch and lifting ring. Container to conform to applicable DOT specifications; to automatically relieve between 850 psi and 100 psi in event of excessive pressure buildup. Super-pressurize filled container with dry nitrogen to 390 psig at 70F to assist rapid distribution. Container designed for on-site reconditioning and refilling. Actuator valve assembly to be an integral part of container.
  - b) Discharge nozzle: Provide series of one-piece, nonclogging nozzles to distribute agent in protected volume. Nozzle size selection determined by container size and geometry of volume to be protected. Nozzles connected through reducer, elbow and piping. Nozzle discharge pattern to deliver uniform agent coverage to all areas of enclosed hazard.
  - c) Actuator: Electrical device to operate on demand to provide path for relief and discharge of agent.
  - d) Mounting bracket: Designed for wall-mounting agent storage container and capable of withstanding 1,000-pound thrust for five seconds in any direction.
  - e) Agent: Liquefied compressed clean agent suppression system conforming to requirements of NFPA 2001.
  - f) Alarm bell: Motor driven, with six-inch gong, 24-volt dc operating voltage, 90 dBA sound-pressure level at one meter and OSHA Safety Red finish.
  - g) Evacuation horn: Vibrating, 24-volt dc, 0.063 amperes, 97 dBA sound-pressure level at one meter.
  - h) Discharge indication light: Flashing device with legend CLEAN AGENT DISCHARGE; 24-volt dc.
  - i) Clean agent suppression system interface box: Data-transmission system (DTS) cabinet specified in Section 16130, with the following additional requirements:
    - (1) Cabinet: Hoffman A161206LP.
    - (2) Terminal strip: 16 terminals minimum.
    - (3) Exterior finish color: OSHA Safety Red.
    - (4) Identify cabinet on cover with COMMUNICATION INTERFACE in one-inch high yellow letters.

## PART 3 - EXECUTION

### 3.01 INSTALLATION:

- A. Fit equipment and appurtenances to space provided and make serviceable.
- B. Provide support beams, concrete pads, platforms, and hangers necessary for proper installation of equipment as recommended by manufacturer.
- C. Install complete fire-protection systems as shown and as specified. During installation, protect work, equipment, and materials. Plug or cap pipe openings.
- D. Flush underground mains before connection to wet-standpipe risers at following minimum flow rates:
  - 1. Six-inch pipe: 750 gpm.
  - 2. Eight-inch: 1,000 gpm.
  - 3. 10-inch pipe: 1,500 gpm.
  - 4. 12-inch pipe: 2,000 gpm.
- E. Fasten escutcheon plates to wall or ceiling. Seal plate collars watertight with mastic.
- F. Welding Procedure:
  - 1. As specified in Section 05120, with the following additional requirements:
    - a. Manual metallic arc process, except for pipe sizes four inches and smaller where oxyacetylene welding may be used.
      - 1) Use electrodes and rods of composition recommended by AWS A5.13 for pipe.
      - 2) Heat surface within three inches from point where weld will start to a temperature warm to hand before welding.
    - b. Leave joint surfaces smooth, uniform and free from fins, tears and other defects which adversely affect proper welding.
    - c. After each pass of weld on multiple-pass welding, clean weld free of slag and other deposits before applying next pass.
    - d. Peen with light blows of blunt-nosed peening hammer. Do not peen surface layers or first pass in groove welds.
    - e. For groove welds, center surface pass substantially on seam, smooth and free from depressions.
    - f. Fillet weld with minimum cutting back of outside surface of pipe.
      - 1) Leave throat of full fillet weld not less than 0.707 of thickness of pipe.
      - 2) Repair excess cutting back and undercutting of base metal in pipe adjoining the weld.
      - 3) Fill craters to full cross section.
    - g. Position pipes to be welded so that joints will be in alignment. Joints misaligned more than 20 percent of pipe wall thickness or maximum of 1/8 inch are prohibited.
    - h. Install welding pipe in accordance with ANSI B31.1.
  - 2. Cut ends of screw-jointed pipes squarely to seat in bottom of recess of fittings. Ream after cutting so waterway is not reduced in size.
  - 3. Apply thread dope or compound to male thread only.
  - 4. Where cathodic protection is shown, apply coal-tar epoxy coating as specified in Section 02535 and test as specified in Section 13115.

- G. Buried Ductile-Iron Pipe: Install as specified in Section 02515, except use mechanical joints.
- H. Steel-Pipe Installation:
1. Maintain OSHA required head clearance.
    - a. Install horizontal piping with minimum pitch of one inch in 40 feet.
    - b. Provide drains at low points: Minimum 3/4-inch valves with hose connection.
    - c. Install vertical pipes near wall from which they are supported.
  2. Make connections to equipment without placing strain on piping and equipment.
  3. Tunnel, vent and fan-shaft piping:
    - a. Joints of the following types:
      - 1) Butt weld joints in pipe recessed in tunnel lining.
      - 2) Use mechanical grooved couplings for remainder of joints in horizontal and vertical mains unless otherwise shown.
      - 3) Use threaded joints in branch lines 2-1/2 inches or smaller.
    - b. Provide number of mechanical couplings necessary to allow minimum 1-1/4 inch expansion per 100 feet of main.
    - c. Use reducing tee for mechanical couplings or mechanical branch outlet at main-to-branch connections.
    - d. Make in-line cut-off valves accessible from floor or walkway level.
  4. Underplatform station piping:
    - a. Provide the following types of joints or couplings:
      - 1) Couplings: Mechanical, grooved, at intervals not to exceed 21 feet.
      - 2) Where possible, cut grooves before galvanizing.
      - 3) Where grooves are cut after galvanizing, apply zinc coating.
      - 4) Other joints:
        - a) In lines four inches and larger: Welded joints.
        - b) In lines less than four inches: Welded or threaded joints.
    - b. Provide anchors, horizontally and vertically rigid, within one foot of one end of each length of pipe jointed with Victaulic-type mechanical couplings. Provide clevis-type support within one foot of other end, at midpoints between mechanical couplings and at each angle hose valve. Locate supports at angle hose valves to ensure resistance to rotation of valves and adjacent piping by water pressure at valve. Provide restraint for every third length of pipe to prevent excessive movement by a horizontal thrust. Roller-type hangers and pipeline guides are not required
  5. Other station piping: Joints in balance of station fireline piping of mechanical-type, grooved or welded couplings for lines four inches and larger and screwed or welded for lines under four inches, except that mechanical-type groove couplings must be accessible.
- I. Mechanical-Type Groove Couplings: Install couplings according to manufacturer's instructions and as follows:
1. After grooving, remove indentations, projections and roll warps as necessary. Cut pipe ends square to tolerance of plus-or-minus 0.03 inch. Provide zinc coating on exposed surface.
  2. Lightly coat pipe ends and coupling gasket with non-petroleum-based lubricant.
  3. Center gasket, install housing and ensure that keys are securely located in pipe grooves.
  4. In underplatform station piping, provide separation of 1/8 inch between ends of adjacent sections of pipe within coupling, based on air temperature of plus 60F. Adjust based on actual air temperature at time of installation.
  5. Install bolts and nuts tightened uniformly to manufacturer's recommended limits using torque wrench, without pinching gaskets.
  6. Provide bonding across couplings for stray-current protection.

- J. In-Line Valves: Install in-line valves by bolting fitting to valve and welding fitting to pipe.
- K. Pipe Anchors: Securely anchor piping as specified, where shown and where necessary for proper installation to force pipe expansion in proper direction.
- L. Expansion-Bolt Anchors: Drill holes and install expansion-bolt anchors in manner recommended by anchor-bolt manufacturer. Do not install less than eight inches from concrete edge.
- M. Pipe Sleeves: Fill annular space between pipe and sleeves with preformed joint filler, tightly placed to form effective seal against groundwater.
- N. Bonding: In accordance with Section 16060, and with the following additional requirements:
  - 1. Bond mechanical joints and fittings, including valves, by exothermic-welding method.
  - 2. Make welds in accordance with manufacturer's recommendations. Clean and coat with coal-tar epoxy.
  - 3. Bond pipe using bonding strap welded to each side of joint not less than six inches from joint. Allow sufficient slack in conductor for expansion of pipe.
- O. Air Vents: Install high-capacity automatic air vent(s) at opposite end(s) of dry-standpipe system from fire-department siamese connection or where shown. Pipe air-vent outlet to nearest drain or as directed.
- P. Firestopping: Section 07841.

### **3.02 PROTECTION OF PIPING AND EQUIPMENT:**

- A. Protect pipe, openings and valves from dirt, foreign objects and damage during construction.
- B. Replace damaged piping, valves and other appurtenances, should damage occur prior to final acceptance of the work.

### **3.03 FIELD QUALITY CONTROL:**

- A. Field Tests:
  - 1. Flush piping with water until clean and free of scale, slag, dirt, oil, grease and other foreign material.
  - 2. Perform final testing, acceptance, and certification in accordance with NFPA 13, 14, and 24, as applicable.
  - 3. Test electrical continuity of bonded joints by measuring resistance. Total resistive value of joint not to exceed calculated resistance of bond cable plus 10 percent.
- B. Water-Pressure Testing:
  - 1. In the presence of the Engineer, test piping, prior to burial or concealment, using specified procedures specified.
  - 2. In the presence of the Engineer, completely test piping system for leaks until approved.
  - 3. Notify the Engineer at least 36 hours prior to tests.
  - 4. Test piping at the following pressures:
    - a. Fire-protection piping, inaccessible: 400 psi-minimum.
    - b. Ductile-iron pipe: At lowest point in system, 150 psi or 1-1/2 times maximum working pressure, whichever is greater.
    - c. Fire-protection piping, exposed and accessible: At lowest point in system, 150 psi or 1-1/2 times maximum working pressure, whichever is greater.

- C. Test Procedures:
1. Test fire-protection piping in accordance with NFPA.
  2. Fire-protection piping, inaccessible:
    - a. Avoid excessive pressure on safety devices and mechanical seals.
    - b. Fill entire system with water and vent air from system at least 24 hours before test pressure is applied.
    - c. Apply test pressure when water and average ambient temperature are approximately equal and constant.
    - d. Maintain test pressure for six hours minimum without drop after force pump has been disconnected.
  3. Water-test entire system with pressure at highest point of 250 psig.
  4. After filling system, shut off water supply and allow it to stand for two hours under test without loss or leakage.
  5. Coordinate with and assist local fire department in performing flow tests. After performing hydrostatic test, drain water from firelines. Perform flow test at rate of 500 gpm with pumper connected to siamese connection, starting testing with sudden full flow into empty firelines.
  6. Drain system immediately after hydrostatic and flow testing.
- D. Repair of Leaks:
1. The following are prohibited:
    - a. Repair of leaks by mechanical caulking.
    - b. Introduction of material inside piping system to stop leakage.
  2. Repair leaks in threaded piping by breaking joint, cutting new threads on pipe and installing new pipe fitting.
  3. Coat field welds and repair damages to zinc-coated surfaces as follows:
    - a. Wire brush areas to be coated to bright metal.
    - b. Apply galvanizing repair compound at rate of two ounces per square foot.
  4. Replace defective coupling assembly as necessary.
  5. Remove defective welds by chipping or gouging.
    - a. Reweld the chipped-out places.
    - b. When base metals of fillet welds are cut back or throat of welds are less than specified, repair defect by adding additional weld metal.

### **3.04 CLEANING:**

- A. Flush firelines with water to remove sediment after completion of tests, repairs or replacements.
- B. Disinfect firelines connected to potable-water system as follows:
1. Use chlorine for disinfection in form of hypochlorite solution or in form of compressed gas applied through approved chlorinator.
  2. Operate valves and equipment during chlorination to ensure that chlorine reaches entire system.
  3. Feed water and chlorination agent into system at rate providing for 50 ppm of chlorine and allow to stand 24 hours before flushing.
  4. Residual chlorine, at end of 24-hour retention period, not less than 10 ppm.
  5. Flush treated water from system completely after disinfection.
  6. Continue flushing until samples show that quality of water delivered is comparable to public water supply and satisfactory to public-health authority having jurisdiction.
  7. Do not take samples from hydrants or through unsterilized hose.

### **3.05 FIELD PAINTING: Section 09920.**

- A. Prepare piping, apply primer, undercoat and finish coats in accordance with Section 09920.

**3.06 IDENTIFICATION OF PIPING AND VALVES: Section 15075.**

**3.07 CLEAN AGENT SUPPRESSION SYSTEM:**

- A. General:
1. Install clean agent suppression system sized and adjusted to discharge seven-percent concentration within protected spaces in accordance with NFPA 2001. Smoke detectors to be cross-zoned so that at least one detector from each loop shall react to smoke before extinguishing system will be activated. First detector actuated to sound alarm bell, illuminate indicator lamp for appropriate alarm zone and energize fan shut-down relays and close dampers of HVAC systems serving involved space. Second detector actuated to energize evacuation time-delay relay in clean agent suppression system control panel, sound evacuation horn and illuminate SYSTEM FIRED indicator light at clean agent suppression system control panel to indicate system discharged. Actuation of manual pull station to by-pass time-delay function, sound evacuation horn, energize fan shut-down relays of HVAC system serving area and release FM200.
- B. Trouble Operation:
1. Opens or ground in wiring to ring bell on FM200 control panel. Silencing switch to silence trouble bell during correcting of fault.
- C. Remote Alarms:
1. Activation of the following to generate alarm indicators at clean agent suppression system control panel:
    - a. Alarm Zone 1.
    - b. Alarm Zone 2.
    - c. System fired.
    - d. Trouble.
- D. Performance Testing:
1. Performance-test completed system except smoke detectors.
  2. Provide instrumentation and test gases-test systems including detection system in accordance with jurisdictional requirements.
  3. Operate mechanical and electrical systems.
  4. Inspect nozzles and agent storage containers.
  5. Full equivalent test of gas discharge into each zone area. Use meter to verify delivery of specified concentrations within required time and maintained for minimum of 10 minutes.
  6. After completion of satisfactory testing, refill storage containers.

**END OF SECTION**

**DIVISION 14 - CONVEYING SYSTEMS**

14000 CONVEYING SYSTEMS

14200 HYDRAULIC ELEVATORS

14210 HOLELESS HYDROLIC ELEVATORS

14240 GEARLESS TRACTION ELEVATORS

14245 GEARED TRACTION ELEVATORS

14300 HEAVY-DUTY ESCALATOR

**END OF SECTION**

**SECTION 14200  
HYDRAULIC ELEVATORS**

**PART 1 – GENERAL**

**1.01 DESCRIPTION**

A. This section specifies work pertaining to heavy-duty hydraulic passenger elevator systems including elevator cars, hoistway equipment, hydraulic piping, valves, cylinders, machinery, control systems, indicators, signs, elevator pit ladders and finish work in the vicinity of the hoistway doors. Work under this section also includes drilling of casing holes, furnishing and installation of 3/8-inch thick steel well hole casings, and concrete in the bottom of the well hole.

B. The following sections include related requirements and are performed by other trades:

1. Specifications Section 02000 – Site Construction
2. Specifications Section 05000 – Metal Fabrication
3. Specifications Section 08800 – Glass and Glazing
4. Specifications Section 09920 – Painting
5. Division 7 Section “Waterproofing” for water proofing of elevator pit
6. Division 15 Sections for heating, ventilating and/or air conditioning of elevator machine room.
7. Division 16 Sections for electrical service to elevator equipment, fire alarm systems and communications systems.

C. Definitions:

All terms in this specification have the meaning as defined in the ASME code.

1. Heavy duty elevator: An elevator designed specifically for the harsh environment and duty load cycles common to transportation system usage.
2. Elevator - a hoisting and lowering mechanism, equipped with a car or platform, which moves in guide rails or racks and serves two or more landings
3. Elevator, passenger - an elevator used primarily to carry persons other than the operator and persons necessary for loading and unloading.
4. Elevator, hydraulic - a power elevator in which the energy applied, by means of a liquid under pressure, in a hydraulic jack.
5. Contractor: The General Contractor.
6. Installer: The responsible party who installs the elevator.
7. OEM: Original Equipment Manufacturer.

8. Dwell time: The period of time the elevator is at a landing while the doors open, passengers transfer and doors close.
9. Substantial completion: The point at which the elevator is ready for use, whether the site is finished or not. This is where the jurisdictional inspection usually takes place.
10. Final Acceptance: The point at which the owner accepts the elevator project as being complete including all submittal requirements. This may be a different point in time than substantial completion.
11. Interim Maintenance: Maintenance from the point of substantial completion, but prior to Revenue Service.
12. Beneficial Use: When the elevator is placed into service, may be prior to the site being ready for public use.
13. Revenue Service: The station or facility opening date.
14. Notice to Proceed (NTP): within this document shall mean the date which the elevator installer is notified to proceed with the project.
15. Override Switch – A switch located in a kiosk panel, which disables the Hall Call Buttons.
16. MSDS - Material Safety Data Sheet.
17. BOM - Bill of Material
18. SMNT - Systems Maintenance (WMATA)
19. WMATA: Washington Metropolitan Area Transit Authority.

## 1.02 REFERENCES AND QUALITY ASSURANCE

### H. Codes, Regulations, Reference Standards and Specifications.

1. Comply with codes and regulations of the Authority Having Jurisdiction.
2. American Society of Mechanical Engineers (ASME) A17.1 Safety Code for Elevators & Escalators and A17.2 Guide for Inspection of Elevators, Escalators and Moving Walks.
3. WMATA Design Criteria requirements indicated in Section VI-Mechanical.
4. American Institute of Steel Construction (AISC).
5. American Iron and Steel Institute (AISI).
6. American National Standards Institute (ANSI): C80.1
7. American Society for Testing and Materials (ASTM): A36, A123, A153, A167, A240, A264, A276, A500, A653, B3, B8, D471.
8. American Wire Gauge (AWG).
9. Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG).

10. American Welding Society (AWS): D1.1.
11. Environmental Protection Agency (EPA).
12. Federal Transit Administration (FTA).
13. Institute of Electrical and Electronic Engineers (IEEE): 1202.
14. International Code Council (ICC) – International Building Code (IBC).
15. National Association of Architectural Metal Manufacturers. (NAAMM): C54, C55.
16. National Institute of Standards and Technology (NIST).
17. National Electrical Code (NEC).
18. National Electrical Manufacturers' Association (NEMA): WC 70, KS 1, AB 1, 250, PB 1, MG 1.
19. National Electrical Safety Code (NESC)
20. National Elevator Industry, Inc. (NEII)
21. National Fire Protection Association (NFPA): NFPA-130-2003.
22. Occupational Safety and Health Act (OSHA).
23. Society of the Plastics Industry (SPI).
24. Underwriters' Laboratories, Inc. (UL), UL-94HB, 6, 50, 62, 98, 360, 486, 489, 514, 1591.
25. United States Department of Transportation (DOT).
26. Any additional requirements imposed by local agencies and/or codes having jurisdiction shall be incorporated into elevator installation.
27. In the event of a conflict between codes, regulations, these specifications or standards, the most stringent requirement as determined by the Contractor and approved by the Authority shall take precedence unless specifically addressed herein.

**B. Elevator Manufacturer and/or Installer's Qualification:**

1. **Manufacturer Qualification:** : Shall provide documents stating that their firm has successfully produced elevators for transit system applications for a minimum of ten (10) years and regularly engaged for the past five (5) years in the manufacture of major components for hydraulic passenger elevators. As a standard of quality the elevator equipment design and installation shall comply with the Code.
2. **Installer's Qualifications:** Shall be the original manufacturer of elevator equipment or manufacturer's authorized agent who is trained and approved for installation of units required for this Project.
3. The Contractor shall obtain and pay for all permits and licenses and perform all required inspections.

**C. Quality Assurance:**

1. The elevator contractor shall guarantee the materials and workmanship of the apparatus furnished under these specifications and will correct any defects not due to ordinary wear and tear within two (2) years from date of completion of each elevator, inclusive of labor and traveling expenses. Defective work shall be repaired or replaced at no additional cost to the Authority.
2. Welding: Welding shall be performed in accordance with the requirements of AWS or CWB Welders shall produce evidence of current certification by AWS or CWB.
3. Labeling Requirements: Every elevator shall be clearly marked with rated load and speed, manufacture serial number and the designated Authority identification.
  - a. All elevators shall be permanently numbered with number designations corresponding to the indications on the kiosk annunciator panel. A station sketch showing the elevator numbers shall be submitted for WMATA ELES Engineering. The elevators shall be numbered in sequence, starting at the north entrance left to right facing to the elevator at each station and proceeding clockwise around the station. The numbering shall proceed into the station toward the end of the platform. Corresponding numerical identification shall be affixed to the equipment in the machine rooms. The elevator numbering shall be approved by the ELES Engineer.

### 1.03 SUBMITTALS

Submit the following for approval in accordance with the Contract Documents and with the additional requirements as specified.

#### A. Product Data

1. The summation of product information shall be submitted, in tabular form, of all parts incorporated in the entire group of elevators supplied under this Contract. Hard copies and electronic copies on the Flash Drive/Compact Discs (CDs) shall be submitted.
  - a. Manufacturer's design data, material specifications, drawings, installation and maintenance instructions including preventive, predictive and general maintenance, and other data pertinent to the components used in the elevator systems, including, but not limited to, detailed repair data for all components, including disassembly, inspection/gauging/torque requirements, reassembly, testing and other related information. Submittals shall cover all mechanical components, operating panels and indicators and electronic equipment to control and monitor elevator control functions. Exploded view drawings shall be included to facilitate repair and maintenance functions.
  - b. Lubricants, sealers, paints and any other potentially hazardous substances are subject to review and approval by the Authority. The Contractor shall submit the necessary Material Safety Data Sheets.
2. The following information shall be provided:

- a. Nomenclature of part.
  - b. Elevator Contractor's part number
  - c. Nomenclature of next higher assembly in which used.
  - d. Manufacturer and part number.
  - e. Model number(s) of elevator(s) on which used.
  - f. Total quantity in entire group of elevators.
  - g. Current unit price to the Authority.
  - h. Recommended spare parts list showing parts with prices for each part. The parts listing shall be provided on or before 90 days prior to scheduled completion
3. Loads on supporting members, reaction points, and deflections under varying loads.
    - a. Loads imposed on the structure shall be coordinated with the Authority and not exceed agreed limits. This requirement shall be verified, documented, and stamped by a registered Professional Engineer Supporting calculations shall be provided for record file.

B. Shop Drawings

The contractor to provide detailed drawings that shows the dimensions and tolerance, specification that may include the material specification, hardness or electrical rating for each component that is being used. In regards to assemblies they must provide a top level drawing with BOM and quantities with detailed material specifications and drawings with dimensional tolerances. The contractor also to provide as-built CAD models of all elevator components.

The name of the manufacturer and type or style designation shall be listed on the each page of the equipment shop drawings. Drawings submitted shall include, but not be limited to, the following.

- a. Fully dimensioned layout in plan and elevation, showing the arrangement of equipment and all pertinent details of each specified elevator unit, including as appropriate
  1. All equipment located in machine rooms.
  2. Location of circuit breaker, switchboard panel or disconnect switch, light switch, and feeder extension points in machine room. These electrical components shall not be blocked by anything.
  3. Location in hoistway of outlets for connection of traveling cables for car light, fire detectors, communication, and control system.
  4. Car, hydraulic cylinder and plunger, supporting beams, guide rails, buffers, and other components located in the hoistways.

5. Maximum guide rail bracket spacing. Guide rail brackets shall be provided at every horizontal structural member and shall be of sufficient strength to meet the ASME Code.
  6. Reactions at points of supports.
  7. Weight of principal parts.
  8. Top and bottom clearance and over-travel of car.
  9. Complete wiring diagram of the elevator system and subsystems. Complete data regarding electrical characteristics and connection requirements.
  10. Refuge space on top of car and pit.
  11. Cab design, dimensions and layout.
  12. Color/material schedule and selection chart for cab and entrance features.
  13. Hoistway Ventilation - Thermostatically Controlled, positive mechanical ventilation system.
  14. Hydraulic Jack Details
  15. Machine/Pump Room area, pit and hoistway layout.
  16. Hydraulic piping layout indicating layout, type, size, and schedule of piping from machine room to elevator pit(s) indicating orientation of valve(s), and location of shut-off valve(s), and shall include calculations of working pressures.
- b. Drawings of the hoistway entrances and doors showing their method of operation, details of construction, and fastenings to the structural members of the station structure.
  - c. Drawings of the car for each design specified, showing dimensions, details of construction, fastenings to platform, car-lighting, ventilation, air conditioning (if applicable), communication, and location of equipment.
  - d. Cuts or drawings showing details of all signal and operating devices, identifying graphics, and detailed design with diagram and schematic of kiosk annunciator panel.
  - e. Hydraulic drive:
    1. Cylinders and plunger.
    2. Power unit, including volume, rate of flow, working pressure, rpm of pump, and horsepower, voltage, frequency, service factor and rpm of the motor.
    3. Piping, fittings, and couplings.
    4. Valves.
    5. Storage tank.
    6. Muffler.

7. Hydraulic Jack Details Drawings
  8. Fluid flow diagram showing all valves, operating devices, and controls.
  9. Complete assembly detail of machine/pump, hydraulic tank mounting, with all load calculations.
- f. Elevator controller, including manufacturer's technical data and catalog cuts, and interface hardware and software requirements.
  - g. Power door operator.
  - h. Door interlocks and electrical contacts including test reports showing that hoistway door interlocks, car door contacts, and car top emergency contacts meet the requirements of the ASME Code and certification by the NIST or other approved laboratory.
  - i. Car ventilation fan.
  - j. Car Air Conditioning (if applicable)
  - k. Car lighting.
  - l. Cabling.
  - m. Buffer, including stroke and certified maximum striking speed for car.
  - n. Communication and intrusion system design details covering electrical, mechanical, and architectural aspects.
  - o. Design and architectural details, including light ray unit locations, of the electrical protective device for car doors.
  - p. Where the use of adjoining dissimilar metals is required, descriptions of protective measures to be employed to avoid corrosive damage.
  - q. Certification from independent testing laboratory that glazing gaskets meet the specified requirements.
  - r. Hall and car fixtures at each landing including the car operating panel (COP).
  - s. Interface wiring diagrams with other systems showing terminal board location and identification.
  - t. Expected heat dissipation of elevator equipment in machine room and control areas (i.e. BTU's/hr.) based on 240 round cycles per hour.
  - u. Complete wiring diagram of the elevator system and subsystems. Complete data regarding electrical characteristics and connection requirements.
  - v. Complete assembly detail of machine/pump, hydraulic tank mounting, with all load calculations.
  - w. Lubricants, sealers, paints and any other potentially hazardous substances are subject to review and approval by the Authority.

The Elevator Contractor shall submit the necessary Material Safety Data Sheets.

C. Samples

1. Three of each of the following samples shall be submitted for approval:
  - a. Steel cladding: Baked-enamel finish, six inches square. The sample shall show the rust-protected surface of the base metal on one side and the prime and finish coats (stepped) of enamel on the other side, although both sides of actual panels are to be enameled as specified.
  - b. Sheet metal: Six inches square of thickness and finish specified.
  - c. Stainless steel cladding: 12 inches square of thickness and finish specified.
  - d. Glass: 12 inches square.
  - e. Floor covering: 12 inches square in the color and finish to be supplied.
  - f. Neoprene gasket: Each type.
  - g. Landing selector button mounted in cover plate with identity marking alongside button.
  - h. Signs: One of each type.
  - i. Ceiling material.

D. Certification:

1. Certificates of inspection and acceptance issued by Jurisdictional Authority.
2. The Acceptance Inspection (Specifications and Code) by the Elevator and Escalator (ELES) Department shall take place prior to the Final Acceptance Inspection by the Jurisdictional Authority, and the elevators and associated equipment shall be free of defective material, imperfect work and faulty operation.

All defective work identified by ELES representatives shall be repaired or replaced at no additional cost to the Authority prior to the Final Acceptance Inspection by the Jurisdictional Authority.

E. Operation & Maintenance Manuals.

Six sets of the approved manuals, elevator installation, operation instructions, troubleshooting techniques and related equipment drawings and software (all publication must be in English) – two copies of which to be delivered to the WMATA/ELES Engineer representing of the Authority prior to installation. Each binder shall have the Binder Cover and Spine Insert which contain the Station Name and Unit ID.

Submit an additional electronic copy on Flash Drive(s)/CD(s). The Information shall be saved/presented as follows:

- a. Graphic images in “.dwg” AutoCad and “.pdf” formats. All revisions shall be made by

using computer software. Hand written changes are not acceptable.

b. Text in Microsoft Word .doc, “.pdf” or approved equal format.

The manuals shall include the following:

1. Complete operation and maintenance Instructions of the elevator equipment included complete illustrated, exploded views of all assemblies and a complete illustrated, exploded view for identification all system parts.
2. Complete nomenclature of replaceable parts, part numbers, current cost, and warehouse location. If product source is another vendor, Contractor shall include name and address of other vendor.
3. Furnish a summation, in tabular form, of all parts incorporated in the elevators supplied under the Contract. Include but not be limited to the following:
  - a. Nomenclature of part.
  - b. Contractor's part number.
  - c. Nomenclature of next higher assembly in which used.
  - d. Manufacturer and part number.
  - e. Model number of elevator on which used.
  - f. Total quantity.
  - g. Current unit price to the Authority.
  - h. Serial numbers of all serialized assemblies, subassemblies, motors, and other major components supplied and installed.
4. Control and schematic electrical wiring diagrams of controller including wiring of safety devices.
  - a. Wiring Diagrams shall be full size (11x17), ladder type, complete "as-built" wiring and single line diagrams showing the electrical connections, functions and sequence of operation of apparatus connected with each elevator, using standard symbols or proprietary symbols defined on the diagram, both in the machine room and in the hoistway, shall be furnished in duplicate for each elevator.
  - b. Wiring diagrams shall incorporate the wiring identification labeling to identify the controller and field wiring used for each circuit. Wiring diagrams shall have sheets numbered with an indication of the total number of sheets in the diagram set. Each page should include unit number where the diagram belongs to.
  - c. After approval, a copy of each print (11x17) shall be laminated and mounted with non-metallic holder in each elevator machine room. A reproducible .003 mil Mylar set of wiring diagrams for each elevator shall be delivered to ELES Engineering Office.
  - d. Coded diagrams are not acceptable.

5. Complete detailed drawings and wiring diagram of elevator system.
6. Lubricants, sealers, paints and any other potentially hazardous substances are subject to review and approval by the Authority.
  - a. Provide MSDS for all the lubricants/chemicals.
  - b. Provide manufacturer part number.
  - c. Provide name of the manufacturer.
7. Detailed lubrication and cleaning schedule.
8. Procedures for adjusting all elevator components.
9. Complete set of contract software including operating control software.
10. Detailed, record and as-built layout drawings.
11. The entire manual, all software upgrades and service tools for elevators shall be provided in an electronic format on Flash Drive/CD-ROM that is acceptable to the WMATA Engineering and Maintenance Department.
12. All hard copy publications shall be in loose-leaf form, on 30-pound paper and with punch holes reinforced with plastic, cloth or metallic material.
  - a. The O&M manual shall only contain information related to equipment installed under this contract. Generic information that does not pertain to the equipment installed shall not be included. Scanned documents are not allowed. The fonts should be standard format.
  - b. All covers shall be resistant to oil, moisture, and wear commensurate with their intended use. Diagrams and illustrations shall not be loose or in pockets. All printed material shall be capable of being reproduced on dry copying machines.
13. Each elevator shall be treated as a whole and not as a grouping of disassociated parts. The material in the Wiring Diagram Manual shall be organized and indexed by the elevator classifications included in this Specification. All manual sections shall be sub-divided, to the extent required by the subject matter, and shall include, but not necessarily limited to the following topics:
  - a. General system or sub-system description and operation.
  - b. Sequence of operation.
  - c. Replacement and step by step adjustment procedure for all components and systems.
  - d. Block diagrams.
  - e. Functional schematics.
  - f. Functional as-built wiring diagram.
  - g. Lubrication and cleaning, including frequency, methods, and trade identifications of recommended materials.
  - h. Component location and description.

- i. Inspection and maintenance standards including wear limits, settings, and tolerances.
  - j. Installation and removal sequence.
  - k. Test and evaluation procedures.
  - l. Spare parts lists and special tools.
14. The contractor shall provide all information: manuals, drawings, design changes, modifications, techniques, procedures and any other documents related to maintenance, safety, operations which relate to any part, component, system, subsystem or material and applicable to the elevator equipment. All operating, programming, control software and licensing keys (if applicable) to the PLC control system for the installation.
15. All of the above referenced shall be provided as it pertains to the original installation and for a period of ten (10) years after final acceptance of the elevator. During a ten (10) years period, In case of any items are obsolete or no longer available from the manufacturer the Elevator Contractor shall provide the alternative products.

#### **1.04 SYSTEM DESCRIPTION AND PERFORMANCE REQUIREMENTS**

##### **A. Design Requirements:**

##### **1. General:**

- a. Elevators furnished under this Contract shall be of the heavy duty automatic, hydraulic-type with direct-acting plunger.
- b. All parts shall be built to standard dimensions, tolerances, and clearances so that similar machines and devices supplied under contract are completely interchangeable. Elevators shall be designed with provision for thermal expansion and contraction of complete elevator assemblies and for any movement of the facility.
- c. Fasteners: Fasteners shall be compatible with materials being fastened. Fasteners shall be furnished with self-locking nuts or retaining rings (spring washers, toothed disks). Fasteners shall be equal to or of greater corrosion resistance than the most corrosion resistant metals being fastened. The mechanical fastening used throughout the equipment on parts subject to wear and requiring replacement shall be key and seat, nut, screw, or other removable and replaceable type not requiring physical deformation or field positioning. The use of rivets or similar devices will not be acceptable as mechanical fastenings for such parts.
- d. Doors of elevators shall be of the horizontal sliding type, single speed, center-opening. The doors shall be arranged for low-speed electric power operation.

##### **2. Capacity, Speed, Travel, Platform Size**

- a. All parts of the elevator equipment shall be of such design, size, and material as to satisfactorily function under all conditions of loading and operation within its rated load and speed, all with a proper factor of safety, maximum mechanical and electrical efficiency, and a minimum wear on parts.
  - b. Hydraulic elevators shall have sufficient capacity to lift the rated load at 150 feet per minute, with a tolerance of plus or minus 8.0 percent.
  - c. The rated load shall be exclusive of the weight of the complete car and shall be determined in accordance with ASME Code requirements for passenger-elevators required to carry freight, Class C3 (ASME A17.1 Section 2.16) or 4500 lbs, whichever is greater.
  - d. The travel, location, terminal floors, number of stops and openings, and the overall car platform size shall be as shown on the Contract Drawings.
  - e. The anticipated freight load (cart) will be approximately 4 feet-1 inch by 2 feet in plan, supported on four 8-inch wheels with 2-inch wide treads spaced approximately 2 feet-4 inches center-to-center longitudinally and one foot five inches center-to-center transversely. The loaded cart will weigh approximately 1,260 pounds.
  - f. The entrance of the cart into the elevator car will produce eccentric forces which, acting through the guide rails, will result in additional deflections and deformation on the hoistway. These deflections and deformations shall not exceed 1/16 inch and shall not be permanent.
  - g. The top enclosure shall be reinforced to support two men and capable of sustaining, without damage or permanent deformation, a load of 300 hundred pounds on any area one feet square and 100 pounds applied at any point. An emergency exit shall be installed in the car top in conformance with the Code.
  - h. In-ground (Holed) hydraulic elevator travel shall not exceed 36 feet.
- B. Performance Requirements
1. The elevators shall be designed for continuous operation seven days per week, 24 hours per day.
  2. Elevators shall be designed to be capable of operating with full specified performance capability while exposed to the climatic and environmental conditions described in the following paragraphs. In addition, during installation and until the beginning of scheduled maintenance service, the elevators will be subject to more extreme environmental conditions. The elevator shall be furnished the amount of protection necessary to prevent any damage to or deterioration of the elevators during this period.

- a. Elevators shall be designed to operate in dry bulb temperature range of  $-10^{\circ}\text{F}$  to  $140^{\circ}\text{F}$  and operate while exposed to the natural elements of weather, including sunlight, rain, snow, slush, salt; all condition of relative humidity, de-icing chemicals, debris, airborne dust, and corrosive elements.
  - b. The elevators shall have a special winter operation. The elevators shall be designed to operate in the event the outside temperature falls below a pre-established minimum value. The elevator contractor shall furnish and install the necessary timers and thermostat to accommodate the desired function
3. Sound Level: No elevator car or elevator power unit shall generate noise in excess of NC45 sound level. Measurement of noise shall be made at a point 3 feet from the hoistway, machine room entrances, and ventilation openings, either free running or under load. For multiple elevator installation, the noise measurements shall be made with only one (1) elevator unit in operation, but with the entire installation complete and in operating condition. An ambient level not to exceed forty-nine (49) decibels shall be maintained prior to units being turned on.
4. Hoistway Movement:
- Elevators shall be designed to sustain the load and operate with the following lateral movements of the hoistway structures:
- a. In any individual glazed area: 1/4 inch.
  - b. In total height of hoistway structure:
    1. Aerial and surface structures: 5/8 inch
    2. Underground structures: 1/2 inch
5. The elevator assembly shall be designed in a manner to avoid corrosion and galvanic action due to physical contact between dissimilar metals or due to other causes.
6. Reliability:
1. Each elevator shall be capable of operating at full load under any of the normal modes of operation at a level of availability of not less than 98 percent over a period of 365 days.
  2. Availability (A) is defined as the portion of normal operational time during which the equipment is available for use. Or

$$A = \frac{MTBF}{MTBF + MTTR}$$

Where:

$MTBF$  = Mean time between failure in days

= Operating time,  $t$  (in days) /Number of failures in time  $t$

*MTTR* = The average time in days required to restore an elevator to operation after a report of a failure.

B. Seismic Loads

1. In accordance with VA-USBC 2003, all structures shall be designed to resist the effects of earthquake motions.
2. The elevator shall be designed to comply with the seismic zone 2 requirements of ASME A17.1.

C. Make provision for and provide a closed circuit television camera (CCTV), in the elevator car(s) with the ability to monitor the CCTV from the Kiosk annunciator panel. Submit drawings for approval before fabrication.

- a. Provide electrical connections, through shielded traveling cables, between camera and the communications terminal block in machine room or pit.

D. Painting: The pit, pit walls and machine room floor shall be painted. All machine room equipment shall be given two coats of approved machinery paint. All new iron work shall be given one coat of rust- inhibiting paint.

E. Workmanship:

1. Joints shall be welded their full length and dressed smooth and flush on exposed surfaces. Spot welding shall be used where practicable in preference to screw or rivet fasteners.
2. Sheet metal materials shall be accurately rolled and leveled, and have smooth finish and uniform color. Joints shall be formed to a tight fit, with abutting edges flush, and shall be securely welded or riveted together in such a manner as to give strength equivalent to the solid sheet. Riveted construction shall have heavy reinforcement on the back, and no rivets shall show on exposed surfaces, Welds shall be solid and dressed flush, and holes for screws or bolts shall be drilled and countersunk.
3. Wrought work shall have joints milled to a tight even fit and, where possible, shall be made without screws. Square turns and comers shall be sharp, Curves and loops shall be true and without visible joints. Abutting members shall be welded, riveted or both. Similar bars shall be halved at intersections and wide bars shall be punched for the small bars to pass through.
4. The finished work shall be strong, rigid and neat, painted in appearance. Plane surfaces shall be smooth and free from warp or buckle. Molded members shall be clean cut, straight, and true. Miters shall be well formed and in true alignment. Fastenings shall be concealed from face side of the material.

G. Corrosion Protection: The contractor shall design the elevator assembly in such a manner to avoid corrosion and galvanic action due to physical contact between dissimilar metals or due to other causes.

## 1.05 PROJECT SITE CONDITIONS

- A. The project site premises shall be visited by the Contractor to thoroughly familiarize with all details of work and working conditions. All dimensions shall be verified in the field and by comparison with the station structural and finish (information) drawings and the Authority shall be informed of any discrepancy before ordering equipment or performing work. Coordination and proper relation of this work to the structure and to the work of all trades shall be performed.
- B. The elevator installer shall install all elevator wiring in the embedded conduit provided by other trades including that to the kiosk. Other trades will bring wiring for their services to either the elevator machine room or the elevator pit, terminated on a terminal block. The elevator installer shall extend wires from the terminal blocks to the appropriate location or device within the elevator enclosure or hoistway. Some of these circuits shall require shielded wires or separate isolated circuits.

### 1.06 WARRANTY

Warranty: Two (2) year warranty of construction shall start at Final Contract completion.

- A. The OEM shall warrant in writing that all equipment manufactured and installed under this specification, for a period of twenty four (24) months from the date of Final Acceptance by the Authority, be free of defects in design, materials, and workmanship, under normal use and service. Defective work shall be repaired or replaced at no additional cost to the Owner.
- B. The warranty shall include materials and labor necessary to correct defects.
- C. The warranty does not begin until all of the following requirements have been met.
  - 1. The Operations and Maintenance Manuals are accepted by WMATA.
  - 2. The required training has been completed to the satisfaction of WMATA.
  - 3. All field tests have been successfully completed.
  - 4. The acceptance testing has been successfully completed.
  - 5. The elevators are in service for passenger/public use.
  - 6. The State and local jurisdictions have inspected the elevators and issued the respective certificates of Operation.
  - 7. All spare parts have been delivered and received by WMATA.
  - 8. Any discrepancy identified by the ELES representative shall be repaired or replaced by the Contractor at no additional cost to the Authority.

### 1.07 OPERATION AND MAINTENANCE TRAINING

- A. Training: The Contractor shall develop and provide operation, troubleshooting and maintenance training in accordance with the General Requirements  
The following training requirements shall be met:
  - 1. Three days of classroom plus two days hands on training on the field shall be provided for 10 students per class. Six training session for a total of 60 students is required.
  - 2. Time and place of training will be determined by the Authority, but

must be completed no later than 30 days prior to the Final Completion.

3. Training shall be organized to make optimum use of the required maintenance and operation manuals including training for replacement of all parts contained in the Parts Inventory list.
4. At the completion of the first training session, a narrated and properly edited training video shall be submitted for the authority on DVD or flash drive. The video shall be taken by the professional camera operator with quality image and sound track and will be used for the future trainings. The video shall cover operation of the elevator, function of the devices, maintenance, adjustment procedures and troubleshooting. The following items shall be included as minimum requirements:
  - 1) Step by step adjustment procedure on the followings:
    - 1.1 Door operators, DCL, DOL, full door opening, and so on...
    - 1.2 Valve adjustment
    - 1.3 Car Leveling and adjustment of leveling sensors and vans
    - 1.4 Door: door interlock, proper pressure, restrictors ...
    - 1.5 Pump motor: belt tension and alignment
  - 2) General overview of major items:
    - 2.1 Packing:
    - 2.2 Piston:
    - 2.3 shut of valve
    - 2.4 Controller:
    - 2.5 Controller display:
    - 2.6 Hydraulic pump
    - 2.7 Hydraulic tank
    - 2.8 Door sills
    - 2.9 Guide rails
  - 3) Daily operation and sequence of operation
  - 4) Replacement and Installation of components:
    - 4.1 hydraulic packing
    - 4.2 door photo eye
    - 4.3 Hydraulic valve
    - 4.4 Door clutch
    - 4.5 Door pickup rollers
  - 5) Proper guide roller adjustment
  - 6) Verification of safety circuit
  - 7) Maintenance procedure and Frequency of maintenance
  - 8) Proper access of pit and top of car for inspection
  - 9) Proper test of fire service operation
  - 10) Proper lubrication of components
  - 11) Troubleshooting techniques
  - 12) How to use proper communication device, machine room, car top, and kiosk

5. Provide one additional copy of all required submittals to the ELES Engineer for Authority use.
  6. Provide two copies in DVD format of training materials along with visuals and handouts to the Engineer for the Authority use.
    - a. Video shall be narrative.
    - b. Video shall be separated by major components Sections
    - c. Equipment Identification shall be as a part of the section title.
  7. Separate training manual shall be submitted for approval prior the scheduling of the training. The O&M manual shall not be used as a training manual.
- B. Scope of Work
1. All training, as described below, shall take place prior to Final Acceptance of equipment or materials by the Authority. Operations and maintenance training may take place as a combined class by agreement of the Office of Elevators and Escalators (ELES). The minimum number of ELES employees to be trained will be no fewer than 60 total with a maximum of 10 per class. Those persons will be identified by WMATA. The contractor shall video tape all training sessions and provide WMATA/ELES with edited copy of the recording as stated above.
  2. Operations training shall be tailored specifically to the furnished and installed equipment, and designed to teach the day-to-day operation of all equipment. The training shall be sufficient to bring personnel to a level of operating proficiency such that routine vendor support is not needed.
  3. Maintenance Training shall be tailored specifically to the furnished and installed equipment, and designed to develop the knowledge and skills required to maintain all item(s) delivered.
  4. Maintenance training shall be subdivided into two major levels as follows:
    - a. System Level Maintenance Training, covering:
      1. Theory of operation of the system and its major components.
      2. System configuration.
      3. Preventative maintenance, consisting of written procedures and schedules for the periodic maintenance of all equipment.
      4. Written and validated inspection procedures and a system-level trouble-shooting guide (to the lowest field-replaceable unit).
    - b. Shop Level Maintenance Training, covering
      1. Detailed theory of operation to module, board, and/or device level.
      2. Component level troubleshooting and component replacement and adjustment.
      3. Testing and alignment procedures of repaired units.

C. Deliverables

1. The following course materials shall be delivered by the Contractor, according to the following specifications:
  - a. An Instructor's Guide containing all the information and direction necessary for the instructor to make an effective presentation. It shall include adequate guidelines to conduct a comprehensive training program. Individual lessons within the course shall be organized as separable blocks (or modules) which may be taught as a unit. The Instructor's Guide shall contain, as a minimum:
    1. Discussion of student prerequisites (if any).
    2. Program overview.
    3. A statement of overall program goals.
    4. Lesson plans (a session-by-session outline containing the following):
      - a. Student learning objectives, stated in measurable term
      - b. Overview of each lesson.
  - b. A Student Manual including all materials for the student to interact in the learning situation. It shall contain, as a minimum:
    1. Program overview and introduction.
    2. Statement of overall program goals.
    3. Learning objectives, stated in measurable terms that specifically describe desired behaviors or knowledge to be gained.
    4. A fully developed prose treatment (not outline format) of content presentation, developed in the same modular format as the Instructor's Guide.
    5. Illustrations, charts, photos and other graphics of actual system components as needed to enhance content presentation.
    6. The training manuals shall be prepared and submitted for approval to WMATA/ELES prior to training. The training manuals shall include procedures for adjustment and replacement of all electrical and mechanical components, and a troubleshooting guide.
  - c. Audio-visual Aids consisting of a narrated video of not less than 90 minutes duration to include, but not limited to, the following:
    1. General overview of major features.
    2. Daily operations.
    3. Maintenance procedures such as lubrication, adjustments, critical measurements, etc.

4. Frequency of maintenance procedures.
  5. Parts replacement such as safety devices, lighting, etc.
  6. Verification of safety circuits, methods of accessing and preserving computerized functional data if required.
  7. Step by step adjustment procedures and installation of components.
  8. Handouts, transparencies and/or slides as necessary to ensure clear and comprehensive presentations.
  9. The training video shall be taken from actual equipment installed under this contract by the professional camera operator
- D. Supplemental Materials consisting of a functional mock-up or a functional representation is required of any equipment that requires theoretical discussion. This may be in the form of an animated schematic, a model of the equipment, an actual device, an interactive video training device, or an Authority approved substitute. All mock-ups shall become the property of the Authority for eventual turn over to WMATA/ELES.
- E. The final copies shall be delivered to the Authority as follows:
1. One complete set of training materials that is completely camera-ready. Camera-ready copy is defined as typewritten or typeset originals or high-quality copies such that further copies can be made from them with no noticeable decrease in copy quality.
  2. Five copies of all student and instructor materials, to be used for archival purposes, in the WMATA ELES Technical Library.
  3. A set of complete student materials including training manuals for each participant enrolled in training classes. The O&M manual, training manuals and special tools shall be approved by the Engineer and delivered to the Authority for eventual turn over to WMATA ELES.
  4. The contractor shall video record all training sessions and provide WMATA/ELES with edited DVD copy of the recording to be used as training guide for other WMATA ELES employees.
- F. The following specifications shall be met in instructional delivery:
1. Instructor Qualifications. A description of instructor qualifications, a resume, curriculum vitae, or other description of instruction qualifications must be submitted at least 60 days prior to the presentation of training. The description shall document a thorough knowledge of the equipment being taught, an understanding of the adult learning process, and demonstrated experience in vocational instructional. The ELES Engineering Office will review and approve the Instructor candidacy.
  2. Course length - The length of the course shall be 5 working days with 3 days in the classroom and 2 days hands-on training.

3. Student qualifications - For the purposes of course development and presentation, vendors shall assume all WMATA students are high school graduates (or equivalent), and that maintenance personnel will possess the ability to use basic hand tools and electronic test equipment.
4. Testing. Instructors must give written and/or practical tests as a measuring device to determine knowledge transference. Tests shall use a multiple-choice or short answer format, and have been validated in a pilot course or by some other means agreed to by the Authority and Contractor. Whenever possible, a practical hands-on test shall be developed to demonstrate the transference of operational/ mechanical skills.

**1.08 SPARE PARTS AND SERVICE FACILITY**

**A. Spare Parts**

At the expiration of the warranty requirements of the General Provisions, the Contractor is responsible to provide a source for spare parts and service facility in the United States which can be obtained for an additional five years. If product source is another vendor, Contractor shall include name and address of other vendor.

1. The Contractor shall propose and provide a spare parts inventory to be approved by the Engineer and provided to the Authority not less than 90 days prior to scheduled completion, equal in value to seven percent of the cost of each elevator.
2. This provision requires the furnishing of a Recommended Spare Parts and Special Tools List based on manufacturer's recommendations, defines criteria to be used by the Contractor in developing spare parts recommendations; defines the manner of identifying spare parts on the list and the labeling and identification of spare parts upon delivery; and the timing of delivery of spare parts.
3. Elevator parts list, grouped by system and subsystem for stocking identification and the list shall contain the following information for each item listed:
  - a. Component name and Part number(s)
  - b. Manufacturer's name
  - c. Model number(s)
  - d. A blank column for WMATA's part number
  - e. Manufacturer's recommended quantity (see Section 1.08A.4 below)
  - f. Anticipated annual usage
  - g. Unit price
  - h. Special storage and handling requirements
4. The manufacturer's recommended quantities shall be based upon the following reliability, usage and lead time considerations:

- a. Wear: Components which may be expected to require replacement under normal maintenance schedule and operations, such as mechanical parts subject to continuous operation within projected mean time between failure levels.
  - b. Consumables or Expendables: Components which are consumed, used up, destroyed, or upon failure, are otherwise made usable for their intended purpose and are economically unrecoverable except for inherent scrap value.
  - c. Recoverable or Repairable: Components which, upon failure, are capable of being repaired or remanufactured to a serviceable, operational condition and maintained available for use within their initial intended purpose.
  - d. Long Lead: Components that are not available from commercial distributors or within 48 hours from the manufacturers such as specifically made or selected components.
5. Cross referencing: Where replacement components are common to more than one system or subsystem, include a cross reference and indexing system in the replacement components list:
  6. Non-Unique parts: In all components lists, items that are not unique to the system and have been manufactured by others shall be identified by the manufacturer's name and part number.
  7. WMATA will provide the Elevator Contractor with shipping instructions, with WMATA part numbers for each item the Elevator Contractor is required to furnish.
  8. The parts shall be shipped to the locations as directed by the Authority. Shipping documents shall identify the Contract number, manufacturer's part number, quantity, unit price and WMATA part number.
  9. Spare parts shall be properly packaged or crated so as to prevent damage during shipment and long-term storage. An individual packing slip shall be included inside the package or crate.
  10. Spare parts shall be the same in all respects as their counterparts furnished as a part of the assembled equipment to be delivered.
  11. Parts furnished in accordance with this provision are WMATA spares, separate and distinct from any Contractor obligation to replace parts, components or assemblies under any warranty provision.
  12. Parts lists contained in Operations and Maintenance Manuals provided under the Contract shall include assigned WMATA part numbers.
  13. A Manufacturer's Recommended Spare Parts List shall be provided. Parts to be provided shall be based on the criteria described herein and require Authority approval and shall be provided prior to Final Acceptance.
  14. Any Special Tool(s) used including, but not limited to, troubleshooting, maintaining the elevator, software and/or hardware shall be provided as part of the spare parts to the Authority. Any tools provided shall be the

same as those issued to the Adjuster and equivalent members of the subcontractor's staff.

- B. The finished elevator installations shall be completely barricaded and enclosed to preclude their use without permission of the Contractor until Final Acceptance and release by the Contractor for general use. The enclosure shall be fabricated to allow easy access for maintenance, testing and adjustment.
- C. The Contractor shall be responsible for the security of the contents of each machine room. The Contractor shall control access to that room, and ensure that it shall remain secure at all times until the completion of the Contractor's interim maintenance obligation.

#### **1.09 SPECIAL TOOLS**

- A. A complete set of special tools and instruments necessary for troubleshooting, maintenance, repair and making all adjustments on every part of the elevator installation, including software and hardware shall be furnished for each elevator and delivered to the Engineer as part of the spare parts inventory. Tools that are designed specifically for tasks associated with elevator inspection, maintenance and repair or that are required for these tasks, and are not readily available through normal purchasing channels are defined as special tools.
- B. Any "Special Tool/ equipment" that is required to troubleshoot, maintain, adjust, and test the system; the tool/equipment shall remain operational for the life of the equipment.
  - a. Provide all special tools and equipment necessary for making all system adjustments to the signal and speed controller and door equipment. A programming unit, approved by equipment manufacturer (OEM) such as a new laptop with 4GB memory, 15-inch display and DVD drive, with all software packages required to setup and program all equipment in the elevator system shall be provided, one per station or location. Software shall be provided for the display unit, DeviceNet, hoist motor drive, if applicable, and any other programmable devices, as well as for the controller PLC. Any hardware or software required for configuring, programming and or communicating to controller or any parts of the elevator shall be submitted to ELES engineering. Using the provided laptop, the contractor shall demonstrate loading, downloading (programming) any and all software that is required for the elevator for all operating needs. This includes display, PLC and any I/O controls. All special tools shall be new and to be provide with casing. No special tools with decaying circuits or clocks are permitted.
- C. Keys: Provide ten (10) sets of keys per elevator to operate all keyed switches and locks prior to completion of the first unit.

#### **1.10 AUTHORITY COORDINATION:**

The elevators shall not be in service for passenger/public use until all of the following requirements have been met.

1. The Operations and Maintenance Manuals have been approved and received by WMATA.
2. The Training and Student Manuals as well as video record of all training sessions have been approved and received by WMATA
3. The required training has been completed in accordance with this specification.
4. All field tests have been successfully completed.
5. The acceptance testing has been successfully completed.
6. All spare parts have been delivered and received by WMATA.
7. All Special Tools/Equipment and Software have been delivered and received by WMATA.
8. All discrepancies identified by the WMATA's CEI (Certified Elevator Inspector) representative shall be completed.

## **PART 2 – PRODUCTS**

### **2.01 MANUFACTURERS**

The major elevator components shall be the products of one of the three manufacturers of established reputation, except they may be the products, either wholly or in part, of another manufacturer of established reputation provided such items are capably engineered and produced under coordinated specifications to ensure a high grade, safe, and smooth operating system. Also, the major components to be furnished for this project shall be of a make or makes that have performed satisfactorily together under conditions of normal use for not less than one year in at least two other elevator installations of equal or greater capacity and speed.

### **2.02 MATERIALS**

#### **A. Stainless Steel**

1. Shapes and Bars:
  - a. ASTM A276, Type 304 or 301 for non-exposed components, and Type 316, all finish panels and exposed components.
2. Plate, Sheet, and Strip
  - a. Over 1/8 inch, ASTM A264 with ASTM A240, Type 316 on ASTM A36 base;
  - b. Under 1/8 inch, ASTM A167, Type 304, Type 316, for all finish panels and exposed components.
3. Stainless steel finish shall be NAAMM NO.4 with vertical grain.
4. Stainless steel screws, bolts and nuts shall be used for fastening and shall be AISI Alloy 303.

#### **B. Steel Sheet and Steel Fabrications**

1. Steel sheet for top enclosure shall be minimum 12-gauge.

2. Steel sheet for hoistway door frame shall be minimum 12-gauge.
3. Steel sheet for corrugated floor decking shall be minimum 10-gauge.
4. Steel sheet for subfloor shall be minimum 3/8-inch thick.
5. Galvanized steel material shall comply with ASTM A123, ASTM A153, and ASTM A653 (G90 Coating) as applicable. All steel sheet and steel fabrications, except lubricated machinery parts, which are not shown or specified to have other applied finishes, shall be galvanized.

C. Steel Finishes

1. Where visible to the public, steel surfaces shall have a baked enamel finish unless otherwise shown.
  - a. Color shall meet the requirements as shown in the finish schedule on the contract drawings.
  - b. Baked enamel finish shall consist of a thorough hot chemical cleaning process, a six-step zinc-phosphate process, two prime coats, and one finish coat of sprayed acrylic enamel (1.25 mils thickness minimum), baked at 350°F for a minimum of 30 minutes.
2. Fasteners

Fasteners securing removable sheet metal materials shall be operable with the aid of simple tools and concealed wherever possible. When the framework to which the metal is fastened is less than 1/4-inch thick, steel backup plates 1/4-inch thick shall be added with tapped holes and clearance holes where necessary. Exposed fasteners shall match the color and finish of the material being fastened, and shall be tamperproof flat-head machine screws of a captive screw fastener design.

- a. Fasteners shall be compatible with materials being fastened.
- b. Fasteners shall be furnished with self-locking nuts or retaining rings (spring washers, toothed disks).
- b. Fasteners shall be equal to or of greater corrosion resistance than the most corrosion resistant metals being fastened.

**2.03 EQUIPMENT AND COMPONENTS**

- A. The hydraulic elevator drive shall be of the oil-electric type with direct-acting plunger, power unit, oil storage tank, and control equipment. The power unit, storage tank, and associated control equipment shall be mounted in the machine room.
  - 1. Cylinder and Plunger:
    - a. The cylinder and plunger unit shall be designed and constructed in accordance with the applicable requirements of the ASME Code and other applicable codes. It shall be of sufficient size to lift the gross load to the height specified and shall be factory-tested at a pressure of 400 psi. Gray cast iron or other brittle materials shall not be used in the construction of the cylinder and plunger unit. The cylinder shall be coated on the outside to prevent rust and corrosion. The bottom of the cylinder shall be closed and the top provided with an internal guide bearing and a cylinder head. The cylinder head shall be equipped with an adjustable packing gland designed to effectively prevent leakage of oil. A scavenger pump shall be provided to return oil to the system. It shall be located so as not to obstruct the path between the pit entrance and the cylinder.
    - b. The packing gland shall be constructed to permit easy repacking.
    - c. The cylinder shall be provided with a means to release air or other gas and shall have a drip ring below the packing gland to collect all oil leakage.
    - d. The cylinder shall be secured to a support, provided by the Contractor, which will transfer and distribute the load to the floor of the hoistway pit.
    - e. Plunger of built-up construction shall be secured to the car platform by means of a suitable platen.
    - f. Plunger shall be designed to prevent its leaving the cylinder.
    - g. The cylinder shall be isolated from soil, ground water, pit channel, building structure and other sources of possible corrosive or galvanic damage by being installed in a PVC casing with the area between the cylinder and the casing left empty and free of water and oil.
    - h. The cylinder shall be coated with corrosion-rust resistant primer and painted with a dark gray industrial epoxy or other approved paint.
    - i. The top of the cylinder shall be jointed to the PVC liner by a victaulic coupling forming a sealed unit.
  - 2. Well Hole and Casing
    - a. Well Hole and Well Hole Casing

1. The well hole shall be plumb enough to provide a plumb installation of the PVC inner casing and pressure cylinder.
  2. The well hole outer casing shall be installed to retain the well hole for installation of the PVC casing and pressure cylinder.
  3. The well hole casing shall be 3/8" thick welded steel pipe.
- b. PVC Casing:
1. The PVC casing inside the well casing shall be ½-inch thick minimum, water tight and free of any liquid or debris after being installed plumb in the well hole.
  2. Exterior surface of casing shall be cleaned prior to application of solvent welding material to ensure watertight connections.
  3. The PVC casing shall be capped with PVC to prevent liquid and debris from getting in the area between the PVC casing and the cylinder.
  4. The PVC casing shall be capped at the bottom.
  5. Provide top of PVC with a PVC pipe coupling connecting with cylinder victaulic coupling.
  6. A PVC pipe shall be installed in the PVC casing to allow installing hydraulic piping to the cylinder. The PVC casing shall be secured at its base relative to the outer casing. Gaps between the PVC and outer casing may be filled using clean, dry backfill or other approved material.
  7. An electronic monitoring device shall be installed to detect the presence of oil or water in the PVC casing. A "Liquid in Casing" alarm signal shall be provided to the elevator controller for display on the fault display and transmitting to the remote monitoring system.
  8. An evacuation tube with an evacuation port shall be provided between the PVC liner and the cylinder.
3. Cathodic Protection
- a. The cathodic protection shall be provided for cylinders and piping and shall be provided by dielectrically isolating the cylinder and piston from the car platen, pit support structure, and pressure piping.
  - b. Gaskets and pads for dielectric insulation shall be neoprene or approved alternative. Insulating sleeves, washers, and oil line coupling shall be provided where specified or shown.

4. Power Unit
  - a. The power unit shall consist of a screw-type or gear-type oil pump driven by an electric induction motor with oil control valves, combined in a self-contained unit fabricated of structural steel. Power unit drive motor is specified under Electrical Work (See Section. Submersible units will not be accepted.
  - b. The oil pump shall be especially designed and manufactured for hydraulic elevator service. It shall be designed for a steady discharge with minimum pulsation to give smooth and quiet operation. The pump shall be of proper size and shall deliver oil into the cylinder in sufficient quantity and pressure to lift the elevator car with specified load at specified speed. During downward trip of elevator, the oil shall be returned to the tank by gravity.
  - c. Geared pumps, when used, shall be provided with accurately cut herringbone or helical gears. The gears shall operate under flooded suction in an accurately machined case with close clearances to assure maximum efficiency. An effective strainer shall be provided in the suction line to the pump. The power unit shall be equipped with a vibration isolation device suitable for use with and approved by the power unit manufacturer. The vibration isolation shall effectively prevent the transmission of power unit vibration to the machine room structure.
5. Piping, Fittings, and Couplings
  - a. Piping, fittings, and couplings shall be furnished and installed between the storage tank, pump, muffler, valves, and cylinder complete with necessary supports.
  - b. All connections between the discharge side of the pump, check valve, muffler, cylinder, and lowering valves shall be of rigid steel with screw, flanged, welded, or approved mechanical couplings.
  - c. Pipe supports shall be provided within 12-inches of every change of direction in piping.
    1. Supports shall not be more than 10-feet apart.
    2. Secure vertical runs properly with iron clamps at sufficiently close intervals to carry weight of pipe and contents and provide supports under pipe to floor.
    3. Furnish and install all piping from remote machine room to hoist way, including necessary supports and/or hangers.
  - d. Size of pipe and couplings between cylinder and pumping unit shall be such that fluid pressure loss is limited to 10 pounds.
  - e. Mechanical couplings, when used, shall be of a self-centering type that provide for some degree of deflection, contraction, and expansion.

1. Couplings that provide for partial or full separation of the two sections of piping being connected are acceptable, provided all other specified requirements are met.
  2. Couplings shall be rated for a pressure at least three times the working pressure of the elevator and shall be so designed that failure of the flexible sealing element or gasket shall not permit the separation of the parts connected.
  3. Flexible sealing elements or gaskets shall be of a type and material suitable for use with the hydraulic fluid furnished.
- f. Where piping, fittings, and couplings supplied by the Contractor are contained within sleeves, conduit, trenches, troughs, or other passage means provided by others to allow for the connection of the power unit with the cylinder and plunger, the Contractor shall provide appropriate devices which shall effectively prevent the transmission of vibration to the surrounding structure.
- g. The Contractor shall install all piping, fittings, and couplings used to connect the power drive to the cylinder and plunger in such a way that these may be removed and replaced at a future date. When Victaulic is used, there shall be access for inspection and maintenance. Destruction of portions of these items in the process of removal is acceptable but efforts shall be made in the designs to minimize the necessity to destroy items.
6. Valves
- a. Valves shall be of the unitized manifold type with no more than four solenoids and arranged so that all adjustments are individually adjustable without the need for sequential readjustment. Valve shall be designed to ensure that oil flow will be controlled in a positive and gradual manner, thereby ensuring smooth starts, operation, and stops of the elevator car.
  - b. Valves shall be designed for quiet operation and shall be mounted above the storage tank in a manner that allows leakage to drain back to the tank.
  - c. A safety check valve shall be provided which will function to hold the elevator car with rated load at any point when the pump stops or the maintained pressure drops below the minimum operating pressure required holding the car in place.

- d. A manually operated lowering valve shall be provided, which shall permit the manual lowering of the elevator car in the event of power failure. The location of the lowering valve and access to it shall be described in white stenciled lettering on the front panel of the pump unit. The lowering valve operating means shall be easily and readily accessible and unobstructed by the valve wiring, conduits or other equipment. A tank shut-off valve shall be provided to permit isolating the oil in the tank during maintenance operations. The location and orientation of the valve shall allow for safe operation of the handle throughout its range of travel.
  - e. All additional pump relief valves and other auxiliary valves required by the ASME Code or necessary to provide smooth, safe and satisfactory operation of the elevator shall be furnished and installed.
  - f. Any relief valves having exposed pressure adjustment shall have their adjustment sealed after being set to the correct pressure.
  - g. Manual shut-off valves shall be provided in the hydraulic oil line in the elevator pit and in the elevator machine room. In any portion of its travel, the machine room shutoff valve handle shall not intrude in the walk space or work space or obstruct access to other equipment.
7. Storage Tank
- a. The storage tank shall be constructed of steel and shall be provided with a steel cover, protected vent opening, overflow connection and a valve drain connection. Tank shall act as a storage tank only. Suitable gauge glasses shall be provided if the top of the tank is over 4 feet above the floor. An initial supply of oil sufficient for proper operation of the elevator shall be provided. The tank shall have a capacity equal to the volume of oil required to lift the elevator to the top terminal plus a reserve of not less than 10 gallons.
  - b. The oil storage tank cover shall be arranged for easy unobstructed access. Clearance of 24 inches vertical and 18 inches horizontal from tank cover shall be maintained for ease of service.
  - c. The permissible minimum liquid level shall be clearly indicated. The manufacturer's recommendation of type of oil to be used shall be included in the written instruction for the care, adjustment, and maintenance of the equipment. The flash point of oil used shall be not less than 400 degrees F.
  - d. Provide an oil filtering system that removes contaminants that can clog valves and settle in the bottom of the tank.
8. Blowout-proof foil-hydraulic muffler of an approved make shall be furnished and installed in the oil line near the power unit to reduce noise to a minimum.

9. Oil Temperature Control/Tank Heater: Hydraulic oil viscosity/temperature control shall be provided by the application of an internally mounted, thermostatically controlled, tank heater. The oil temperature shall be maintained at a maximum 110 degrees Fahrenheit with the use of a 120 VAC powered tank heater. Unit shall be permanently mounted, integral with oil reservoir, and with a lighted switch/indicator to visually confirm unit is powered. Tank heater shall include the switch for disconnection of power during maintenance/repair operations. Unit shall be hard wired to electrical source per ASME A17.1.
  10. Elevator Car Buffers: Heavy-duty spring buffers shall be provided, mounted on the supporting channel or block on the pit floor. The buffers shall comply with the requirements of the ASME Code. Buffer anchorage at pit floor shall be arranged to avoid damaging the waterproofing.
  11. Car guides consist of a guide rail and guide-rollers. Guide rails for the elevator cars shall be of planed steel standard T-section. Guide rails shall be erected plumb and parallel with a maximum deviation of 1/8 inch and shall be securely fastened to the bracket or other supports by approved heavy rail clamps.
  12. Car Roller Guides:
    - a. The elevator car shall be provided with roller guides.
    - b. Roller guides shall be spring-loaded and allow rail-to-rail and front-back adjustment of the rollers.
    - c. Three or more rollers per guide and shall have 4-inch minimum sound-deadening wheels.
- B. Operation:
1. Operation shall be automatic. Automatic operation by means of car and landing buttons. Stops registered by momentary actuation of car buttons to be made irrespective of number of buttons actuated or of sequence in which buttons are actuated.
  2. Operating station in car containing bank of buttons numbered to correspond to landing served position indicators. EMERGENCY CALL button, keyed EMERGENCY STOP button, DOOR OPEN/DOOR CLOSE buttons, independent maintenance key switch, and key-operated light and fan switches, with legends as specified. Identification as specified for emergency telephone. Emergency call button connected to bell that serves as emergency signal. Panel finish: Stainless Steel.
  3. Landing: Single push-button fixture at each terminal landing. Button fixture having push buttons with UP and DOWN legends at intermediate landing. Button identification as specified for Person with disabilities per latest ADA regulation (ADA rule 4.10.3).
  4. Momentary pressure on car button or landing button illuminates that button, which remains illuminated until call is answered. Illuminated buttons serve as visual indication that call has been registered and that car will stop at that landing. The Push Buttons shall be flush, round, have a Metalized Halo and center jewel. The metalized halo shall be from different color and approved by ELES Engineer.

5. Stops, registered by momentary actuation of landing buttons. All stops subject to respective car or landing button being actuated sufficiently in advance of arrival of car at that landing to enable stop to be made. Direction of travel for idle car established by first car or landing button actuated.
6. UP landing calls answered while car is traveling in up direction and DOWN landing calls answered while car is traveling down, car reversing after uppermost or lowermost car or landing call has been answered and proceed to answer car calls and landing calls registered in opposite direction of travel.
7. Elevators to park at the secure landing level selected by the Engineer.
8. Push-button units to be Dupar US85 or approved equal with button identification as specified by latest ADA regulation.
9. Emergency-stop shall be key operated rather than push-pull arrangement with key removal only in off position.
10. All elevator car control panel operating devices shall be designated by Braille and by raised standard alphabet characters for letters, Arabic characters for numerals, and standard symbols as required by the Code and ADAAG.
11. Lettering shall have a highly visible coloring, such as white, that is permanently affixed.
12. Independent Service: Provide a key switch in the car operating panel which, when actuated, shall cancel previously registered car calls, disconnect the elevator from the hall buttons and allow operation from the car buttons only. Car door shall remain open unless closed fully by the door close button.
13. Two-Stop Collective Simplex Automatic Operation:  
The two-stop collective simplex automatic operation shall be used and checked for the following:
  - a. System shall be designed so that when the car is standing at either terminal landing, pressure on car button for the other terminal shall automatically dispatch car to that landing. Pressure of landing button at either terminal landing shall call car automatically to that landing. If a landing call is registered while the car is making its trip, that call shall remain registered until the car responds to that call. If no car calls are registered car shall start automatically and respond to hall calls. Provide time limit relay arranged to hold car at landing at which it has stopped for predetermined time after car stops. After all car landing calls have been answered, car shall remain parked at landing where last used with car and hoistway doors closed until another call is registered. Pressing the landing button at floor at which car is parked shall automatically open car and hoistway doors. In all normal operations, the starting of the car shall be contingent upon establishment of hoistway door interlock and car door circuits.

- b. Automatic dispatching operation: all two stop elevators shall include "Step-in-and-Go" feature. Calls for the opposite landing will be automatically set when the elevator opens its doors for a hall call. This feature shall be provided for all elevators that have public access for two stops (i.e., any elevators with key operated service landings will be included).

C Position Indicators:

1. Car indicator: In accordance with ADA requirements. Mounted in vertical row in car-operating panel to show position of car in hoistway by illumination of indicators corresponding to landing at which the car is stopped or passing. Finish for exposed-to-view metal components: Stainless Steel.
2. Landing indicator: In accordance with ADA requirements. Two-element direction-of-travel indicator mounted above call station or hoistway entrance as shown, including one red and one white indicator. Direction of car's operation shown by illumination of red indicator for DOWN and white indicator for UP.
3. In-car signals: Audible signal indicating car's direction of travel, signal sounding once for UP direction and twice for DOWN direction.
4. Landing signals: Audible signal at each hoistway entrance indicating car's direction of travel, signal sounding once for UP direction and twice for DOWN direction.

D. Lighting:

1. Machine Room Emergency Lighting: Emergency lighting shall be provided in each elevator machine room.
  - a. There shall be a minimum of one lighting fixture.
2. Car interior: LED fixture, 120-volt operation, with clear prismatic glass diffuser, flush mounted in ceiling, cool white bulbs. Illumination level shall be 15-foot candles minimum at car operating panel.
3. Car top and underside of car floor: Medium-base porcelain lamp receptacles, with wire lamp guards.
4. Car Emergency Lighting:
  - a. Fixture: Recess mounted, with stainless steel frame, location as shown.
  - b. Diffuser: Prismatic polycarbonate plastic.
  - c. Lamps: Two, size 16-51
  - d. Remote power supply:
    - 1) Power pack: Sealed gel cell battery with integral regulating charger and an alarm bell.

- 2) Capable of operating bell for one-hour minimum and light at car-operating panel at 0.2 low candles minimum for four hours minimum.
  - 3) Location: in top of car or COP with easy access provided.
- E. Inspection Operation: Key switch in car to nullify car and landing buttons permitting operation of elevator from top of car for inspection purposes:
1. Top of Car Inspection Station: The Inspection Station contains continuous pressure UP and DOWN buttons, emergency stop button and toggle switch to activate inspection devices. The device shall also have an 110v ac outlet for extension cord and provided with a light and guard.
- F. Leveling: Automatic leveling device to stop car within 1/8 inch of landing level regardless of load or direction of travel. Landing level maintained within leveling zone irrespective of hoistway doors being open or closed.
- G. Emergency Service:
1. Controls to return elevator to designated floor by means of key-operated switch outside street or ground floor hoistway entrance in compliance with ANSI/ASME A17.1.
  2. In-car control during emergency operation by means of key switch in compliance with ANSI/ASME A17.1.
  3. Terminals on elevators controllers for connection of circuit from heat and smoke sensing devices, with wiring from sensing devices to elevator controller.
- H. Telephone Facilities:
1. Provide all audio/visual communication, signaling, and monitoring in accordance with ADA and ANSI. "Hands-free" phone integral with control panel, mounted in accordance with ADA requirements; having inscription EMERGENCY TELEPHONE as specified for Person with disabilities; finish exposed-to-view components to match stainless steel control panel; color of letters to contrast with panel.
    - a. Provide emergency communicators in accordance with ADA requirements to include auxiliary push button to summon help and visual feedback indicating that the call has been responded to.
  2. Provide wiring and jacks for a portable self-contained battery-powered maintenance telephone system. Jacks shall be located on car top, inside car, and in machine room. Furnish three telephone instruments for use of maintenance personnel.
- I. Electrical Equipment:
1. Electric equipment for elevator shall be designed, selected, and fabricated in accordance with NEC, NEMA, IEEE, ANSI Standards, applicable jurisdictional codes, and additional specified requirements. All equipment including motors, controllers, service cabinets, circuit breakers, switches, panelboards, indicators, lighting, wiring, conduit, boxes and other appurtenances for proper installation and operation of the elevator shall be furnished and installed by the Contractor.

2. Cable and wire for external circuits between the various items of elevator equipment, exclusive of the traveling cable, shall comply with the requirements specified below. The talk pair of the voice communications intercom system shall be shielded with 0.008-inch, minimum, copper shield.
  - a. General Requirements for Single-Conductor and Multiple-Conductor Cable:
    1. Type and size: As shown or as required by code.
    2. Rated voltage: 600 volts.
    3. Conductors:
      - a. ASTM B3 or ASTM B8 annealed copper
      - b. Size 10 AWG and smaller: Solid or Class B or Class C stranded.
      - c. Size 8 AWG and larger: Class B stranded.
      - d. Other constructions as specified.
    4. Standards: Except as modified, wires and cable complying with the following:
      - a. Cross-linked polyethylene (XLPE) insulated cable: NEMA WC 70.
      - b. Other cable: NEMA WC 70.
    5. Nonmetallic jacket for single-conductor cable and individual conductors of multiple-conductor cable and as overall covering on multiple-conductor cable:
      - a. Chlorosulfonated polyethylene, or cross-linked polyolefin.
      - b. Cross-linked polyolefin complying with the following physical requirements.
    6. Properties tested in accordance with NEMA WC 70 if ethylene-propylene-rubber (EPR) insulation is used, or with NEMA WC 70 if cross-linked polyethylene insulation is used. Jacket material free of PVC and PVC-based compounds.
      - a. Tensile strength, minimum pounds per square inch: 1,800.
      - b. Elongation at rupture, minimum percent: 150.
      - c. Aging requirement: After 168 hours in air oven test at 100EC, plus or minus one degree C:
        - a) Tensile strength, minimum percentage of unaged value: 100.
        - b) Elongation at rupture, minimum percentage of unaged value: 80.

- d. Oil immersion: 18 hours at 121EC, plus or minus one degree C, ASTM D471, Table 1, No. 2 oil:
    - a) Tensile strength, minimum percentage of unaged value: 80.
    - b) Elongation at rupture, minimum percentage of unaged value: 80.
    - c) Jacket materials other than cross-linked polyolefin complying with NEMA WC 70. Jacket material free of PVC and PVC-based compounds.
  - e. Flame retardancy: Single-conductor and multiple-conductor cable demonstrating flame retardancy in accordance with the following:
    - a) Single-conductor cable and individual conductors of multiple-conductor cable passing vertical flame test in accordance with UL 1591 or NEMA WC 70. Cable size for testing: 14 AWG.
    - b) Single-conductor and individual conductors of multiple-conductor cable passing vertical tray flame test using ribbon gas burner in accordance with IEEE 1202.
    - c) Multiple-conductor cable passing vertical tray flame test, using ribbon gas burner in accordance with IEEE 1202.
  - f. Applied voltage testing:
    - a) Single-conductor cable and individual conductors of multiple-conductor cable to be given applied ac voltage dielectric strength test, i.e., six-hour water-immersion test.
    - b) For single conductors of multiple-conductor cable, conduct tests prior to assembly as multiple-conductor cable.
    - c) Test procedures:
      - (a) Polyethylene insulated conductors: In accordance with NEMA WC 70
      - (b) Other conductors: In accordance with NEMA WC 70.
- b. Single-Conductor Cable:
- 1. Insulated with ethylene-propylene-rubber with non-metallic jacket or unjacketed filled cross-linked polyethylene. UL-labeled Type RHW or XHHW.

2. Color coding: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.
- c. Multiple-Conductor Cable:
1. Individual conductors:
    - a. Number of conductors: As shown or as required by code.
    - b. Construction: Complying with one of the following:
      - a) Insulated with ethylene-propylene-rubber, with or without nonmetallic jacket as specified.
      - b) Insulated with composite compound of ethylene-propylene-rubber and polyethylene, UL Class EPCV, without outer jacket.
      - c) Insulated with filled cross-linked polyethylene without jacket.
    - c. Phase and neutral conductors: Individually insulated.
    - d. Neutral conductors: Same size as phase conductors.
    - e. Bare ground conductors: Sized in accordance with the NEC, unless otherwise shown.
    - f. UL-listed as Type RHW or XHHW.
  2. Conductors assembled with non-wicking, flame-retardant filler to form cable of circular cross section.
  3. Metallic-sheath: Provide one of the following
    - a. Continuous smooth aluminum sheath in accordance with NEMA WC 70.
    - b. Continuous corrugated aluminum sheath in accordance with NEMA WC 70.
    - c. Interlocked aluminum tape armor.
    - d. Multiple-conductor cable provided with overall nonmetallic jacket as specified.
    - e. Cable UL-listed as follows: Metallic-sheathed cable: Type MC, suitable for wet and dry locations.
  4. Color coding:
    - a. Power cables: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.
    - b. Control cables: In accordance with NEMA WC 70
- d. Fixture Wire: UL 62, with the following additional requirements:

1. Type: Suit temperature rating of lighting fixture, minimum 194EF.
  2. Conductor: Stranded copper conductor 16 AWG or larger as shown.
- e. Bare Conductor: ASTM B3 or B8, annealed copper conductor; 8 AWG and larger, class B stranded.
3. Traveling Cable
  - a. The elevator car traveling cable shall be type ETT conforming with the requirements of the NEC with minimum conductor sizes as specified in the NEC. Individual conductors in the cable shall have a distinctive color code for identification. Each traveling cable shall have one two-conductor stranded 18 AWG, twisted shielded pair for elevator intercom and a minimum of ten spare conductors. Traveling cable exceeding 100 feet in length shall have steel supporting fillers. Traveling cable 100 feet or less in length shall have steel or non-metallic fillers.
  - b. For surface elevators only, the traveling cable shall be provided in addition to the above requirements, with one RG-6u coaxial cable, and one two-conductor, twisted shielded pair, stranded 18 AWG power cable for CCTV camera.
4. Connector, Terminal Lugs and Fittings
  - a. In accordance with UL 486.
  - b. For 10 AWG and smaller conductor cable: Tin-plated copper pressure connectors with nonflammable, self-extinguishing insulation grip with temperature rating equal to that of conductor insulation.
  - c. For 8 AWG to 4/0 AWG conductor cable: Tin-plated copper compression connectors and terminal lugs with insulating sleeve or heat shrinkable insulator for insulation grip.
  - d. For multiple-conductor cable: Watertight aluminum fittings with stainless steel pressure ring and set screws or compression cone for grounding of aluminum sheath of Type MC cable.
  - e. Terminal lugs used for bonding connections to metallic structures shall be installed on bare/uncoated metallic surfaces to assure minimum contact resistance.
  - f. All wires shall run inside conduits. Wires and cables shall not be spliced inside or outside of conduit. Wire and cable shall only be connected at terminal strips or devices inside boxes, controller or approved enclosures.
5. Self-extinguishing nylon bundling straps having a temperature range of minus 65EF to plus 250EF shall be used for bundling or cabling of conductors where required. Strap shall have a hub complete with stainless steel locking barb on one end and a taper on the other.

6. Conduits and Fittings:
  - a. Rigid conduit and fittings shall be UL-Listed rigid galvanized steel conforming to the requirements of UL 6 and ANSI C80.1. The minimum diameter shall be 3/4 inch for power circuits, one inch for fire and intrusion circuits, and two inches for audio and control circuits.
  - b. Liquid-tight flexible conduit shall conform to the requirements of UL 360 and consist of a flexible galvanized steel core containing a copper bonding conductor spiral-wound between convolutions and a neoprene or PVC jacket overall. Fittings for liquid-tight flexible conduit shall be watertight and shall conform to the requirements of UL 514.
  - c. All conduits (rigid steel and liquid tight flexible) should be permanently secured with metallic clamps. Zip ties are not acceptable to use as permanent use.
7. Auxiliary gutters, wireways, and raceways shall be constructed of galvanized sheet steel conforming to the requirements of the NEC and shall be UL-listed. Raceway, conduit and wireways within the hoistway exposed to public view shall be concealed within steel cladding.
8. Electrical Boxes:
  - a. Outlet, junction and pull boxes shall be galvanized sheet steel or galvanized malleable iron, cast iron or ductile iron conforming to the requirements of UL 50, UL 514 and NEC paragraph 370-C. Pull boxes shall have screw cover with a liquid-tight gasket.
  - b. Junction boxes on car bottom and hoistway connecting the traveling cable shall contain approved terminal blocks for connection of traveling cable conductors. Terminal blocks shall have indelible identification numbers for each terminal connection.
  - c. All wire connection terminal blocks shall have the same identification number as labeled on the associated electrical wiring. All electrical wires shall use a labeling tube and heat shrink and match the terminal numbers.
  - d. During field installation of junction boxes or control boxes, the contractor/subcontractor shall not drill or cut into the top sides of the box for wiring.
  - e. All boxes shall be accessible without removal of other components.
  - f. All boxes in machine room or pit shall be mounted on strut channels in order to prevent future corrosion and water damage. The strut channels shall be mounted on the wall and has a minimum of 1-1/2 inches thickness and 18 inches above the floor.
  - g. All solid state and electrical components located on top of the car enclosure or in the hoistway shall be installed within NEMA 4X enclosures.

9. Disconnect Switches for Car Lights and Mainline Power
  - a. Disconnect switches shall be the following: UL 98, NEMA KS 1, heavy-duty, quick-make/quick-break switching mechanism with operating handle external to enclosure, with positions labeled ON and OFF, defeatable interlock to prevent opening of enclosure door when switch is ON. Enclosures shall be NEMA 250 Type 4x. Label disconnect switches in accordance with the NEC.
  - b. Mainline power disconnect switch shall be located in close proximity to the machine room entrance and shall be easily identifiable from other disconnect.
10. Circuit Breakers and Panelboards
  - a. Circuit breakers shall be the following: NEMA AB 1, UL 489, molded-case, bolt-on quick-make/quick-break, mechanically trip-free switching mechanism, with thermal trip for inverse time delay overcurrent protection and magnetic trip for instantaneous short-circuit protection. Designed to carry continuous rating in ambient temperature of 40°C.
  - b. Panelboards shall be the following: UL 50, NEMA PB 1, latch and handle in accordance with UL 50, minimum side gutter size of four inches, bus bar of 98-percent-conductivity copper with contact surfaces silver-plated or tin-plated, rating of neutral and ground buses equal to phase bus rating, neutral bus mounted on insulated block, neutral and ground buses equipped with integral mechanical connectors, one-inch high engraved plastic nameplate with 2-inch high letters on black and attached with stainless steel fasteners. Enclosures shall be NEMA 250 Type 12.
11. Pit Receptacles and Lights
  - a. Electrical power receptacles shall be furnished and installed in the elevator hoistway, pit, and top of car as shown or required by code. Each receptacle shall be duplex, ground fault interrupter type, resettable at the receptacle; waterproof; grounded; rated for 120 volts at 20 amperes.
  - b. Maintenance lighting shall be furnished and installed in the elevator hoistway as shown or required by code. Lighting shall be vapor-tight service lights with quick start type PL compact fluorescent lamp. Furnish and install light switches; waterproof; grounded. The light switches shall be so located as to be accessible from the pit access door.
12. Drive Unit Motor
  - a. Motor shall be designed specifically for elevator service. The drive motor shall be of the alternating current, intermittent duty, 120 starts per hour, 1.15 service factor, squirrel cage induction type design adapted to the severe requirements of elevator service. Elevator drive motor shall be single-speed. The motor shall be suitable for operation on a 480-volt, three-phase, 60-Hertz supply and capable of developing the required starting torque.

- b. The motor shall be rated in accordance with NEMA Standard MG 1 for 60-minute rating motors and shall have sufficient capacity to operate the elevator with specified rated load at specified rated speed without overheating. The insulation and the starting and running torque of the motor shall be capable of permitting operation in accordance with NEMA MG 1. Standard factory motor test data and motor dimensions shall be submitted to the Contractor for approval. Each motor nameplate shall include the motor hp rating, voltage, full-load amperes, locked rotor amperes, full-load speed, design temperature rise, and NEMA design rating of the motor. Each motor shall be provided with ring or other suitable lifting means. The motor frame shall be tapped and drilled for a copper cable grounding connection.
  - c. Insulation of windings shall be NEMA Class B, fully impregnated and baked to prevent the absorption of moisture and oil. The insulation resistance between motor frame and windings shall be greater than one megohm.
  - d. Motor bearings shall be of the ball or roller type arranged for grease lubrication and fitted with grease gun connections and drain plugs or fitted with sealed-for-life bearings. The bearings shall incorporate dust-tight lubricant seals.
  - e. Motor shall be provided with an electronic soft start feature and thermal overload protection for each phase.
  - f. Connect motor and pump with multiple V-belt.
    - 1. Belts and sheaves shall be sized for duty involved and designed to prevent any metallic contact between motor and pump shaft.
    - 2. Furnish and install isolation units of rubber in shear to prevent transmission of pump and motor vibration to building.
    - 3. Furnish and install expanded metal sheave guard that can be easily removed for servicing and inspection.
13. Elevator Controller:
- 1. An Allen Bradley (or ELES Engineering approved equal) PLC-based controller shall be provided, governing starting and stopping as well as preventing damage to the motor from overload or excessive current. It shall automatically cut off the motor current and bring the car to rest in the event any of the safety devices are activated.
    - a. System shall coordinate the functioning of elevator drive unit relative to actual location and status of elevator. It shall interface with door control and all required safety circuits, switches and devices. The controller shall be mounted in a NEMA 4X stainless steel air-conditioned cabinet within the controller room.

- b. The diagnostic system shall be an integral part of the controller and provide user-friendly interaction between the service person and the controller system.
  - c. The supervisory logic shall be performed by a main controller or coordinated between the elevator controllers which will interface directly into the Allen Bradley DH485 (or ELES Engineering approved equal) protocol Remote Monitoring network, transmitting data from the elevator controller through a data concentrator to the Authority's AEMS RTU computer control and data system. The supervisory logic will coordinate dispatching assignments, interfacing operational demand data accumulated from car and corridor operating fixtures, selector and door control functions.
  - d. Controller shall be capable of operating with an operating temperature range of 32<sup>0</sup> F to 140<sup>0</sup> F with non-drip environment and no more than 90 percent relative humidity. However the air conditioner on controller cabinet shall maintain the operating temperature in range of 50<sup>0</sup> F to 90<sup>0</sup> F.
2. An Allen Bradley CompactLogix 1769-L32E (or ELES Engineering approved equal) based PLC control system shall be provided. (take to #1)
- 1) The exclusive Allen Bradley DH485 protocol data port will transmit data from the elevator controller to the station or facility data concentrator. The contractor shall provide a controller data interface to a DH 485 network. Contractor shall provide Data cables to connect from the PLC controller to data concentrator in the station and available for connection to the controller DH485 interface. The contractor shall pull Belden 9842, or ELES Engineering approved equal, cables to connect the controller into the monitoring DH485 network. The DH 485 controller interface shall be programmable for data rates up to 115 Kbps. The interface shall allow other nodes such as other elevators and escalators to be readily incorporated into the DH 485 network.
  - 2) A data concentrator PLC shall be installed using an Allen Bradley MicroLogix 1400 or SLC5/05 PLC per station to function as data concentrated or to consolidate data from all controllers in the station. The software for the data concentrator shall receive controller data over the local monitoring DH 485 network and provide formatted data to the AEMS RTU through an RS232 link. The data concentrator shall provide an Ethernet port for interfacing with the WMATA wide area network. A data concentrator connection to the WMATA wide area network shall be provided.
4. The PLC shall accommodate the following Signal List, as Applicable, and provide data to the data concentrator as specified in specification.

5. The PLC CPU module shall store the last 99 faults, accessible via laptop connection, controller fault/status display and remote communications. The contractor shall provide WMATA with a programming and monitoring unit, such as a laptop computer with the newest version of Allen Bradley RS-Logix and any other software required to setup and program all electronic items in the control system, for each elevator, for the purpose of troubleshooting and remote monitoring modifications. The laptop should allow uploading, editing, and downloading any software that is being used on this elevator for any operation.
6. An Allen Bradley PanelView Plus 6, EZAutomation or ELES Engineering approved equal, fault/status display/interface shall be provided in the controller cabinet. Control system timers and other setup criteria shall be programmable through this unit. All fault, status and setup data shall be stored in the controller CPU module.
7. In cases where the programming is done by the supplier, the supplier shall provide a copy of all working programs, including labels for all inputs and outputs, data tables and internal logic points, on Flash Drives/CD-R disks as well as a printed program listing. The programs and setup data shall require a password for access and modification. The password shall be provided to ELES Engineering as part of the Submittal.
8. The main control of an elevator shall contain at least the following devices or electronic sensing: phase failure line voltage monitor, motor current and ground fault monitor.
9. The controller cabinet shall contain a permanently mounted fault indicator panel with LED indicator lights. Tripped safety devices, door position, door reversal, car running status, and control system status shall be indicated.
10. All terminals shall have identification markings and all wires, including field wires, shall be provided with permanent heat shrink sleeve cable markers. These wiring identifications shall be provided in the wiring diagram at each end of the circuit connections.
11. The controller shall be equipped with the AC vector drive installed in-line before the motor contactor and the motor.
12. The AC vector drive shall be capable of accelerating and decelerating the motor smoothly and gradually.
13. Adjustable settings for acceleration and deceleration ramps shall be provided.
14. The controller shall have, at least, one dedicated serial port for interface to the DH485 monitoring network and programming access without disconnecting any other port.
15. The Programmable Controller shall have, at least, one dedicated port to support the controller fault/status display.
16. The controller PLC shall provide the following Remote Monitoring and diagnostic network support:
  - a) All applicable faults, statuses and data listed in Table 1 shall be provided

- b) Fault indications shall remain until reset in the controller.
  - c) Status and analog data shall be provided for the duration of the condition.
  - d) Software in the controller PLC shall format monitoring data responses to data concentrator polling as specified in the specification.
  - e) The monitoring data port in the controller shall be setup for DH485 protocol with the port network identification number programmed for the particular elevator identification. For instance, identification number 11 applies to elevator 1, 12 to elevator 2, etc.
  - f) All faults, statuses and data shall be held by the controller CPU and sent from the CPU when polled by the data concentrator.
17. Provide sufficient non-volatile CPU memory, for non-volatile retention of program memory, system status and operating parameters.
18. Diagnostics
- a) The processor shall have built-in diagnostics and self-test, such that each time power is cycled, the processor does a complete CPU and RAM memory test. Additionally the power-up test will momentarily light up all diagnostic LEDs to be sure they are working. A power up test will not be performed if the internal flag (bit) for Firemans Service Phase I is latched. The processor shall be capable of reporting major and minor fault codes and processor status information back to the data concentrator, provided the fault is not a catastrophic hardware failure where the processor is unable to power up.
  - b) The processor shall have a built-in watchdog timer to ensure that all processor program scans occur within the time limit set by the watchdog timer.
  - c) The processor shall have individual LED indicators that are clearly visible and labeled for easy identification. At a minimum the following indicators must be provided:
    - (1) CPU is in RUN mode
    - (2) CPU is FAULTED
    - (3) CPU battery is LOW
    - (4) I/O points are FORCED and are not under program control  
COMMUNICATION channels are active.
19. Input/Output Modules
- a) The Input/Output modules shall be compatible with the PLC processor I/O structure. Each module shall be provided with a detachable terminal strip to connect wiring to the module. Each wire on the terminals shall be identified by the module terminal.
  - b) Discrete Input Modules: Suitable for the input voltage and compatible with the Allen Bradley system
  - c) Discrete Output Modules: Suitable for the voltage and load and

- compatible with the Allen Bradley system.
- d) Analog Input Modules: Converts analog signals to proportional twelve-bit binary values. The module shall accept 4 to 20 mA signals. Provide modules compatible with the Allen-Bradley system.
20. I/O Chassis and Power Supply
- a) The controller chassis shall have an additional three spare modules.
- b) Power supplies shall provide power to the PLC processors, I/O and other function modules. The power supply shall be suitable for operation of 120 VAC, single phase power. Power supply capacity shall be a minimum of 150% of the connected load.
21. Air Conditioning
- Provide an independent air conditioning unit for each controller to maintain manufacturers' recommended operating temperatures. Condensate from the air conditioning unit must be piped to a suitable drain.
22. Selective Collective Operating: As defined by ASME A17.1 and shall be the pressure upon one or more car buttons to correspond to landings in the order in which the landings are reached by the car, irrespective of the sequence in which the buttons are pressed, provided the hoistway door interlock and car door switch circuits are completed. During this operation, the car shall also answer calls from the landings, which are in the prevailing direction of travel. Each landing call shall be canceled when answered
- a. Momentary pressure on car button or landing button illuminates that button, which remains illuminated until call is answered. Illuminated buttons serve as visual indication that call has been registered and that car will stop at that landing.
- b. Operation shall be automatic by means of the car and landing buttons. Stops registered by the momentary actuation of the car or landing buttons shall be made in the order in which the landings are reached in each direction of travel after the buttons have been actuated.
- c. UP landing calls answered while car is traveling in up direction and DOWN landing calls answered while car is traveling down, car reversing after uppermost or lowermost car or landing call has been answered and proceed to answer car calls and landing calls registered in opposite direction of travel.
- d. Should both an up and a down call be registered at an intermediate landing, only the call responding to the direction in which the car is traveling shall be canceled upon the stopping of the car at the landing.

23. Supervisory Control: A processor based system to coordinate dispatching assignments, interfacing operational demand data accumulated from car and corridor operating fixtures and other special feature commands issuing from computer processing, selector and door control functions. Incorporate in the system specific operational features as herein described.
- a. Allocate service to demand, make decisions to prevent crowding, save energy, and provide efficient coverage throughout the building. Respond in real time to prevailing traffic conditions as well as historical traffic patterns.
  - b. Constantly compare passenger demand, car load, anticipated demand, car motion status, machine status and other prevailing conditions and evaluate this information in the context of the following dispatching approaches:
    - 1) Give priority to contiguous calls, assigning calls on adjacent floor to the same car if other criteria is satisfied.
    - 2) Give priority to coincident calls, having the same car let a riding passenger off and a waiting passenger on at the same floor.
    - 3) Anticipate demand based on hall calls and car calls already registered and floors with a high possibility of demand.
    - 4) Evaluate relative system response time for each car in the group, weighing all of the above factors.
    - 5) Allocate calls and position cars to minimize waiting time, response time and travel time. The other elevator shall respond for hall calls without any delay after the first elevator left the door zone.
    - 6) When there is a hall call registered and an elevator left the landing, the other elevator shall run toward opposite landing.
  - c. Provide the capability to make both car to call or call to car assignments.
  - d. During light traffic conditions, assign cars without demand to specific parking areas until requested for a hall call. Continuously evaluate dispatching assignment and immediately release a car from its assigned area to meet heavy demand elsewhere in the building.
  - e. In determining relative system response time for a car to answer a hall call, factor in round-trip calculations for each car as well as other system parameters before deciding which car shall respond to a hall call.

24. Other Features:
- a. Independent Operation: Provide TWO-position keyed switch (ChicagoLock 7500) marked Independent Service, OFF and ON in the lower portion of the car operating panel of all cars. The switch shall be spring loaded type. When placed in ON position, car will be removed from the automatic operating system and will not respond to demands registered at the hall push buttons. It will respond only to floor with doors open until another demand is registered in the car. Demands registered at the landing will remain registered until answered by another elevator. The car only responds to car calls and that the doors remain open after a stop until closed by continuous pressure on the door close button.
  - b. The controller shall be designed to operate automatically on standby power.
25. Control Room Two Way Communication Device: Provide within each controller/machine room a two way communication device that will interface with any type of ADA compliant telephone. The device shall be mounted directly on or within hands distance proximity to the elevator controller.
26. Any junction boxes installed in the machine room or hoistway shall be accessible for Maintenance.
- a. Drilling or opening top end of enclosure is not acceptable
  - b. Wire nuts or splicing without terminal strips is prohibited.
  - c. All openings shall be properly sized for the conduits.
- J. Emergency Lowering
1. Provide a separate battery powered unit that senses loss of power and which shall operate as follows:
    - a. Elevator automatically descends to bottom landing.
    - b. Doors open automatically when car arrives at bottom landing and remain open until power is restored.
    - c. Elevator shall remain inoperative until normal power is restored.
  2. The system shall differentiate between actual power failure and manual operation of disconnect switch.
  3. Failure protection (operational/power) battery shall be a 12 volt minimum, sealed, lead-acid, or approved alternative. The separate box shall be used for battery and not stored within the main controller.
    - a. Unit shall be connected to a power source
    - b. Unit shall automatically maintain the battery at its proper charge.
  4. Provide a manual lowering valve to allow the car to return to the lowest landing. The manual lowering shall be easily accessible and reachable.
  5. Provide all wiring, sensors and associated connections to the main line power and disconnect.
- K. Elevator Hoistway Entrances and Doors

1. Doors of elevators shall be of the horizontal sliding type, single-speed, center-opening. All elevator door openings shall be a minimum of 42-inches wide per the Americans with Disabilities Act.
2. Entrance frames shall be of welded or bolted construction for complete one-piece unit assembly. All frames shall be securely fastened to fixing angles mounted in the hoistway and shall be type 316 stainless steel. Provide an additional type 316 stainless steel sill angle support. The landing sills shall be extruded stainless steel with a mill finish.
3. All materials and finished surfaces exposed to public view shall be stainless steel with embossed finish and/or glass panels as indicated on Contract drawings. Glass panels (if provided) to be completely flush with door assembly. In a glass hoistway the struts or any brackets should not be visible to public.
4. Fascia and Dust Cover in the hoistway shall be galvanized or type 316 stainless steel and extend at least the full width of door opening on each side. Toe guard shall be fastened to the sill at the lowest landing.
5. Hoistway doors are to be stainless steel and provided with keyways as required for operating mechanisms and door hangers. Provide glass panels that are completely flush with door, as indicated in A17.1. Each door panel shall have stainless steel bottom guides that run in landing sill slots. Guides shall be replaceable without removing door panels. All doors shall have fixed fire gibs.
6. Interlocks and Contacts:
  - a. The doors at each hoistway entrance shall be equipped with approved hoistway door interlocks of the hoistway unit system type tested as required by the Code. Interlock shall prevent operation of the car away from a landing until doors are locked in the closed position. Interlock shall prevent doors from opening at any landing from the corridor side unless car is at rest at that landing, or is in the leveling zone and stopping at that landing.
  - b. Provide key-operated hoistway door unlocking devices. A device shall conform to the requirements of the Code and shall permit authorized persons to open the hoistway doors from the landing when car is away from landing. The key for emergency use shall be mounted in a receptacle with a breakable transparent cover clearly marked in letter at least 1/8 inch high ELEVATOR DOOR KEY FOR FIRE DEPARTMENT AND EMERGENCY USE ONLY. The location of the receptacle shall be as directed by the Engineer.
7. Provide raised floor/level designations in characters and Braille on each jamb at 60 inches from floor to centerline. Characters shall be two inches high and in accordance with ADA requirements.

- a. Sills shall be stainless steel and shall be supported on and attached to galvanized steel anchors securely fastened to the sill plate support. The sill and its assembly shall be capable of supporting 1260-pound service load for the transfer cart used by WMATA. Grooves for the door guides shall be machined with minimum clearance for the guides. The Contractor shall provide sill plates. Sill plates and all other sill support structure including shims and jack bolts shall be hot-dipped galvanized.
  - b. Struts and closer angles shall be hot-dipped galvanized structural steel angles of sufficient size to accommodate and support the hoistway door header plate. Angles shall be continuous and securely bolted to the sills and building beams or structure above.
8. Hanger supports shall be 1/8-inch minimum thickness formed sections securely bolted to the strut angles.
  9. Fascia Plates: Galvanized Steel cladding reinforced to ensure a flat, even surface throughout, and shall be securely fastened to hanger supports and sills above.
  10. Dust Covers: Galvanized or Stainless Steel cladding which shall extend over the hanger support the width of the jamb opening plus the jamb flanges, at the top landing for which fascia plates are not supplied.
  11. Hanger cover plate sections above the door openings shall be arranged for opening or removal from within the car.
  12. Sill guards: Sill guards (galvanized steel cladding) shall be supplied for the lowest landing. On glass hoistways, they shall extend the full width of the hoistway and to bottom of pit.
  13. Door hangers and tracks shall be provided for each hoistway, sliding door sheave type, two-point suspension hangers and tracks, complete. Sheaves shall not be less than 2-1/4 inch diameter with ball bearings properly sealed to retain grease lubrication and shall be mounted on stands arranged for attaching to the doors by two capscrews. Hangers shall be equipped with adjustable ball bearing rollers to take the up--thrust of the doors.
  14. The tracks shall be high-carbon steel or formed steel with nylon inserts, shaped to permit free movement of the sheaves.
  15. All inside surfaces of doors shall have baked-enamel finish as shown on the finish schedule.
- L. Elevator Components
1. The elevator car and car components shall conform to the requirements of the Code, and shall operate without squeaks or metallic sounds.  
  
Entire car assembly, including car frame and platform, shall be free from warps, buckles, and squeaks and rattles. Joints shall be lightproof.

2. Frame and Platform
  - a. The car frame shall be constructed of structural steel members. The platform shall consist of a steel frame with necessary steel stringers all welded together. The frame and platform shall be braced and reinforced to prevent the transmission of strain to the elevator car. Steel framing shall conform to the requirements of ASTM A500, Grade B, modified to minimum yield strength if required. The variation in straightness of individual members and the frame as a whole shall not exceed 1/8 inch. Secondary straightening may be performed if necessary. The car enclosure shall be securely fastened to the car platform and so supported that it cannot loosen or become displaced during ordinary service, on the application of the car safety or on buffer engagement.
  - b. Platform shall be provided with a steel floor designed for specified loading and sealed watertight. The platform shall be isolated from the cylinder by suitable rubber pads or other equally effective platen isolation.
  - c. All structural steel in the frame and platform shall be hot-dipped galvanized.
3. Car enclosure walls shall be structural steel tubing with stainless steel cladding, in-filled with aluminum framed laminated fully tempered safety glass. Stainless steel cladding shall be #4 satin finish.
4. Railings and Handrails: Car handrails shall be 1/2 inch by 6 inch stainless steel #4 satin finished tube suitably mounted.
5. Car threshold shall be stainless steel with a non-slip surface.
6. Toe Guard Aprons:
  - a. The toe guard apron (cladding) at entrance side of elevator cab shall be not less than 16 U.S. Standard Gauge (USSG) galvanized steel or stainless steel, and shall extend at least three inches beyond entrance jambs at each side. Toe guard shall have a straight vertical face, extending below the level of finished car floor, of not less than the depth of leveling zone plus three inches. The bottom of guard shall extend three inches below vertical face and be beveled at a 15-degree angle from the vertical. The toe guard shall be secured to car platform construction and be reinforced and braced to withstand a constant force of 150 pounds on its face without permanent deformation or deflection exceeding 1/4 inch.
  - b. On glass elevators, the toe guard shall extend full width of cab.
7. Suspended Ceiling:
  - a. The suspended ceiling shall be faced and edged with solid stainless steel panels, 0.075-inch thick with a fully adhered 3/4-inch thick core of noncombustible, sound-absorbent material and backed with galvanized sheet steel. ASTM A653M, G90 coating or better.

- b. Mounting brackets and any necessary holes for the CCTV camera shall be provided on the top of the ceiling, as further specified in Section A. Coordinate bracket configuration and location with the CCTV subcontractor.
    - c. Mounting brackets and any necessary holes for the smoke and fire detection sensors shall be provided on the top of the ceiling, as further specified. Coordinate bracket configuration and location with the fire and intrusion system subcontractor
8. Glass shall be laminated fully tempered safety glass conforming to ANSI Z97.1 and the requirements of Specification Section 08\_81\_00.
  - a. Glass shall be laminated. Heat-strengthened, safety glass conforming to requirements of ASTM C 1048 and ANSI Standard Z97.1 and shall consist of two pieces of ¼ inch thick glass and a 0.060 inch thick polyvinyl butyryl interlayer, laminated together.
  - b. Color: Tint by Globe-Amerada Co., used as a standard of quality, or comparable and approved equal.
  - c. Weatherproof tape for field installation of final edge seating shall be compatible with the interlayer.
9. Dry Pressure Glazing Materials:
  - a. The setting blocks, edge blocks, and face gaskets shall be ozone-resistant, virgin neoprene.
  - b. Setting blocks for installation at each quarter point of the sill shall be 90 durometer, shore A hardness, approximately full channel width, four inches long, and high enough to afford correct cover and 3/8-inch edge clearance for the glass.
  - c. Edge blocks, for vertical installation at the bottom of each joint channel, shall be 50 durometer, shore. hardness approximately full channel width, three inches long, and provide 3/8-inch edge clearance for the glass.
  - d. Face gaskets shall be continuous, 50 durometer hardness, and provide 3/16-inch face clearance both inside and outside.
10. Sub floor material to be nominal ¼" stainless steel to prevent water infiltration between finished floor, cab and platform base.

Floor covering: Poured Acrylic Epoxy, polymer system or approved equal, color selection and samples to be submitted to the Authority for approval by the Engineer, with slip-resistant surface, ¼ inch thickness, covering elevator car floor area. Flooring shall be non-shrinking, manufactured of prime quality compound, free of calendaring and curing defects, resistant to grease, oil, chemicals, aging, and ozone. Flooring shall be poured incorporating a full membrane system for the entire cab floor width and depth.
11. Emergency exit: Car shall have a top emergency exit conforming to the requirement of the ASME Code, and the applicable jurisdictional requirements. The door shall open toward the top of elevator and shall have a latching mechanism to keep it in place.

12. Ventilation: A 350-cfm two-speed exhaust fan for continuous car ventilation shall be provided and located above the car ceiling or outside the enclosure.
  - a. Ventilating fans shall be securely mounted in place.
  - b. Ventilation openings shall comply with the ASME and local codes, and shall be suitably sized and distributed to provide uniform airflow within the car.
  - c. Connect continuous ventilation fan to emergency power system. Provide battery backup for fan operation of at least 1 hour in the event of power loss.
  - d. The exhaust fan shall be controlled from the car operating panel with Chicago Lock 7500 (similar to existing WMATA Elevators keys).
13. Cab air conditioning (if applicable), in addition to the exhaust fan, shall be installed as specified in the contract and shall be a self-contained, packaged design for easy mounting, maintenance, and replacement.
  - a. Packaged air conditioners shall be installed on the top of the elevator car.
    1. If not installed in original scope, space provisions shall be made for future installation of packaged air conditioning units.
    2. Installation area shall be coordinated with electrical, structural, and other trades to ensure no interferences with current or future installation.
    3. Electrical power of the proper voltage and capacity shall be available for the air conditioning unit installation current or future.
14. Lighting Fixtures and Plug Receptacles:
  - a. Car lighting shall provide a minimum of 15-foot candles measured at any point on the cab floor and shall be of the LED type. Car lighting shall be provided with emergency battery backup upon failure or interruption of normal car lighting. Emergency lighting unit shall provide required lighting for a minimum of four (4) hours. Battery charger shall be capable of restoring battery to full charge within sixteen (16) hours after resumption of normal power.
  - b. Exterior car lighting shall be as specified. On glass-enclosed elevators they shall be concealed under access panels flush with cab top or bottom surfaces, respectively. A duplex plug receptacle shall be provided in the pit and on top and bottom of each car. The lighting fixtures and receptacles on exterior of car shall be controlled by a switch adjacent to each fixture.

- c. Provide 115 volt ac plug receptacle (GFCI) within 12 inches of CCTV camera location. Coordinate the installation of CCTV equipment within the design of the elevator cab as the elevator contractor is responsible for the installation of the camera and wiring to the control room.
15. Car Doors and Door Equipment:
- a. Car doors and door frames shall be suitably reinforced and provided with a laminated stainless steel #4 finish on cab side and baked enamel finish on hoistway side. Doors shall protect the full width and height of car entrance opening when in the fully closed position. Car door frame shall be integral with front wall of cab.
  - b. Hanger cover plate sections above the door opening shall be removable from the hoistway. Doors shall be guided at the bottom by composition gibs engaging threshold grooves with minimum clearance.
  - c. Car/Hoistway Door Operator: Car and hoistway doors at each landing shall be opened and closed quietly and smoothly by a direct current electric operator.
  - d. Door operation automatic at each landing with door opening being initiated as car arrives at landing and closing taking place after expiration of specified time interval, with electric contact to prevent starting elevator away from landing unless car door is in its fully closed position.
    - 1. Time door closing to start 5 seconds minimum from notification that car is answering landing call.
    - 2. Time doors to remain open five seconds minimum.
    - 3. Time shall be adjustable to 20 seconds.
    - 4. The interval of time that the doors remain open at intermediate landings shall be less for a stop made in response to a landing call. Door open time at a dispatching terminal shall be longer than the time for a stop in response to an intermediate landing call.
    - 5. All door timers shall be adjustable from the controller display panel.
16. Capacity Plate:
- a. The car capacity plate shall be of plain stainless steel and, in addition to data required by the ASME Code, but shall not bear the name of elevator manufacturer.
17. Door Operator Equipment:
- a. Provide a water resistant heavy-duty GAL MOVFR or ELES Engineering approved equal door operator with encoderless VVVF drive. Closed loop door operator designed to operate car and hoistway doors simultaneously at the speed specified. Door shall open automatically when car stops at landing to discharge

passengers or to answer valid calls and close automatically after predetermined time interval has elapsed. The doors shall be capable of smooth and quiet operation without slam or shock. Door operator to have the following features::

1. ½ hp motor and heavy-duty sprocket, chain, belt, and sheaves.
  2. Closed loop regulated speed performance.
  3. Hand-held keypad programming.
  4. Adjustments can be stored in the keypad and downloaded to another operator.
  5. Adjustable door obstruction reversal.
  6. Optical cams with LED indicators.
  7. Test switches for open, close, nudging and speed zone set up.
  8. Universal inputs for open, close, and nudging.
  9. Reversing switch to back up the door reversal device.
  10. Designed for interior and exterior applications.
- b. Provide a non-contact door reversal device with light immunity: The Door Reopening Device shall cause both the car and hoistway doors to reverse, should they detect an obstruction in the elevator entrance. The device electrical wiring shall be supplied with quick disconnects terminals to facilitate replacement. The infrared curtain detector shall include the following:
- a. A protective infrared detector field extending from 1 1/2" above the car sill to a height of 68".
  - b. A fail-safe control system to prevent the doors from closing in case of power loss to the detector.
  - c. A one-piece full door height protective lens cover designed to be completely waterproof and to withstand impact, abrasion and vandalism.
- M. Normal and final terminal stopping devices shall be provided for elevator conforming to the ASME Code requirements.
1. Final terminal stopping devices, located in hoistway or on the car and operated by cams, shall be fitted with rollers having a rubber or other approved composition tread to provide silent operation when actuated by the cam.
  2. Normal terminal stopping device may be mounted in hoistway, on top of the car, or in the machine room.
- N. Signal Devices and Fixtures:
- 1) Car Operating Station:

- a. Provide one (1) main station in the front and one (1) auxiliary station. The COP shall be a vertical type.
- b. General: Provide signal fixtures and control devices for each elevator. Buttons and signals shall be tamper resistant of the illuminated type that light-up when activated and remain lit until call or other function has been fulfilled. All signal fixture and control device faceplates shall be of Type 316L, nominal 0.135 inch thick stainless steel with No. 4 finish, unless otherwise shown on the Contract Drawings.
- c. Car operating stations shall contain Braille plates adjacent to each call button. Contractor to coordinate proper landing call outs based on maximum characters as indicated on Contract drawings. Buttons for DOOR-OPEN, DOOR-CLOSE, ALARM, EMERGENCY PHONE call functions are to be supplied. Buttons are to be vandal resistant and of the positive stop type.
- d. Station shall have a locked service cabinet for keyed switches of the car light; exhaust fan, independent operation, GFI duplex outlet as indicated on the Contract drawings.
- e. Provide Emergency Communication: "Hands-free" ADA compliant telephone/intercom.
  - 2) Hall Station: Riser of hall stations of the push-button, call acknowledging, stainless steel, tamper resistant type shall be mounted at all elevator landings. Highest landing shall have a single DOWN button. Lowest landing shall have a single UP button. Incorporate ADA compliant telephone with each hall station. Braille Indicator Plate shall be provided. Faceplate finish shall be Type 316L stainless steel #4 finish. The Hall Station shall be flush to the surface and shall not be projected out.
  - 3) Hall Lanterns:
    - a. Tamper resistant hall lanterns shall be equipped with illuminated (LED type) UP and DOWN signal arrows, but provide single arrow where only one direction is possible. Provided units projecting from faceplate for ease of angular viewing. Match materials, finishes and mounting method with hall stations.
    - b. In conjunction with each hall lantern, provide an adjustable electronic chime signal to indicate that a car is arriving in response to a hall call and to indicate direction of car travel. Signal shall sound one for up direction of travel and twice for down direction.
  - 4) Bell Alarm System: Bell alarm system for each elevator shall be properly located within building and audible outside hoistway when activated by the EMERGENCY ALARM call button on each car control building/station. When emergency stop switch is activated inside fire service box, the bell alarm system should not be activated.

- 5) Firefighters' Service System: Firefighters' service system shall be provided in compliance with code requirements.
- O. Drip pans constructed of 26 USSG galvanized sheet steel shall be provided below all bearings to catch lubricant drippings, except for bearings that are fitted with effective approved grease seals.
- P. Metal parts visible to the public shall be field painted.
- Q. A metal cabinet of suitable size shall be provided in each machine room for the storage of special tools and necessary spare parts. The cabinet shall be mounted on legs or a pedestal, a minimum of 4 inches off the floor. A Mobile Tool Storage Cabinet with wheels is not allowed.
- R. A complete set of special tools or wrenches that are designed specifically for tasks associated with elevator inspection, maintenance and repair shall be provided with a case or suitably mounted in the storage cabinet.
- S. At the expiration of the warranty requirements, the Contractor shall provide a spare parts and service facility in the United States at no additional cost to the Authority from which all manufactured parts and components of the equipment furnished and installed can be obtained for an additional three years.

#### **2.04 KIOSK SURVEILLANCE CONTROL AND COMMUNICATION:**

- A. Surveillance Camera Provisions (Surface Elevators). All requirements for CCTV shall comply with the WMATA SMNT Department.
  1. Space provisions and mounting holes shall be provided for closed-circuit television (CCTV) cameras to be furnished and install by CCTV subcontractor.
    - a. The Contractor shall coordinate with the CCTV subcontractor and install wiring from the CCTV location within the elevator cab to an interface terminal and video transmitter located on the elevator car. Final equipment selection has not been performed and is subject to change. Coordinate model, configuration, and location with the CCTV subcontractor.
      - 1) Power will be required by the video transmitter and CCTV camera and shall be provided.
      - 2) Equipment: Fiber Optic Video Transmitters (Elevator Cameras)
    - b. The Contractor shall work with the CCTV subcontractor to install CCTV subcontractor-provided fiber-optic cable and transmitter to a terminal location specified by the CCTV subcontractor. The Contractor shall tag the cables appropriately, indicating that they are for future use by others.

B. Supply the following status indication, control, and communication functions for each elevator car and landing at an annunciator panel in the kiosk: indication, control, and communication functions in each elevator and landing; and all interconnecting wiring required to provide a complete and operable system. Systems to be provided and installed include the following:

1. Kiosk annunciator panel: Panel shall be a single panel approximately 7-½ by 19 inches. Coordinate design to ensure that the panel is compatible with the mounting provisions, previous designs, and human factors. The panels shall contain:
  - a. Indicators:
    - 1) Visual display of elevator car status, to include landing stopped at or being approached and direction of travel:
      - a) Designate elevator by functional name, e.g., Garage 1.
      - b) For garage elevators designate landing by garage floor level.
    - 2) Out of service because of malfunction.
    - 3) In-Car stop switch is actuated.
    - 4) Continuous audible alarm activated when emergency alarm switch in car is initiated.
    - 5) Indicator lamps shall be LEDs, with life expectancy of 50,000 average rated hours.
  - b. Controls:
    - 1) Out of service.
    - 2) Override control.
    - 3) Door open.
    - 4) Landing selection.
    - 5) Push button switches shall have limited over-travel to prevent damage due to abuse and shall be equipped with lift-up covers to avoid inadvertent operation, have mechanical and electrical life of 25,000 cycles, with integral or isolated illumination circuit and be normally open with momentary action or alternate action circuitry.
    - 6) When the override control switch is OFF, the kiosk controls shall function in parallel with the car and landing controls, i.e., the selective/collective control system shall respond to a kiosk-initiated landing selection with the normal priority afforded the remaining system landing selection and call buttons.
    - 7) When the override control switch is ON, the following actions shall take place:
      - a) If the car is stationary at a landing, it shall remain at the landing and the doors, if open, shall close and remain closed.

- b) If the car is in motion, it shall stop at the first landing reached and the doors shall remain closed.
  - c) The elevator control system shall then respond only to the kiosk controls and car station.
  - d) The car shall park at the designate landing.
- 8) When the OUT OF SERVICE switch is actuated, the elevator shall return to the lowest landing before shutting off.
2. Elevator fire detection sensor: Provide space and mounting holes for smoke and fire detection sensors to be furnished and installed as required by building, electrical, elevator and local codes. Install wiring from the sensor location in the car to interface terminal cabinet in the machine room, for connection from the sensors to the smoke and fire detection system. Coordinate with installers to allow installation of sensors and operational checkout of the system.
3. Passenger - Kiosk communications (VIOP) system:
- a. Communications signal button in elevator car momentary contact to illuminate back-lighted signal button in car and latch on a continuous audible signal and illuminated indicator in the kiosk.
  - b. Communications buttons at landings, momentary contact, to illuminate back lighted signal button at the landing and latch on a continuous audible signal and illuminated indicator in the kiosk.
  - c. Push button in kiosk to activate intercom system and reset indicator lamps and audible alarm.
  - d. Each passenger operated device shall have identification markings as specified for car operating devices.
  - e. The voice communication intercom system shall function as a master remote network. The master station shall be located in the kiosk annunciator panel and shall include a speaker-microphone, audio amplifier, on-off indicator lamp, audible signal device control and push button lamp for the operations. A remote station shall include a speaker-microphone and a communications signal button shall light the signal button and cause a continuous audible signal at the master station and light indicator lamp corresponding to the calling remote station. Communications between master and remote station shall be established upon the actuation of the master station push-button control corresponding to the calling remote station with the master station push to talk control determining the direction of transmission.
  - f. If successive calls are received from other remote stations while communication is in progress with one remote station, the audible signal shall sound the indicator lamps corresponding to the calling remote stations shall light and both shall remain on the indicate waiting calls.

- g. Means shall be provided to clear the indicating lamps independently. Communication initiated from the master station shall be established upon actuation of the push button control corresponding to the called remote station, with the master station push-to-talk control determining the direction of transmission.
- h. The audio amplifier at the master station shall be all solid state in construction and shall control incoming and outgoing volumes for all of the remote stations. The volume levels shall be preset during installation and shall be adjustable to provide a maximum of five watts rms at the speaker-microphones.
- i. The power supply shall supply all ac and dc voltages necessary for all circuitry associated with the voice communications intercom system, and shall operate from the 120-volt ac, 60 Hertz emergency power supply located in the elevator machine room.
- j. The audio amplifier and the speaker-microphones shall have a frequency response of plus or minus three Db from 300 Hertz to 5,000 Hertz. Power consumption shall be 5 watts maximum in standby and 50 watts maximum under load.
- k. The Contractor shall be responsible for shielding, grounding and other measures necessary to protect the voice communications intercom system from interference from other electrical systems.
- l. Speaker grilles shall have a minimum of 35 percent open area over the entire surface of the speaker cone.
- m. Switches and relays used with this system shall have an operating life exceeding 5,000,000 cycles. Documentation shall be provided by the Contractor to the Engineer, for his approval, to substantiate this life cycle level.
- n. The system shall perform adequately, as approved by the Engineer, with both the remote and the master station test personnel speaking from three feet away from the speaker-microphones.
- o. Communication in the car shall also rollover to a 24-hour manned site (Rail Operations Control Center) in the event that the kiosk does not respond to the call.
- p. Each passenger-operated device shall be identified in accordance with ADA/ADAAG requirements.
  - 1. ADA requirement for providing emergency two-way communications between an elevator and a point outside the hoist way (the Kiosk).
  - 2. Device mounting heights shall comply with:
    - a. ADAAG requirements.
    - b. ASME A17.1-2007. The highest operable part of the two-way communication system shall be a maximum of 48 inches from the floor.

3. A Braille Instruction Plate shall be permanently affixed on each remote intercom unit.
  - a. ADA Standards: Raised symbol and lettering (Signage) located adjacent to the device.

## **PART 3 – EXECUTION**

### **3.01 EXAMINATION**

- A. Prior to beginning installation of elevator equipment, examine the following and verify that no irregularities exist that would affect quality or execution of work as specified.
  1. Hoistway size and plumbness.
  2. Sill pockets.
  3. Anchor brackets
  4. Sill supports.
  5. Spreader/Divided beams.
  6. Machine beams and any other supplied by others.
  7. Pit Depth
  8. Overhead clearance
- B. Do not proceed with installation until previous work conforms to project requirements.

### **3.02 INSTALLATION**

- A. Electrical Installation:
  1. The Contractor shall install all raceways and wiring necessary for the proper connection and operation of all equipment. The installation shall comply with the applicable requirements of the NEC and local codes.
  2. Raceway:
    - a. Rigid conduit connecting the various items of elevator equipment and electrical boxes in the machine room and hoistway shall be run parallel to the ceilings and walls. Metal wireway and auxiliary gutters in the machine room shall run exposed in readily accessible locations and shall not protrude into the working space around equipment.
    - b. Liquid-tight flexible conduit shall be used for connections to motor, limit switch, interlock push-button box, door operator motor, and similar devices. A length of liquid-tight flexible conduit 18 to 24 inches long shall be used for connection to the elevator drive motor.
    - c. Raceway terminal fittings shall be free from burrs, shoulders, or other projections that will reduce internal passage area or cause abrasion of conductors.
    - d. Electrical boxes shall be installed in accordance with the requirements of NEC paragraph 370.

3. Wiring:
  - a. All wiring shall be run in conduit, metal wireway, or auxiliary gutter, with the following exceptions:
    1. Flexible hard-service cord, type SO, used between fixed car wiring and switches on car doors.
    2. The traveling cable connection to the elevator car.
  - b. Wire and cable shall be sized for their respective duty so that the maximum current carried shall not exceed limits prescribed by the NEC and local codes. The minimum sizes of conductor shall be 12 AWG for lighting and receptacle circuits and 16 AWG for operating, control and signal circuits, except for traveling cable, where 14 AWG shall be the minimum size for elevator lighting circuit conductors.
  - c. In glass hoistways, wiring shall be installed only in the locations shown with the requirement that wiring and conduit be hidden from public view.
  - d. The traveling cable shall run from a junction box on the bottom of car to a junction box approximately midway in the hoistway. The cable shall be anchored and suspended to minimize any strain on individual cable conductors. The cable shall be free from contact with the hoistway construction, car, or other equipment. The overall covering of cable shall remain intact between junction boxes. The Contractor shall ensure that the cable shall not bend to a radius less than 12 times the outer diameter at any position of elevator travel.
  - e. Traveling cable shall be suspended by the wire rope center or self-gripping devices where cable weight will not cause excessive crushing forces.
4. Splices and terminations of conductors shall be made only in outlet, junction. Splices in conduit or raceways will not be permitted. Splices and terminal connections shall be made only by means of solderless connectors and terminal lugs as specified. Splices shall be covered with electrical insulating tape to an insulation level equivalent to that of the conductors. Terminal lugs used for bonding connections to metallic structures shall be installed on bare/uncoated metallic surfaces to assure minimum contact resistance.
5. Grounding:
  - a. The Contractor shall be responsible for grounding and bonding all parts of the elevator metallic structure, equipment and raceway in accordance with the applicable requirements of the NEC and the codes and regulations of the jurisdictional authorities. An equipment grounding conductor will be furnished and installed by other trades in each feeder to the elevator machine room and terminated in a disconnect device or junction box.



8. Provide Mats of insulating rubber or other suitable floor insulation in the front of the Controllers.
  - a. The Resistance range shall be  $1 \times 10^4 < 1 \times 10^6$  and shall meet ANSI/ESD requirements.
  - b. The rubber mat shall be the width of the controller plus 12".
  - c. The length of rubber mat shall be a minimum of 24".
  - d. The rubber mat shall be a 1/4" thickness and beveled at each end.
- C. Hydraulic Elevator Cylinder
  1. The Contractor shall set the hydraulic elevator cylinders true and plumb
    - a. Dielectric Insulation Installation
      1. Each cylinder shall be electrically isolated from the building steel and other earth ground sources
      2. The following are minimum requirements:
        - a. Install an insulating gasket between the platen plate and floor of the elevator cab. Use insulating sleeves and washers on the bolts.
        - b. Use insulating pads to insulate the cylinder support members (channels) from the guide rails and other structures at ground potential.
        - c. Use insulating sleeves and washers on the bolts that connect the cylinder to the support channels.
        - d. Install an insulating coupling on the oil supply line between the pump and cylinder, located as close to the cylinder as possible.
  2. Insulating gaskets shall be installed in the same manner as a normal gasket.
    - a. Sleeves shall not be forced through misaligned bolt holes. Where misalignment occurs, the holes shall be reamed true, and all metal, chips shall be carefully removed.
    - b. The sleeves shall extend into the plastic washer on both sides of the flange. Any sleeves or washer cracked during installation shall be replaced immediately.
    - c. After making up the flange, the resistance of each bolt to the flange shall be tested using a 500-volt megohmmeter. If the resistance of any bolt is less than 50 megohms, the sleeve and washer shall be checked and changed, if necessary, to provide the required resistance.

### 3.03 DEMONSTRATION

- A. Acceptance Tests:

1. The Contractor shall submit an operational test plan to the Authority for approval. When each elevator, furnished, installed, and tested, is ready to be placed in interim service, the Contractor, at no additional cost to the Authority, shall perform operational tests described below. The Authority shall be notified at least 48 hours prior to each scheduled test so that arrangements can be made for the presence of appropriate personnel to witness the tests. Acceptance Tests and inspections will be based upon the elevator meeting the requirements of the Specification and as evidenced by the operational test shall be witnessed by WMATA representative.

**B. Elevator Tests**

1. When the elevator work is fully completed, the Contractor shall demonstrate to the satisfaction of the Authority and Authorities Having Jurisdiction that the proper operation of every part of the equipment complies with all applicable requirements including the ASME Code.
  - a. The inspection procedure outlined in the ASME A17.2 will form a part of the final inspection.
  - b. No shop test of elevator motor and no certified test sheets will be required.
  - c. The heating, insulation and resistance of the motors will be determined under actual conditions after installation.
2. The Elevator Contractor shall furnish all test instruments and materials, required at the time of final inspection, to determine compliance of the work with the Contract requirements. Materials and instruments furnished shall include standard 50-pound test weights, megohmmeter, voltmeter and ammeter, Centigrade calibrated thermometers, spirit level, and stop watch. At the time of final inspection, tests shall include, but not be limited to, the following:
  - a. After installation, each elevator shall be tested without load by the Contractor. The elevator shall be subjected to a test for a period of eight-hours continuous run. During the test run, the car shall be stopped at top and bottom levels, in both directions of travel with a standing period of 10 seconds at each landing.
  - b. Full-Load Run Test
    1. The elevator shall be subjected to a test for a period of one-hours continuous run, with full specified rated load in the car. During the test run, the car shall be stopped at top and bottom levels, in both directions of travel with a standing period of 10 seconds at each landing.
  - c. Speed Test
    1. The actual speed of the elevator car shall be determined in both directions of travel, with full specified rated load and with no load in the elevator car.

2. Speed tests shall be made before and after the full-load run test.
  3. For hydraulic elevators, speed shall be determined with a temporarily mounted tachometer on the guide rail or stop.
  4. Car speed when ascending shall be not more than 10 percent above not more than 10 percent below the specified car speed.
  5. Car speed when descending shall be not more than 25 percent above not more than 10 percent below the specified car speed.
- d. Temperature Rise Test
1. The temperature rise of the drive unit motor shall be determined during the full-load test run. Temperatures shall be measured as specified in NEMA and IEEE Standards. Under these conditions the temperature rise of the motor shall not exceed NEMA and IEEE specified temperature rise. Test shall be started only when all parts of equipment are within 9 degrees Fahrenheit of the ambient temperature at time of starting test.
- e. Car Leveling Test
1. Elevator car leveling devices shall be tested for ¼-inch accuracy of landing at all floors with no load in car and with full load in car, in both directions of travel.
  2. One re-level operation is permitted when full load is in the car.
  3. Accuracy of floor leveling shall be determined both before and after the full-load run test.
- f. Insulation Resistance Test
1. The complete wiring system of elevator shall be free from short circuits and accidental grounds. The insulation resistance of the system shall be more than one megohm when tested by using a 500-volt megohmmeter. The elevator structure, equipment, and raceway shall be tested for continuity to ground.

### 3.04 ELEVATOR PROTECTION

1. The finished elevator installations shall be completely barricaded and enclosed to preclude their use without permission of the Contractor until Final Acceptance and release by the Contractor for general use. The enclosure shall be fabricated to allow easy access for maintenance, testing and adjustment.

2. The Contractor shall be responsible for the security of the contents of each machine room. The Contractor shall control access to that room, and ensure that it shall remain secure at all times until the completion of the Contractor's interim maintenance obligation.
3. Protection: During installation and until all elevator systems are fully operational and accepted by WMATA, make all necessary provisions to protect all elevator components from damage, deterioration, and adverse environmental conditions. Do not use or allow the use of the elevator for construction purposes such as hauling materials or worker transport during construction.
4. Security Of Machine Rooms: The Contractor shall be responsible for the security of the contents of each machine room. The Contractor shall control access to that room and ensure it shall remain locked and secure at all times.
5. Field Painting:
  - A. The pit, pit walls and machine room floor shall be painted. All machine room equipment shall be given two coats of approved machinery paint. All new iron work shall be given one coat of rust-inhibiting paint.
  - B. Metal parts visible to the public shall be field painted where specifically shown or authorized by the Authority.

**3.05 MAINTENANCE**

The Contractor shall perform full maintenance service for a period of two years on each elevator in accordance with the manufacturer's maintenance manual and WMATA ELES maintenance program prior to WMATA providing permanent maintenance. The period of maintenance shall begin after test(s) and Provisional Acceptance of each elevator and shall extend to the scheduled date of Final Acceptance for all units in the same facility plus a period of two years. In no case shall the interval between inspections and testing be greater than one month. The maintenance service during the warranty period shall be provided by fully trained elevator mechanics. The maintenance tasks shall include, but not be limited to, the following:

- a. Inspection of completed installation and periodic testing to maintain the elevators in completely operable condition.
- b. Contractor shall provide support for periodic, accident and incident, PM compliance inspections.
- c. Lubrication of parts, and the protection of the equipment.
- d. Replacement of defective parts at no additional cost to the Authority.
- e. Annual clean down of the elevator and hoistway enclosure is required. Make necessary arrangements with Authority in order to minimize any inconvenience.
- f. Contractors performing maintenance are responsible for all service, repair work and emergency call. The contractors shall provide unlimited service during revenue hours and twenty-four (24) hour

(including Holidays) emergency call back service at no additional cost.

- 1) Provide twenty (24) hour (including Holidays) emergency service during the maintenance period consisting of a prompt response (within 1 hour) to emergency request by telephone or otherwise from Authority or designated representative if an elevator is inoperable or in case of injury, entrapment, or potential injury to persons.
  - 2) Unlimited service callbacks are included with a required response time of one (1) hour (including Holidays).
- g. Periodic maintenance (based on WMATA schedule) shall be performed off peak hours to minimize service interruption as long as the other elevator serving the same platform is operational.
  - h. Reporting: Detailed monthly records of tasks performed including names of individuals performing the tasks, date and time performed, and other pertinent data. In addition, the reports are to be provided in an electronic format acceptable to WMATA's needs.
  - i. Contractor performed maintenance shall follow the WMATA Office of Elevator and Escalator Operations procedures, schedules and check charts.

Within three (3) months prior to the termination of this contract, the Authority or his designated representative(s) shall make a thorough maintenance inspection of all equipment covered under this contract. The contractor shall provide personnel to remove, test, and operate equipment as necessary. All deficiencies found as a result of this inspection shall be corrected by the Contractor as required in this agreement with no additional cost for the Authority.

### **3.06 REMOTE MONITORING SPECIFICATIONS:**

- A. Allen Bradley DF1 or ELES Engineering approved equal or industry standard Modbus protocol shall be provided to transmit data from the Elevator/Escalator controller to the Authority's AEMS RTU computer control and data system. The Design-Builder shall provide a controller data interface to a DH-485 network located in the Elevator /Escalator machine room. The DH-485 controller interface shall be programmable for data rates up to 115Kbps. The interface shall allow other nodes such as other Elevator or Escalators to be readily incorporated into the DH-485 network. The controller data interface shall include one Allen Bradley SLC PLC per station to function as a data concentrator to consolidate data from all the controllers in the station. The software for the data concentrator shall be as specified by the Authority. The data concentrator shall receive controller data over the DH-485 data network and provide formatted data to the AEMS RTU through a RS 232 link. This data transmission may be accomplished by a separate PLC controller integrated into the control system.

- B. The Elevator /Escalator control system shall automatically initiate the transmittal of data when data is requested by the Authority's AEMS system and continue until all data is received by the AEMS RTU in the station AC switchboard room. The Authority will perform final integration of the data in the AEMS system.
- C. The Contractor shall also provide the required hardware to download data from any fault finding annunciator panel to a supplied laptop PC being utilized at the Elevator/Escalator location. The provided software shall permit the downloading and storage of data on the supplied laptop PC from multiple fault finding annunciator panels.
- D. The Contractor shall install an Allen Bradley network interface module, (model 1761-NET-AIC, or approved alternative) beside the PLC in the controller and provide 24 VDC power to the module. The Allen Bradley PLC will be used for remote monitoring capabilities into WMATA established engineering monitoring network.
  - a) The Contractor shall provide all wiring and programming of the PLC to communicate with station data concentrators on the DH-485 network. Coordinate work with WMATA ELES Engineering.
  - b) The Contractor shall pull all remote monitoring cables to the interface in the elevator controller from the remote monitoring network going back to WMATA's Automated Energy Management System (AEMS) remote terminal unit (RTU).
  - c) Provide Ethernet communication between the elevator machine room and WMATA's communication room. The communication port shall be located less than 6' from the controller and shall have minimum of two ports for data communication.

E. Terms and Definitions

- 1. Boolean - A single bit data type.
- 2. DF1 - A Rockwell Automation Company proprietary communications protocol.
- 3. DH485 - An industrial communications network used by Allen Bradley programmable controllers.
- 4. Integer - A data type 16 bit signed (range -32768 to 32767).
- 5. PLC - Programmable Logic Controller.
- 6. QEI - QEI Inc. Springfield NJ
- 7. RTU - Remote Terminal Unit

F. Elevator Remote Monitoring Data Specification

1. Overview

The design of the WMATA escalator & elevator monitoring system shall include a data concentrator PLC to gather data from the elevator control PLC's over an Allen Bradley DH 485 network or ELES Engineering approved equal. The QEI RTU shall read data from the WMATA data concentrator PLC via an RS 232 serial connection to a 1746-BAST (or ELES Engineering approved equal) module using Allen Bradley DF1 (or ELES Engineering approved equal) protocol. See figure 1.1 for reference. This specification defines data to be presented by the

WMATA data concentrator PLC to the QEI RTU. The WMATA data concentrator PLC station shall poll the escalator & elevator controller(s) periodically for data and format the data into blocks within the WMATA data concentrator. An Ethernet TCP/IP connection is available at the Data concentrator PLC. The data concentrator PLC has been designed to collect data from up to (10) escalators and/or elevators. The data concentrator PLC is to be mounted into the existing QEI RTU enclosures and powered by a 120 VAC source from within the RTU. For Metro stations where more than (10) escalators and elevators are present additional data concentrator PLC's will be required.

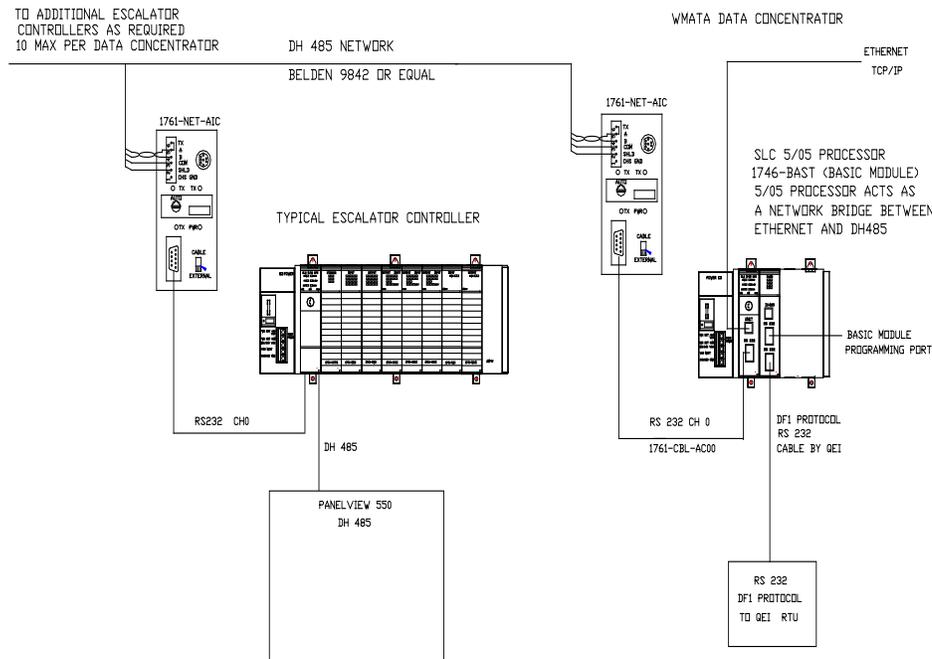


Figure 1.1

2. Data Concentrator PLC Data File Assignments.

The WMATA data concentrator PLC shall store data for up to (10) escalators and/or elevators in any combination as defined in table 2.1.

Table 1

Escalator DH485 node #	Elevator H485 node #	Status bits File	Analog Data File	DC PLC MSG file#	DC PLC MSG buffer file#
1		N20	N21	N81	N101
2		N22	N23	N82	N102
3		N24	N25	N83	N103
4		N26	N27	N84	N104
5		N28	N29	N85	N105
6		N30	N31	N86	N106
7		N32	N33	N87	N107
8		N34	N35	N88	N108
9		N36	N37	N89	N109
10		N38	N39	N90	N110
	11	N40	N41	N121	N141
	12	N42	N43	N122	N142
	13	N44	N45	N123	N143
	14	N46	N47	N124	N144
	15	N48	N49	N125	N145
	16	N50	N51	N126	N146
17		N52	N53	N127	N147
18		N54	N55	N128	N148
19		N56	N57	N129	N149
20		N58	N59	N130	N150

Concentrator PLC (DC)	25	N80	N79		
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Each data file shall begin with word 1 (example: escalator #1 status bits begin with N20:1 and end at N20:20)

The data concentrator PLC communication ports shall be configured as follows.

**Channel 1**

Driver: Ethernet  
 IP Address: TBD  
 Subnet Mask: TBD  
 Gateway Address: TBD

**Channel 2**

Driver: DH485  
 Baud Rate: 19.2K  
 Node Address: 25

1756-BAST basic module communication ports shall be configured as follows.

**Port 1:** Programming port

Settings -- 19,200 Baud, No parity, 8 bits, 1 stop bit, No handshaking

**Port 2:** DF1 port

Settings -- 19,200 Baud, No parity, 8 bits, 1 stop bit, No handshaking

DF1 – Op Code 19 (Full Duplex, NHS, ER, Enable DPD, CRC error checking,

Timeout = 50

Retries = 3

RTS on delay = 20 msec

RTS off delay = 20 msec

Module address = 10

**DH485 Port** – Not Available

**3. Data Format**

Data Concentrator status in File N80 per table 3.0

**Table 3.0 Data Concentrator Status Bits**

WORD	BIT	DATA TYPE	DESCRIPTION	"0" STATE	"1" STATE
1	0	BOOLEAN	Spare		
	1	BOOLEAN	Data Concentrator PLC Battery Status	FAULT	NORMAL
	2	BOOLEAN	Data Concentrator Basic Module Battery Status	FAULT	NORMAL
	3	BOOLEAN			
	4	BOOLEAN			
	5	BOOLEAN			
	6	BOOLEAN			
	7	BOOLEAN			
	8	BOOLEAN			
	9	BOOLEAN			
	10	BOOLEAN			
	11	BOOLEAN			
	12	BOOLEAN			
	13	BOOLEAN			
	14	BOOLEAN			
	15	BOOLEAN			

WORD	BIT	DATA TYPE	DESCRIPTION	"0" STATE	"1" STATE
2		BYTE	Data Concentrator checksum byte1		

3		BYTE	Data Concentrator checksum byte2		
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Words 4 through 20 of the Data Concentrator status file (N80) are unused.

The Data Concentrator Analog data file (N79) is unused.

**Elevator data:**

Two 20 word (40 BYTE) blocks of data shall be developed for each elevator one block for status bits and one block for analog data. Table 3.3 defines the format of data for status bits. Table 3.4 defines the format for analog data.

**Table 3.3 Elevator Status Bits**

WORD	BIT	FAULT TYPE	DESCRIPTION	"0" STATE	"1" STATE
1	0	FAULT	24 VDC POWER SUPPLY	FAULT	NORMAL
	1	FAULT	SAFETY CIRCUIT GOOD	FAULT	NORMAL
	2	FAULT	TOP FINAL LIMIT TRIPPED	FAULT	NORMAL
	3	FAULT	BOTTOM FINAL LIMIT TRIPPED	FAULT	NORMAL
	4	FAULT	DRIVE FAULTED	FAULT	NORMAL
	5	FAULT	OVERLOAD TRIPPED	FAULT	NORMAL
	6	FAULT	STOP BUTTON ACTIVATED	FAULT	NORMAL
	7	STATUS	IN-CAR ALARM BUTTON PRESSED	ALARM	NORMAL
	8	FAULT	OUT OF SERVICE BY DELAY	FAULT	NORMAL
	9	FAULT	MOTOR LIMIT TIMER TRIPPED	FAULT	NORMAL
	10	FAULT	VALVE LIMIT TIMER TRIPPED	FAULT	NORMAL
	11	STATUS	INSPECTION OPERATION ON	ON	OFF
	12	STATUS	INDEEDENDANT SERVICE ON	ON	OFF
	13	STATUS	VISCOSITY CONTROL ON	ON	OFF
	14	STATUS	CONTROLLER TEST SWITCH ON	ON	OFF

	15	STATUS	FIRE SERVICE PHASE 1 ON	ON	OFF
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WORD	BIT	FAULT TYPE	DESCRIPTION	"0" STATE	"1" STATE
2	0	STATUS	FIRE SERVICE PHASE 2 ON	ON	OFF
	1	FAULT	SMOKE SENSOR @ MAIN ON	ON	OFF
	2	FAULT	SMOKE SENSOR @ OTHERS ON	ON	OFF
	3	STATUS	EMERGENCY POWER OPERATION	ON	OFF
	4	STATUS	OVERRIDE ON	ON	OFF
	5	STATUS	CAR IS RUNNING UP	NOT-RUN	RUNNING
	6	STATUS	CAR IS RUNNING DOWN	NOT-RUN	RUNNING
	7	STATUS	BRAKE LIFTED	LIFTED	NORMAL
	8	STATUS	CAR IS IN DOOR ZONE	IN ZONE	IN ZONE
	9	STATUS	INTERLOCKS ARE MADE	OPEN	NORMAL
	10	STATUS	FRONT DOOR GATE SWITCH MADE	OPEN	NORMAL
	11	STATUS	FRONT DOOR FULLY CLOSED	OPEN	CLOSED
	12	STATUS	FRONT DOOR FULLY OPEN	CLOSED	OPEN
	13	STATUS	FRONT DOOR REVERSAL ACTIVATED	OFF	ACTIVE
	14	STATUS	FRONT DOOR PROTECTION ACTIVATED	OFF	ACTIVE
	15	STATUS	REAR DOOR GATE SWITCH MADE	OPEN	NORMAL

WORD	BIT	FAULT TYPE	DESCRIPTION	"0" STATE	"1"STATE
3	0	STATUS	REAR DOOR FULLY CLOSED	OPEN	CLOSED
	1	STATUS	REAR DOOR FULLY OPEN	CLOSED	OPEN
	2	STATUS	REAR DOOR REVERSAL ACTIVATED	OFF	ACTIVE
	3	STATUS	REAR DOOR PROTECTION ACTIVATED	OFF	ACTIVE
	4	FAULT	DOOR REVERSAL DEVICE FAILURE	FAULT	NORMAL
	5	FAULT	ROPE BRAKE SET	FAULT	NORMAL
	6	FAULT	LEVELING SYSTEM FAILURE	FAULT	NORMAL
	7	FAULT	WATER INTRUSION ALARM ACTIVE	FAULT	NORMAL
	8	STATUS	ELEVATOR SLC 5/03 LOW BATTERY	FAULT	NORMAL
	9	STATUS	ELEVATOR SLC 5/03 COMM. ACTIVE	FAULT	NORMAL
	10	STATUS	ELEVATOR SLC 5/03 LOCAL/REMOTE	REMOTE	LOCAL
	11	STATUS	ELEVATOR SLC 5/03 RUN/PROG	PROG	RUN
	12	FAULT	FAULTED	FAULT	NORMAL
	13	STATUS	Out of Service	FAULT	NORMAL
	14		SPARE		
	15		SPARE		

WORD	BIT	FAULT TYPE	DESCRIPTION	"0" STATE	"1"STATE
4	0	STATUS	CAR POSITION 1	NOT AT POSITION	AT POSITION
	1	STATUS	CAR POSITION 2	NOT AT POSITION	AT POSITION
	2	STATUS	CAR POSITION 3	NOT AT POSITION	AT POSITION
	3	STATUS	CAR POSITION 4	NOT AT POSITION	AT POSITION
	4	STATUS	CAR POSITION 5	NOT AT POSITION	AT POSITION
	5	STATUS	CAR POSITION 6	NOT AT POSITION	AT POSITION
	6	STATUS	CAR POSITION 7	NOT AT POSITION	AT POSITION
	7	STATUS	CAR POSITION 8	NOT AT POSITION	AT POSITION
	8				
	9				
	10				
	11				
	12				
	13				
	14				
	15				

Words 5 through 20 are unused.

Table 3.4 Elevator Analog Data

WORD	DATA TYPE	MIN VALUE	MAX VALUE	UNITS	SCALE FACTOR	DESCRIPTION
1	INTEGER			AMPS	X10	DRIVE MOTOR AMPS
2	INTEGER			KWH	X1	PRE DAY KWH
3	INTEGER				X1	PRE DAY UP COUNT
4	INTEGER				X1	PRE DAY DOWN COUNT
5	INTEGER				X1	PRE DAY FRONT DOOR CYCLES
6	INTEGER				X1	FAULT CODE
7	INTEGER				X1	PRE DAY REAR DOOR CYCLES
8	INTEGER					
9	INTEGER					
10	INTEGER					
11	INTEGER					
12	INTEGER					
13	INTEGER					
14	INTEGER					
15	INTEGER					
16	INTEGER					
17	INTEGER					
18	INTEGER					
19	INTEGER					
20	INTEGER					

Note: All analog values are multiplied by 16 in the data concentrator to bit shift left 4 bits to align with QEI's 12 bit analog data types.

A note on communication loss

A 60 second watchdog timer is coded into each escalator file. If communications are lost between the data concentrator and the escalator controller for more than 60 seconds the watchdog timer will timeout. When the timer has timed out the communications loss bit will be reset (0) to indicate the communications loss condition.

**3. Time and date sync**

The QEI RTU shall provide clock synchronization to the WMATA data concentrator PLC every 5 minutes. Table 4.1 defines the address and data format of the clock registers in the WMATA data concentrator PLC. The data concentrator PLC shall set the escalator controller date and time every day at 3 AM.

**Table 4.1**

FUNCTION	ADDRESS	FORMAT
YEAR	N13:10	4 DIGITS
MONTH	N13:11	2 DIGITS
DAY	N13:12	2 DIGITS
HOUR	N13:13	2 DIGITS 24 HOUR
MINUTE	N13:14	2 DIGITS
SECOND	N13:15	2 DIGITS

**4. Data Concentrator PLC Program**

The data concentrator PLC includes code to monitor up to 10 escalators and 5 elevators. Each escalators and elevators has an independent code file and a configuration bit. If an elevator is to be monitored the configuration bit must be set corresponding to the DH485 station address of the elevator controller. If the configuration bit is reset (0), the status and analog data table values for the elevator or escalator will be set to 0.

The configuration bits are as follows.

Escalator Configuration Bit	DH485 Address of Escalator Controller	Elevator Configuration Bit	DH485 Address of Elevator Controller
B9:0/1	1	B9:1/1	11
B9:0/2	2	B9:1/2	12
B9:0/3	3	B9:1/3	13
B9:0/4	4	B9:1/4	14
B9:0/5	5	B9:1/5	15
B9:0/6	6	B9:1/6	16
B9:0/7	7	B9:1/7	17
B9:0/8	8	B9:1/8	18
B9:0/9	9	B9:1/9	19
B9:0/10	10	B9:1/10	20

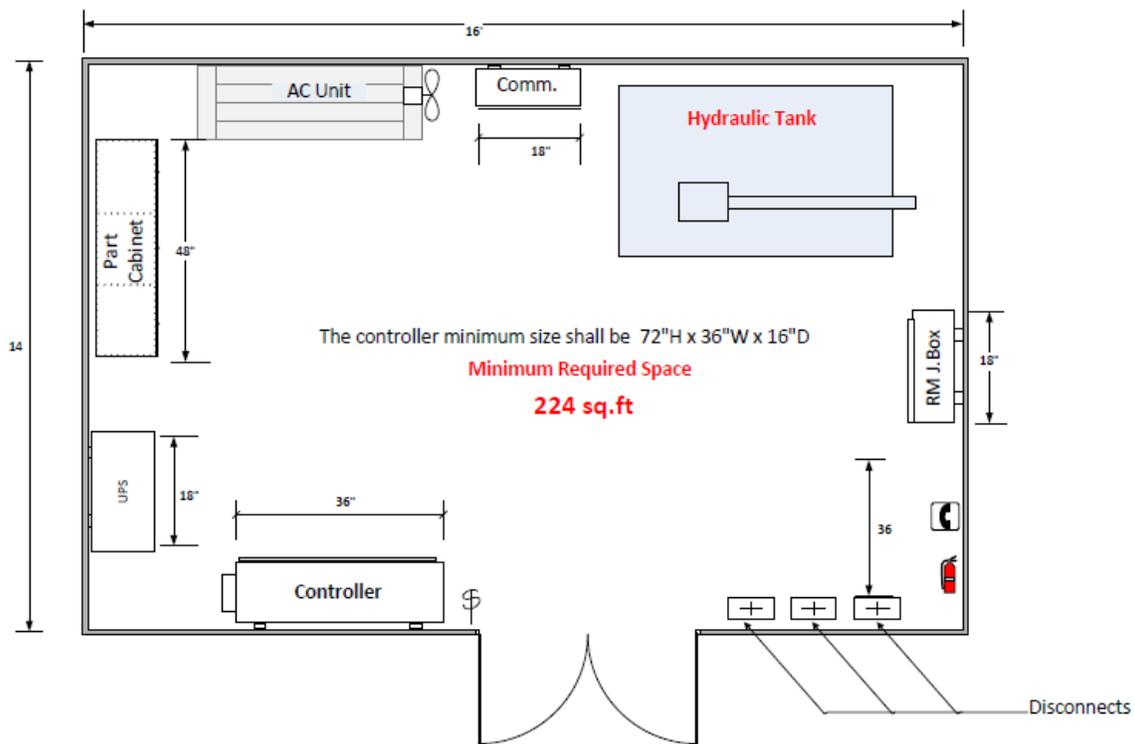
### 3. Data Concentrator Gateway IP addresses.

The Data concentrator PLC acts as a gateway between the Ethernet and DH485 networks. The PLC contains a list of IP addresses, known as the routing table which will be allowed access to the DH485 network. The routing table will contain 20 addresses.

Station	IP Address
1	TBD
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	

17	
18	
19	
20	

**3.07 EXHIBIT 1. Hydraulic Single Elevator Machine Room**



**END OF SECTION**

**SECTION 14210  
HOLELESS HYDRAULIC**

**PART 3 – GENERAL**

**3.01 DESCRIPTION**

- A. This section specifies work pertaining to heavy-duty hydraulic passenger elevator systems including elevator cars, hoistway equipment, hydraulic piping, valves, cylinders, machinery, control systems, indicators, signs, elevator pit ladders and finish work in the vicinity of the hoistway doors as shown on the Contract Drawings and as specified..
- B. The following sections include related requirements and are performed by other trades:
  - 1. Specifications Section 02000 – Site Construction
  - 2. Specifications Section 05000 – Metal Fabrication
  - 3. Specifications Section 08800 – Glass and Glazing
  - 4. Specifications Section 09920 – Painting
  - 5. Division 7 Section “Waterproofing” for water proofing of elevator pit
  - 6. Division 15 Sections for heating, ventilating and/or air conditioning of elevator machine room.
  - 7. Division 16 Sections for electrical service to elevator equipment, fire alarm systems and communications systems.
- C. Definitions:

All terms in this specification have the meaning as defined in the ASME code.

  - 1. Heavy duty elevator: An elevator designed specifically for the harsh environment and duty load cycles common to transportation system usage.
  - 2. Elevator - a hoisting and lowering mechanism, equipped with a car or platform, which moves in guide rails or racks and serves two or more landings
  - 3. Elevator, passenger - an elevator used primarily to carry persons other than the operator and persons necessary for loading and unloading.
  - 4. Elevator, hydraulic - a power elevator in which the energy applied, by means of a liquid under pressure, in a hydraulic jack.
  - 5. Contractor: The General Contractor.
  - 6. Installer: The responsible party who installs the elevator.
  - 7. OEM: Original Equipment Manufacturer.

8. Dwell time: The period of time the elevator is at a landing while the doors open, passengers transfer and doors close.
9. Substantial completion: The point at which the elevator is ready for use, whether the site is finished or not. This is where the jurisdictional inspection usually takes place.
10. Final Acceptance: The point at which the owner accepts the elevator project as being complete including all submittal requirements. This may be a different point in time than substantial completion.
11. Interim Maintenance: Maintenance from the point of substantial completion, but prior to Revenue Service.
12. Beneficial Use: When the elevator is placed into service, may be prior to the site being ready for public use.
13. Revenue Service: The station or facility opening date.
14. Notice to Proceed (NTP): within this document shall mean the date which the elevator installer is notified to proceed with the project.
15. Override Switch – A switch located in a kiosk panel, which disables the Hall Call Buttons.
16. MSDS - Material Safety Data Sheet.
17. BOM - Bill of Material
18. SMNT - Systems Maintenance (WMATA)
19. WMATA: Washington Metropolitan Area Transit Authority.

### 3.02 REFERENCES AND QUALITY ASSURANCE

- B. Codes, Regulations, Reference Standards and Specifications.
  6. Comply with codes and regulations of the Authority Having Jurisdiction.
  7. American Society of Mechanical Engineers (ASME) A17.1 Safety Code for Elevators & Escalators and A17.2 Guide for Inspection of Elevators, Escalators and Moving Walks.
  8. WMATA Design Criteria requirements indicated in Section VI-Mechanical.
  9. American Institute of Steel Construction (AISC).
  10. American Iron and Steel Institute (AISI).
  11. American National Standards Institute (ANSI): C80.1
  12. American Society for Testing and Materials (ASTM): A36, A123, A153, A167, A240, A264, A276, A500, A653, B3, B8, D471.
  13. American Wire Gauge (AWG).
  14. Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG).

15. American Welding Society (AWS): D1.1.
16. Environmental Protection Agency (EPA).
17. Federal Transit Administration (FTA).
18. Institute of Electrical and Electronic Engineers (IEEE): 1202.
19. International Code Council (ICC) – International Building Code (IBC).
20. National Association of Architectural Metal Manufacturers. (NAAMM): C54, C55.
21. National Institute of Standards and Technology (NIST).
22. National Electrical Code (NEC).
23. National Electrical Manufacturers' Association (NEMA): WC 70, KS 1, AB 1, 250, PB 1, MG 1.
24. National Electrical Safety Code (NESC)
25. National Elevator Industry, Inc. (NEII)
26. National Fire Protection Association (NFPA): NFPA-130-2003.
27. Occupational Safety and Health Act (OSHA).
28. Society of the Plastics Industry (SPI).
29. Underwriters' Laboratories, Inc. (UL), UL-94HB, 6, 50, 62, 98, 360, 486, 489, 514, 1591.
30. United States Department of Transportation (DOT).
26. Any additional requirements imposed by local agencies and/or codes having jurisdiction shall be incorporated into elevator installation.
27. In the event of a conflict between codes, regulations, these specifications or standards, the most stringent requirement as determined by the Contractor and approved by the Authority shall take precedence unless specifically addressed herein.

**B. Elevator Manufacturer and/or Installer's Qualification:**

1. **Manufacturer Qualification:** : Shall provide documents stating that their firm has successfully produced elevators for transit system applications for a minimum of ten (10) years and regularly engaged for the past five (5) years in the manufacture of major components for hydraulic passenger elevators. As a standard of quality the elevator equipment design and installation shall comply with the Code.
2. **Installer's Qualifications:** Shall be the original manufacturer of elevator equipment or manufacturer's authorized agent who is trained and approved for installation of units required for this Project.
3. The Contractor shall obtain and pay for all permits and licenses and perform all required inspections.

**C. Quality Assurance:**

1. The elevator contractor shall guarantee the materials and workmanship of the apparatus furnished under these specifications and will correct any defects not due to ordinary wear and tear within two (2) years from date of completion of each elevator, inclusive of labor and traveling expenses. Defective work shall be repaired or replaced at no additional cost to the Authority.
2. Welding: Welding shall be performed in accordance with the requirements of AWS or CWB Welders shall produce evidence of current certification by AWS or CWB.
3. Labeling Requirements: Every elevator shall be clearly marked with rated load and speed, manufacture serial number and the designated Authority identification.
  - a. All elevators shall be permanently numbered with number designations corresponding to the indications on the kiosk annunciator panel. A station sketch showing the elevator numbers shall be submitted for WMATA ELES Engineering. The elevators shall be numbered in sequence, starting at the north entrance left to right facing to the elevator at each station and proceeding clockwise around the station. The numbering shall proceed into the station toward the end of the platform. Corresponding numerical identification shall be affixed to the equipment in the machine rooms. The elevator numbering shall be approved by the ELES Engineer.

**3.03 SUBMITTALS**

Submit the following for approval in accordance with the Contract Documents and with the additional requirements as specified.

A. Product Data

1. The summation of product information shall be submitted, in tabular form, of all parts incorporated in the entire group of elevators supplied under this Contract.. Hard copies and electronic copies on the Flash Drive/Compact Discs (CDs) shall be submitted.
  - a. Manufacturer's design data, material specifications, drawings, installation and maintenance instructions including preventive, predictive and general maintenance, and other data pertinent to the components used in the elevator systems, including, but not limited to, detailed repair data for all components, including disassembly, inspection/gauging/torque requirements, reassembly, testing and other related information. Submittals shall cover all mechanical components, operating panels and indicators and electronic equipment to control and monitor elevator control functions. Exploded view drawings shall be included to facilitate repair and maintenance functions.
  - b. Lubricants, sealers, paints and any other potentially hazardous substances are subject to review and approval by the Authority. The Contractor shall submit the necessary Material Safety Data Sheets.
2. The following information shall be provided:

- a. Nomenclature of part.
  - b. Elevator Contractor's part number
  - c. Nomenclature of next higher assembly in which used.
  - d. Manufacturer and part number.
  - e. Model number(s) of elevator(s) on which used.
  - f. Total quantity in entire group of elevators.
  - g. Current unit price to the Authority.
  - h. Recommended spare parts list showing parts with prices for each part. The parts listing shall be provided on or before 90 days prior to scheduled completion
3. Loads on supporting members, reaction points, and deflections under varying loads.
- a. Loads imposed on the structure shall be coordinated with the Authority and not exceed agreed limits. This requirement shall be verified, documented, and stamped by a registered Professional Engineer Supporting calculations shall be provided for record file.

B. Shop Drawings

The contractor to provide detailed drawings that shows the dimensions and tolerance, specification that may include the material specification, hardness or electrical rating for each component that is being used. In regards to assemblies they must provide a top level drawing with BOM and quantities with detailed material specifications and drawings with dimensional tolerances. The contractor also to provide as-built CAD models of all elevator components.

The name of the manufacturer and type or style designation shall be listed on the each page of the equipment shop drawings. Drawings submitted shall include, but not be limited to, the following.

- a. Fully dimensioned layout in plan and elevation, showing the arrangement of equipment and all pertinent details of each specified elevator unit, including as appropriate
  - 1. All equipment located in machine rooms.
  - 2. Location of circuit breaker, switchboard panel or disconnect switch, light switch, and feeder extension points in machine room. These electrical components shall not be blocked by anything.
  - 3. Location in hoistway of outlets for connection of traveling cables for car light, fire detectors, communication, and control system.
  - 4. Car, hydraulic cylinder and plunger, supporting beams, guide rails, buffers, and other components located in the hoistways.

5. Maximum guide rail bracket spacing. Guide rail brackets shall be provided at every horizontal structural member and shall be of sufficient strength to meet the ASME Code.
  6. Reactions at points of supports.
  7. Weight of principal parts.
  8. Top and bottom clearance and over-travel of car.
  9. Complete wiring diagram of the elevator system and subsystems. Complete data regarding electrical characteristics and connection requirements.
  10. Refuge space on top of car and pit.
  11. Cab design, dimensions and layout.
  12. Color/material schedule and selection chart for cab and entrance features.
  13. Hoistway Ventilation - Thermostatically Controlled, positive mechanical ventilation system.
  14. Hydraulic Jack Details
  15. Machine/Pump Room area, pit and hoistway layout.
  16. Hydraulic piping layout indicating layout, type, size, and schedule of piping from machine room to elevator pit(s) indicating orientation of valve(s), and location of shut-off valve(s), and shall include calculations of working pressures.
- b. Drawings of the hoistway entrances and doors showing their method of operation, details of construction, and fastenings to the structural members of the station structure.
  - c. Drawings of the car for each design specified, showing dimensions, details of construction, fastenings to platform, car-lighting, ventilation, air conditioning (if applicable), communication, and location of equipment.
  - d. Cuts or drawings showing details of all signal and operating devices, identifying graphics, and detailed design with diagram and schematic of kiosk annunciator panel.
  - e. Hydraulic drive:
    1. Cylinders and plunger.
    2. Power unit, including volume, rate of flow, working pressure, rpm of pump, and horsepower, voltage, frequency, service factor and rpm of the motor.
    3. Piping, fittings, and couplings.
    4. Valves.
    5. Storage tank.
    6. Muffler.

- 7) Hydraulic Jack Details Drawings
  - 8. Fluid flow diagram showing all valves, operating devices, and controls.
  - 9) Complete assembly detail of machine/pump, hydraulic tank mounting, with all load calculations.
- f. Elevator controller, including manufacturer's technical data and catalog cuts, and interface hardware and software requirements.
  - g. Power door operator.
  - h. Door interlocks and electrical contacts including test reports showing that hoistway door interlocks, car door contacts, and car top emergency contacts meet the requirements of the ASME Code and certification by the NIST or other approved laboratory.
  - i. Car ventilation fan.
  - j. Car Air Conditioning (if applicable)
  - k. Car lighting.
  - l. Cabling.
  - m. Buffer, including stroke and certified maximum striking speed for car.
  - n. Communication and intrusion system design details covering electrical, mechanical, and architectural aspects.
  - o. Design and architectural details, including light ray unit locations, of the electrical protective device for car doors.
  - p. Where the use of adjoining dissimilar metals is required, descriptions of protective measures to be employed to avoid corrosive damage.
  - q. Certification from independent testing laboratory that glazing gaskets meet the specified requirements.
  - r. Hall and car fixtures at each landing including the car operating panel (COP).
  - s. Interface wiring diagrams with other systems showing terminal board location and identification.
  - t. Expected heat dissipation of elevator equipment in machine room and control areas (i.e. BTU's/hr.) based on 240 round cycles per hour.
  - u. Complete wiring diagram of the elevator system and subsystems. Complete data regarding electrical characteristics and connection requirements.
  - v. Complete assembly detail of machine/pump, hydraulic tank mounting, with all load calculations.
  - w. Lubricants, sealers, paints and any other potentially hazardous substances are subject to review and approval by the Authority.

The Elevator Contractor shall submit the necessary Material Safety Data Sheets.

C. Samples

6. Three of each of the following samples shall be submitted for approval:

- a. Steel cladding: Baked-enamel finish, six inches square. The sample shall show the rust-protected surface of the base metal on one side and the prime and finish coats (stepped) of enamel on the other side, although both sides of actual panels are to be enameled as specified.
- b. Sheet metal: Six inches square of thickness and finish specified.
- c. Stainless steel cladding: 12 inches square of thickness and finish specified.
- d. Glass: 12 inches square.
- e. Floor covering: 12 inches square in the color and finish to be supplied.
- f. Neoprene gasket: Each type.
- g. Landing selector button mounted in cover plate with identity marking alongside button.
- h. Signs: One of each type.
- i. Ceiling material.

D. Certification:

- 1. Certificates of inspection and acceptance issued by Jurisdictional Authority.
- 2. The Acceptance Inspection (Specifications and Code) by the Elevator and Escalator (ELES) Department shall take place prior to the Final Acceptance Inspection by the Jurisdictional Authority, and the elevators and associated equipment shall be free of defective material, imperfect work and faulty operation.

All defective work identified by ELES representatives shall be repaired or replaced at no additional cost to the Authority prior to the Final Acceptance Inspection by the Jurisdictional Authority.

E. Operation & Maintenance Manuals.

Six sets of the approved manuals, elevator installation, operation instructions, troubleshooting techniques and related equipment drawings and software (all publication must be in English) – two copies of which to be delivered to the WMATA/ELES Engineer representing the Authority prior to installation. Each binder shall have the Binder Cover and Spine Insert which contain the Station Name and Unit ID.

Submit an additional electronic copy on Flash Drive(s)/CD(s). The Information shall be saved/presented as follows:

- a. Graphic images in “.dwg” AutoCad and “.pdf” formats. All revisions shall be made by

using computer software. Hand written changes are not acceptable.

b. Text in Microsoft Word .doc, “.pdf” or approved equal format.

The manuals shall include the following:

1. Complete operation and maintenance Instructions of the elevator equipment included complete illustrated, exploded views of all assemblies and a complete illustrated, exploded view for identification all system parts.
2. Complete nomenclature of replaceable parts, part numbers, current cost, and warehouse location. If product source is another vendor, Contractor shall include name and address of other vendor.
3. Furnish a summation, in tabular form, of all parts incorporated in the elevators supplied under the Contract. Include but not be limited to the following:
  - a. Nomenclature of part.
  - b. Contractor's part number.
  - c. Nomenclature of next higher assembly in which used.
  - d. Manufacturer and part number.
  - e. Model number of elevator on which used.
  - f. Total quantity.
  - g. Current unit price to the Authority.
  - h. Serial numbers of all serialized assemblies, subassemblies, motors, and other major components supplied and installed.
4. Control and schematic electrical wiring diagrams of controller including wiring of safety devices.
  - a. Wiring Diagrams shall be full size (11x17), ladder type, complete "as-built" wiring and single line diagrams showing the electrical connections, functions and sequence of operation of apparatus connected with each elevator, using standard symbols or proprietary symbols defined on the diagram, both in the machine room and in the hoistway, shall be furnished in duplicate for each elevator.
  - b. Wiring diagrams shall incorporate the wiring identification labeling to identify the controller and field wiring used for each circuit. Wiring diagrams shall have sheets numbered with an indication of the total number of sheets in the diagram set. Each page should include unit number where the diagram belongs to.
  - c. After approval, a copy of each print (11x17) shall be laminated and mounted with non-metallic holder in each elevator machine room. A reproducible .003 mil Mylar set of wiring diagrams for each elevator shall be delivered to ELES Engineering Office.
  - d. Coded diagrams are not acceptable.

5. Complete detailed drawings and wiring diagram of elevator system.
6. Lubricants, sealers, paints and any other potentially hazardous substances are subject to review and approval by the Authority.
  - a. Provide MSDS for all the lubricants/chemicals.
  - b. Provide manufacturer part number.
  - c. Provide name of the manufacturer.
7. Detailed lubrication and cleaning schedule.
8. Procedures for adjusting all elevator components.
9. Complete set of contract software including operating control software.
10. Detailed, record and as-built layout drawings.
11. The entire manual, all software upgrades and service tools for elevators shall be provided in an electronic format on Flash Drive/CD-ROM that is acceptable to the WMATA Engineering and Maintenance Department.
12. All hard copy publications shall be in loose-leaf form, on 30-pound paper and with punch holes reinforced with plastic, cloth or metallic material.
  - a. The O&M manual shall only contain information related to equipment installed under this contract. Generic information that does not pertain to the equipment installed shall not be included. Scanned documents are not allowed. The fonts should be standard format.
  - b. All covers shall be resistant to oil, moisture, and wear commensurate with their intended use. Diagrams and illustrations shall not be loose or in pockets. All printed material shall be capable of being reproduced on dry copying machines.
13. Each elevator shall be treated as a whole and not as a grouping of disassociated parts. The material in the Wiring Diagram Manual shall be organized and indexed by the elevator classifications included in this Specification. All manual sections shall be sub-divided, to the extent required by the subject matter, and shall include, but not necessarily limited to the following topics:
  - a. General system or sub-system description and operation.
  - b. Sequence of operation.
  - c. Replacement and step by step adjustment procedure for all components and systems.
  - d. Block diagrams.
  - e. Functional schematics.
  - f. Functional as-built wiring diagram.
  - g. Lubrication and cleaning, including frequency, methods, and trade identifications of recommended materials.
  - h. Component location and description.

- i. Inspection and maintenance standards including wear limits, settings, and tolerances.
  - j. Installation and removal sequence.
  - k. Test and evaluation procedures.
  - l. Spare parts lists and special tools.
14. The contractor shall provide all information: manuals, drawings, design changes, modifications, techniques, procedures and any other documents related to maintenance, safety, operations which relate to any part, component, system, subsystem or material and applicable to the elevator equipment. All operating, programming, control software and licensing keys (if applicable) to the PLC control system for the installation.
15. All of the above referenced shall be provided as it pertains to the original installation and for a period of ten (10) years after final acceptance of the elevator. During a ten (10) years period, In case of any items are obsolete or no longer available from the manufacturer the Elevator Contractor shall provide the alternative products.

**3.04 SYSTEM DESCRIPTION AND PERFORMANCE REQUIREMENTS**

A. Design Requirements:

1. General:

- a. Elevators furnished under this Contract shall be of the heavy duty automatic, hydraulic-type with direct-acting plunger.
- b. All parts shall be built to standard dimensions, tolerances, and clearances so that similar machines and devices supplied under contract are completely interchangeable. Elevators shall be designed with provision for thermal expansion and contraction of complete elevator assemblies and for any movement of the facility.
- c. Fasteners: Fasteners shall be compatible with materials being fastened. Fasteners shall be furnished with self-locking nuts or retaining rings (spring washers, toothed disks). Fasteners shall be equal to or of greater corrosion resistance than the most corrosion resistant metals being fastened. The mechanical fastening used throughout the equipment on parts subject to wear and requiring replacement shall be key and seat, nut, screw, or other removable and replaceable type not requiring physical deformation or field positioning. The use of rivets or similar devices will not be acceptable as mechanical fastenings for such parts.
- d. Doors of elevators shall be of the horizontal sliding type, single speed, center-opening. The doors shall be arranged for low-speed electric power operation.

2. Capacity, Speed, Travel, Platform Size

- a. All parts of the elevator equipment shall be of such design, size, and material as to satisfactorily function under all conditions of loading and operation within its rated load and speed, all with a proper factor of safety, maximum mechanical and electrical efficiency, and a minimum wear on parts.
  - b. Hydraulic elevators shall have sufficient capacity to lift the rated load at 150 feet per minute, with a tolerance of plus or minus 8.0 percent.
  - c. The rated load shall be exclusive of the weight of the complete car and shall be determined in accordance with ASME Code requirements for passenger-elevators required to carry freight, Class C3 (ASME A17.1 Section 2.16) or 4500 lbs, whichever is greater.
  - d. The travel, location, terminal floors, number of stops and openings, and the overall car platform size shall be as shown on the Contract Drawings.
  - e. The anticipated freight load (cart) will be approximately 4 feet-1 inch by 2 feet in plan, supported on four 8-inch wheels with 2-inch wide treads spaced approximately 2 feet-4 inches center-to-center longitudinally and one foot five inches center-to-center transversely. The loaded cart will weigh approximately 1,260 pounds.
  - f. The entrance of the cart into the elevator car will produce eccentric forces which, acting through the guide rails, will result in additional deflections and deformation on the hoistway. These deflections and deformations shall not exceed 1/16 inch and shall not be permanent.
  - g. The top enclosure shall be reinforced to support two men and capable of sustaining, without damage or permanent deformation, a load of 300 hundred pounds on any area one feet square and 100 pounds applied at any point. An emergency exit shall be installed in the car top in conformance with the Code.
  - h. Car travel shall not exceed 15 feet with Holeless type hydraulic elevator.
- B. Performance Requirements
- 1. The elevators shall be designed for continuous operation seven days per week, 24 hours per day.
  - 2. Elevators shall be designed to be capable of operating with full specified performance capability while exposed to the climatic and environmental conditions described in the following paragraphs. In addition, during installation and until the beginning of scheduled maintenance service, the elevators will be subject to more extreme environmental conditions. The elevator shall be furnished the amount of protection necessary to prevent any damage to or deterioration of the elevators during this period.

- a. Elevators shall be designed to operate in dry bulb temperature range of  $-10^{\circ}\text{F}$  to  $140^{\circ}\text{F}$  and operate while exposed to the natural elements of weather, including sunlight, rain, snow, slush, salt; all condition of relative humidity, de-icing chemicals, debris, airborne dust, and corrosive elements.
  - b. The elevators shall have a special winter operation. The elevators shall be designed to operate in the event the outside temperature falls below a pre-established minimum value. The elevator contractor shall furnish and install the necessary timers and thermostat to accommodate the desired function
3. Sound Level: No elevator car or elevator power unit shall generate noise in excess of NC45 sound level. Measurement of noise shall be made at a point 3 feet from the hoistway, machine room entrances, and ventilation openings, either free running or under load. For multiple elevator installation, the noise measurements shall be made with only one (1) elevator unit in operation, but with the entire installation complete and in operating condition. An ambient level not to exceed forty-nine (49) decibels shall be maintained prior to units being turned on.
  4. Hoistway Movement:  
Elevators shall be designed to sustain the load and operate with the following lateral movements of the hoistway structures:
    - a. In any individual glazed area: 1/4 inch.
    - b. In total height of hoistway structure:
      1. Aerial and surface structures: 5/8 inch
      2. Underground structures: 1/2 inch
  5. The elevator assembly shall be designed in a manner to avoid corrosion and galvanic action due to physical contact between dissimilar metals or due to other causes.
  6. Reliability:
    1. Each elevator shall be capable of operating at full load under any of the normal modes of operation at a level of availability of not less than 98 percent over a period of 365 days.
    2. Availability (A) is defined as the portion of normal operational time during which the equipment is available for use. Or

$$A = \frac{MTBF}{MTBF + MTTR}$$

Where:

*MTBF* = Mean time between failure in days

= Operating time,  $t$  (in days) /Number of failures in time  $t$

*MTTR* = The average time in days required to restore an elevator to operation after a report of a failure.

B. Seismic Loads

6. In accordance with VA-USBC 2003, all structures shall be designed to resist the effects of earthquake motions.
7. The elevator shall be designed to comply with the seismic zone 2 requirements of ASME A17.1.

C. Make provision for and provide a closed circuit television camera (CCTV), in the elevator car(s) with the ability to monitor the CCTV from the Kiosk annunciator panel. Submit drawings for approval before fabrication.

- a. Provide electrical connections, through shielded traveling cables, between camera and the communications terminal block in machine room or pit.

D. Painting: The pit, pit walls and machine room floor shall be painted. All machine room equipment shall be given two coats of approved machinery paint. All new iron work shall be given one coat of rust- inhibiting paint.

E. Workmanship:

1. Joints shall be welded their full length and dressed smooth and flush on exposed surfaces. Spot welding shall be used where practicable in preference to screw or rivet fasteners.
2. Sheet metal materials shall be accurately rolled and leveled, and have smooth finish and uniform color. Joints shall be formed to a tight fit, with abutting edges flush, and shall be securely welded or riveted together in such a manner as to give strength equivalent to the solid sheet. Riveted construction shall have heavy reinforcement on the back, and no rivets shall show on exposed surfaces, Welds shall be solid and dressed flush, and holes for screws or bolts shall be drilled and countersunk.
3. Wrought work shall have joints milled to a tight even fit and, where possible, shall be made without screws. Square turns and comers shall be sharp, Curves and loops shall be true and without visible joints. Abutting members shall be welded, riveted or both. Similar bars shall be halved at intersections and wide bars shall be punched for the small bars to pass through.
4. The finished work shall be strong, rigid and neat, painted in appearance. Plane surfaces shall be smooth and free from warp or buckle. Molded members shall be clean cut, straight, and true. Miters shall be well formed and in true alignment. Fastenings shall be concealed from face side of the material.

G. Corrosion Protection: The contractor shall design the elevator assembly in such a manner to avoid corrosion and galvanic action due to physical contact between dissimilar metals or due to other causes.

### 3.05 PROJECT SITE CONDITIONS

- A. The project site premises shall be visited by the Contractor to thoroughly familiarize with all details of work and working conditions. All dimensions shall be verified in the field and by comparison with the station structural and finish (information) drawings and the Authority shall be informed of any discrepancy before ordering equipment or performing work. Coordination and proper relation of this work to the structure and to the work of all trades shall be performed.
- B. The elevator installer shall install all elevator wiring in the embedded conduit provided by other trades including that to the kiosk. Other trades will bring wiring for their services to either the elevator machine room or the elevator pit, terminated on a terminal block. The elevator installer shall extend wires from the terminal blocks to the appropriate location or device within the elevator enclosure or hoistway. Some of these circuits shall require shielded wires or separate isolated circuits.

### 3.06 WARRANTY

Warranty: Two (2) year warranty of construction shall start at Final Contract completion.

- A. The OEM shall warrant in writing that all equipment manufactured and installed under this specification, for a period of twenty four (24) months from the date of Final Acceptance by the Authority, be free of defects in design, materials, and workmanship, under normal use and service. Defective work shall be repaired or replaced at no additional cost to the Owner.
- B. The warranty shall include materials and labor necessary to correct defects.
- C. The warranty does not begin until all of the following requirements have been met.
  - 1) The Operations and Maintenance Manuals are accepted by WMATA.
  - 2) The required training has been completed to the satisfaction of WMATA.
  - 3) All field tests have been successfully completed.
  - 4) The acceptance testing has been successfully completed.
  - 5) The elevators are in service for passenger/public use.
  - 6) The State and local jurisdictions have inspected the elevators and issued the respective certificates of Operation.
  - 7) All spare parts have been delivered and received by WMATA.
  - 8) Any discrepancy identified by the ELES representative shall be repaired or replaced by the Contractor at no additional cost to the Authority.

### 3.07 OPERATION AND MAINTENANCE TRAINING

- A. Training: The Contractor shall develop and provide operation, troubleshooting and maintenance training in accordance with the General Requirements  
The following training requirements shall be met:
  - 1. Three days of classroom plus two days hands on training on the field shall be provided for 10 students per class. Six training session for a total of 60 students is required.
  - 2. Time and place of training will be determined by the Authority, but

- must be completed no later than 30 days prior to the Final Completion.
3. Training shall be organized to make optimum use of the required maintenance and operation manuals including training for replacement of all parts contained in the Parts Inventory list.
  4. At the completion of the first training session, a narrated and properly edited training video shall be submitted for the authority on DVD or flash drive. The video shall be taken by the professional camera operator with quality image and sound track and will be used for the future trainings. The video shall cover operation of the elevator, function of the devices, maintenance, adjustment procedures and troubleshooting. The following items shall be included as minimum requirements:
    1. Step by step adjustment procedure on the followings:
      - 1.1 Door operators, DCL, DOL, full door opening, and so on...
      - 1.2 Valve adjustment
      - 1.3 Car Leveling and adjustment of leveling sensors and vans
      - 1.4 Door: door interlock, proper pressure, restrictors ...
      - 1.5 Pump motor: belt tension and alignment
    2. General overview of major items:
      - 2.1 Packing:
      - 2.2 Piston:
      - 2.3 shut of valve
      - 2.4 Controller:
      - 2.5 Controller display:
      - 2.6 Hydraulic pump
      - 2.7 Hydraulic tank
      - 2.8 Door sills
      - 2.9 Guide rails
    3. Daily operation and sequence of operation
    4. Replacement and Installation of components:
      - 4.1 hydraulic packing
      - 4.2 door photo eye
      - 4.3 Hydraulic valve
      - 4.4 Door clutch
      - 4.5 Door pickup rollers
    5. Proper guide roller adjustment
    6. Verification of safety circuit
    7. Maintenance procedure and Frequency of maintenance
    8. Proper access of pit and top of car for inspection
    9. Proper test of fire service operation
    10. Proper lubrication of components
    11. Troubleshooting techniques
    12. How to use proper communication device, machine room, car top, and kiosk

5. Provide one additional copy of all required submittals to the ELES Engineer for Authority use.
  6. Provide two copies in DVD format of training materials along with visuals and handouts to the Engineer for the Authority use.
    - a. Video shall be narrative.
    - b. Video shall be separated by major components Sections
    - c. Equipment Identification shall be as a part of the section title.
  7. Separate training manual shall be submitted for approval prior the scheduling of the training. The O&M manual shall not be used as a training manual.
- B. Scope of Work
6. All training, as described below, shall take place prior to Final Acceptance of equipment or materials by the Authority. Operations and maintenance training may take place as a combined class by agreement of the Office of Elevators and Escalators (ELES). The minimum number of ELES employees to be trained will be no fewer than 60 total with a maximum of 10 per class. Those persons will be identified by WMATA. The contractor shall video tape all training sessions and provide WMATA/ELES with edited copy of the recording as stated above.
  7. Operations training shall be tailored specifically to the furnished and installed equipment, and designed to teach the day-to-day operation of all equipment. The training shall be sufficient to bring personnel to a level of operating proficiency such that routine vendor support is not needed.
  8. Maintenance Training shall be tailored specifically to the furnished and installed equipment, and designed to develop the knowledge and skills required to maintain all item(s) delivered.
  9. Maintenance training shall be subdivided into two major levels as follows:
    - a. System Level Maintenance Training, covering:
      1. Theory of operation of the system and its major components.
      2. System configuration.
      3. Preventative maintenance, consisting of written procedures and schedules for the periodic maintenance of all equipment.
      4. Written and validated inspection procedures and a system-level trouble-shooting guide (to the lowest field-replaceable unit).
    - b. Shop Level Maintenance Training, covering
      1. Detailed theory of operation to module, board, and/or device level.
      2. Component level troubleshooting and component replacement and adjustment.

3. Testing and alignment procedures of repaired units.
- C. Deliverables
6. The following course materials shall be delivered by the Contractor, according to the following specifications:
    - a. An Instructor's Guide containing all the information and direction necessary for the instructor to make an effective presentation. It shall include adequate guidelines to conduct a comprehensive training program. Individual lessons within the course shall be organized as separable blocks (or modules) which may be taught as a unit. The Instructor's Guide shall contain, as a minimum:
      1. Discussion of student prerequisites (if any).
      2. Program overview.
      3. A statement of overall program goals.
      4. Lesson plans (a session-by-session outline containing the following):
        - a) Student learning objectives, stated in measurable term
        - b) Overview of each lesson.
    - b. A Student Manual including all materials for the student to interact in the learning situation. It shall contain, as a minimum:
      1. Program overview and introduction.
      2. Statement of overall program goals.
      3. Learning objectives, stated in measurable terms that specifically describe desired behaviors or knowledge to be gained.
      4. A fully developed prose treatment (not outline format) of content presentation, developed in the same modular format as the Instructor's Guide.
      5. Illustrations, charts, photos and other graphics of actual system components as needed to enhance content presentation.
      6. The training manuals shall be prepared and submitted for approval to WMATA/ELES prior to training. The training manuals shall include procedures for adjustment and replacement of all electrical and mechanical components, and a troubleshooting guide.
    - c. Audio-visual Aids consisting of a narrated video of not less than 90 minutes duration to include, but not limited to, the following:
      1. General overview of major features.
      2. Daily operations.

3. Maintenance procedures (lubrication, adjustments, critical measurements, etc.).
  4. Frequency of maintenance procedures.
  5. Parts replacement safety devices, lighting, etc.
  6. Verification of safety circuits, methods of accessing and preserving computerized functional data if required.
  7. Step by step adjustment procedures and installation of components.
  8. Handouts, transparencies and/or slides as necessary to ensure clear and comprehensive presentations.
  9. The training video shall be taken from actual equipment installed under this contract by the professional camera operator.
- D. Supplemental Materials consisting of a functional mock-up or a functional representation is required of any equipment that requires theoretical discussion. This may be in the form of an animated schematic, a model of the equipment, an actual device, an interactive video training device, or an Authority approved substitute. All mock-ups shall become the property of the Authority for eventual turn over to WMATA/ELES.
- E. The final copies shall be delivered to the Authority as follows:
6. One complete set of training materials that is completely camera-ready. Camera-ready copy is defined as typewritten or typeset originals or high-quality copies such that further copies can be made from them with no noticeable decrease in copy quality.
  7. Five copies of all student and instructor materials, to be used for archival purposes, in the WMATA ELES Technical Library.
  8. A set of complete student materials including training manuals for each participant enrolled in training classes. The O&M manual, training manuals and special tools shall be approved by the Engineer and delivered to the Authority for eventual turn over to WMATA ELES.
  9. The contractor shall video record all training sessions and provide WMATA/ELES with edited DVD copy of the recording to be used as training guide for other WMATA ELES employees.
- F. The following specifications shall be met in instructional delivery:
6. Instructor Qualifications. A description of instructor qualifications, a resume, curriculum vitae, or other description of instruction qualifications must be submitted at least 60 days prior to the presentation of training. The description shall document a thorough knowledge of the equipment being taught, an understanding of the adult learning process, and demonstrated experience in vocational instructional. The ELES Engineering Office will review and approve the Instructor candidacy.
  7. Course length - The length of the course shall be 5 working days with 3 days in the classroom and 2 days hands-on training.

8. Student qualifications - For the purposes of course development and presentation, vendors shall assume all WMATA students are high school graduates (or equivalent), and that maintenance personnel will possess the ability to use basic hand tools and electronic test equipment.
9. Testing. Instructors must give written and/or practical tests as a measuring device to determine knowledge transference. Tests shall use a multiple-choice or short answer format, and have been validated in a pilot course or by some other means agreed to by the Authority and Contractor. Whenever possible, a practical hands-on test shall be developed to demonstrate the transference of operational/ mechanical skills.

### **3.08 SPARE PARTS AND SERVICE FACILITY**

#### **A. Spare Parts**

At the expiration of the warranty requirements of the General Provisions, the Contractor is responsible to provide a source for spare parts and service facility in the United States which can be obtained for an additional five years. If product source is another vendor, Contractor shall include name and address of other vendor.

1. The Contractor shall propose and provide a spare parts inventory to be approved by the Engineer and provided to the Authority not less than 90 days prior to scheduled completion, equal in value to seven percent of the cost of each elevator.
2. This provision requires the furnishing of a Recommended Spare Parts and Special Tools List based on manufacturer's recommendations, defines criteria to be used by the Contractor in developing spare parts recommendations; defines the manner of identifying spare parts on the list and the labeling and identification of spare parts upon delivery; and the timing of delivery of spare parts.
3. Elevator parts list, grouped by system and subsystem for stocking identification and the list shall contain the following information for each item listed:
  - a. Component name and Part number(s)
  - b. Manufacturer's name
  - c. Model number(s)
  - d. A blank column for WMATA's part number
  - e. Manufacturer's recommended quantity (see Section 1.08A.4 below)
  - f. Anticipated annual usage
  - g. Unit price
  - h. Special storage and handling requirements
4. The manufacturer's recommended quantities shall be based upon the following reliability, usage and lead time considerations:

- a. Wear: Components which may be expected to require replacement under normal maintenance schedule and operations, such as mechanical parts subject to continuous operation within projected mean time between failure levels.
  - b. Consumables or Expendables: Components which are consumed, used up, destroyed, or upon failure, are otherwise made usable for their intended purpose and are economically unrecoverable except for inherent scrap value.
  - c. Recoverable or Repairable: Components which, upon failure, are capable of being repaired or remanufactured to a serviceable, operational condition and maintained available for use within their initial intended purpose.
  - d. Long Lead: Components that are not available from commercial distributors or within 48 hours from the manufacturers such as specifically made or selected components.
5. Cross referencing: Where replacement components are common to more than one system or subsystem, include a cross reference and indexing system in the replacement components list:
  6. Non-Unique parts: In all components lists, items that are not unique to the system and have been manufactured by others shall be identified by the manufacturer's name and part number.
  7. WMATA will provide the Elevator Contractor with shipping instructions, with WMATA part numbers for each item the Elevator Contractor is required to furnish.
  8. The parts shall be shipped to the locations as directed by the Authority. Shipping documents shall identify the Contract number, manufacturer's part number, quantity, unit price and WMATA part number.
  9. Spare parts shall be properly packaged or crated so as to prevent damage during shipment and long-term storage. An individual packing slip shall be included inside the package or crate.
  10. Spare parts shall be the same in all respects as their counterparts furnished as a part of the assembled equipment to be delivered.
  11. Parts furnished in accordance with this provision are WMATA spares, separate and distinct from any Contractor obligation to replace parts, components or assemblies under any warranty provision.
  12. Parts lists contained in Operations and Maintenance Manuals provided under the Contract shall include assigned WMATA part numbers.
  13. A Manufacturer's Recommended Spare Parts List shall be provided. Parts to be provided shall be based on the criteria described herein and require Authority approval and shall be provided prior to Final Acceptance.
  14. Any Special Tool(s) used including, but not limited to, troubleshooting, maintaining the elevator, software and/or hardware shall be provided as part of the spare parts to the Authority. Any tools provided shall be the

same as those issued to the Adjuster and equivalent members of the subcontractor's staff.

- B. The finished elevator installations shall be completely barricaded and enclosed to preclude their use without permission of the Contractor until Final Acceptance and release by the Contractor for general use. The enclosure shall be fabricated to allow easy access for maintenance, testing and adjustment.
- C. The Contractor shall be responsible for the security of the contents of each machine room. The Contractor shall control access to that room, and ensure that it shall remain secure at all times until the completion of the Contractor's interim maintenance obligation.

#### **1.09 SPECIAL TOOLS**

- A. A complete set of special tools and instruments necessary for troubleshooting, maintenance, repair and making all adjustments on every part of the elevator installation, including software and hardware shall be furnished for each elevator and delivered to the Engineer as part of the spare parts inventory. Tools that are designed specifically for tasks associated with elevator inspection, maintenance and repair or that are required for these tasks, and are not readily available through normal purchasing channels are defined as special tools.
- B. Any "Special Tool equipment" that is required to troubleshoot, maintain, adjust, and test the system; the tool/equipment shall remain operational for the life of the equipment.
  - a. Provide all special tools and equipment necessary for making all system adjustments to the signal and speed controller and door equipment. A programming unit, approved by equipment manufacturer (OEM) such as a laptop with 4GB memory, 15-inch display and DVD drive, with all software packages required to setup and program all equipment in the elevator system shall be provided, one per station or location. Software shall be provided for the display unit, DeviceNet, motor drive, if applicable, and any other programmable devices, as well as for the controller PLC. Any hardware or software required for configuring, programming and or communicating to controller or any parts of the elevator shall be submitted to ELES engineering. Using the provided laptop, the contractor shall demonstrate loading, downloading (programming) any and all software that is required for the elevator for all operating needs. This includes display, PLC and any I/O controls. All special tools shall be new and to be provide with casing. No special tools with decaying circuits or clocks are permitted.
- C. Keys: Provide ten (10) sets of keys per elevator to operate all keyed switches and locks prior to completion of the first unit.

#### **1.10 AUTHORITY COORDINATION:**

The elevators shall not be in service for passenger/public use until all of the following requirements have been met.

1. The Operations and Maintenance Manuals have been approved and received by WMATA.
2. The Training and Student Manuals as well as video record of all training sessions have been approved and received by WMATA
3. The required training has been completed in accordance with this specification.
4. All field tests have been successfully completed.
5. The acceptance testing has been successfully completed.
6. All spare parts have been delivered and received by WMATA.
7. All Special Tools/Equipment and Software have been delivered and received by WMATA.
8. All discrepancies identified by the WMATA's CEI (Certified Elevator Inspector) representative shall be completed.

## **PART 4 – PRODUCTS**

### **4.01 MANUFACTURERS**

- D. The major elevator components shall be the products of one of the three manufacturers of established reputation, except they may be the products, either wholly or in part, of another manufacturer of established reputation provided such items are capably engineered and produced under coordinated specifications to ensure a high grade, safe, and smooth operating system. Also, the major components to be furnished for this project shall be of a make or makes that have performed satisfactorily together under conditions of normal use for not less than one year in at least two other elevator installations of equal or greater capacity and speed.

### **4.02 MATERIALS**

- A. Stainless Steel
  1. Shapes and Bars:
    - a. ASTM A276, Type 304 or 301 for non-exposed components, and Type 316, all finish panels and exposed components.
  2. Plate, Sheet, and Strip
    - a. Over 1/8 inch, ASTM A264 with ASTM A240, Type 316 on ASTM A36 base;
    - b. Under 1/8 inch, ASTM A167, Type 304, Type 316, for all finish panels and exposed components.
  3. Stainless steel finish shall be NAAMM NO.4 with vertical grain.
  4. Stainless steel screws, bolts and nuts shall be used for fastening and shall be AISI Alloy 303.
- B. Steel Sheet and Steel Fabrications
  6. Steel sheet for top enclosure shall be minimum 12-gauge.

7. Steel sheet for hoistway door frame shall be minimum 12-gauge.
8. Steel sheet for corrugated floor decking shall be minimum 10-gauge.
9. Steel sheet for subfloor shall be minimum 3/8-inch thick.
10. Galvanized steel material shall comply with ASTM A123, ASTM A153, and ASTM A653 (G90 Coating) as applicable. All steel sheet and steel fabrications, except lubricated machinery parts, which are not shown or specified to have other applied finishes, shall be galvanized.

C. Steel Finishes

6. Where visible to the public, steel surfaces shall have a baked enamel finish unless otherwise shown.
  - a. Color shall meet the requirements as shown in the finish schedule on the contract drawings.
  - b. Baked enamel finish shall consist of a thorough hot chemical cleaning process, a six-step zinc-phosphate process, two prime coats, and one finish coat of sprayed acrylic enamel (1.25 mils thickness minimum), baked at 350°F for a minimum of 30 minutes.
7. Fasteners

Fasteners securing removable sheet metal materials shall be operable with the aid of simple tools and concealed wherever possible. When the framework to which the metal is fastened is less than 1/4-inch thick, steel backup plates 1/4-inch thick shall be added with tapped holes and clearance holes where necessary. Exposed fasteners shall match the color and finish of the material being fastened, and shall be tamperproof flat-head machine screws of a captive screw fastener design.

- a. Fasteners shall be compatible with materials being fastened.
- b. Fasteners shall be furnished with self-locking nuts or retaining rings (spring washers, toothed disks).
- b. Fasteners shall be equal to or of greater corrosion resistance than the most corrosion resistant metals being fastened.

#### 4.03 EQUIPMENT AND COMPONENTS

- A. The hydraulic elevator drive shall be of the oil-electric type with direct-acting plunger, power unit, oil storage tank, and control equipment. The power unit, storage tank, and associated control equipment shall be mounted in the machine room.
1. Cylinder and Plunger:
    - a. The cylinder and plunger unit shall be designed and constructed in accordance with the applicable requirements of the ASME Code and other applicable codes. It shall be of sufficient size to lift the gross load to the height specified and shall be factory-tested at a pressure of 400 psi. Gray cast iron or other brittle materials shall not be used in the construction of the cylinder and plunger unit. The cylinder shall be coated on the outside to prevent rust and corrosion. The bottom of the cylinder shall be closed and the top provided with an internal guide bearing and a cylinder head. The cylinder head shall be equipped with an adjustable packing gland designed to effectively prevent leakage of oil. A scavenger pump shall be provided to return oil to the system. It shall be located so as not to obstruct the path between the pit entrance and the cylinder.
    - b. The packing gland shall be constructed to permit easy repacking.
    - c. The cylinder shall be provided with a means to release air or other gas and shall have a drip ring below the packing gland to collect all oil leakage.
    - d. The cylinder shall be secured to a support, provided by the Contractor, which will transfer and distribute the load to the floor of the hoistway pit.
    - e. Plunger of built-up construction shall be secured to the car platform by means of a suitable platen.
    - f. Plunger shall be designed to prevent its leaving the cylinder.
    - g. The cylinder shall be isolated from rails, pit channel, building structure and other sources of possible corrosive or galvanic damage by dielectric insulation of the cylinders.
    - h. The cylinder shall be coated with corrosion-rust resistant primer and painted with a dark gray industrial epoxy or other approved paint.
  2. Cathodic Protection
    - a. The cathodic protection shall be provided for cylinders and piping and shall be provided by dielectrically isolating the cylinder and piston from the car platen, pit support structure, and pressure piping.
    - b. Gaskets and pads for dielectric insulation shall be neoprene or approved alternative. Insulating sleeves, washers, and oil line coupling shall be provided where specified or shown.

### 3. Power Unit

- a. The power unit shall consist of a screw-type or gear-type oil pump driven by an electric induction motor with oil control valves, combined in a self-contained unit fabricated of structural steel. Power unit drive motor is specified under Electrical Work (See Section. Submersible units will not be accepted.
- b. The oil pump shall be especially designed and manufactured for hydraulic elevator service. It shall be designed for a steady discharge with minimum pulsation to give smooth and quiet operation. The pump shall be of proper size and shall deliver oil into the cylinder in sufficient quantity and pressure to lift the elevator car with specified load at specified speed. During downward trip of elevator, the oil shall be returned to the tank by gravity.
- c. Geared pumps, when used, shall be provided with accurately cut herringbone or helical gears. The gears shall operate under flooded suction in an accurately machined case with close clearances to assure maximum efficiency. An effective strainer shall be provided in the suction line to the pump. The power unit shall be equipped with a vibration isolation device suitable for use with and approved by the power unit manufacturer. The vibration isolation shall effectively prevent the transmission of power unit vibration to the machine room structure.

### 4. Piping, Fittings, and Couplings

- a. Piping, fittings, and couplings shall be furnished and installed between the storage tank, pump, muffler, valves, and cylinder complete with necessary supports.
- b. All connections between the discharge side of the pump, check valve, muffler, cylinder, and lowering valves shall be of rigid steel with screw, flanged, welded, or approved mechanical couplings.
- c. Pipe supports shall be provided within 12-inches of every change of direction in piping.
  1. Supports shall not be more than 10-feet apart.
  2. Secure vertical runs properly with iron clamps at sufficiently close intervals to carry weight of pipe and contents and provide supports under pipe to floor.
  3. Furnish and install all piping from remote machine room to hoistway, including necessary supports and/or hangers.
- d. Size of pipe and couplings between cylinder and pumping unit shall be such that fluid pressure loss is limited to 10 pounds.
- e. Mechanical couplings, when used, shall be of a self-centering type that provide for some degree of deflection, contraction, and expansion.

1. Couplings that provide for partial or full separation of the two sections of piping being connected are acceptable, provided all other specified requirements are met.
  2. Couplings shall be rated for a pressure at least three times the working pressure of the elevator and shall be so designed that failure of the flexible sealing element or gasket shall not permit the separation of the parts connected.
  3. Flexible sealing elements or gaskets shall be of a type and material suitable for use with the hydraulic fluid furnished.
- f. Where piping, fittings, and couplings supplied by the Contractor are contained within sleeves, conduit, trenches, troughs, or other passage means provided by others to allow for the connection of the power unit with the cylinder and plunger, the Contractor shall provide appropriate devices which shall effectively prevent the transmission of vibration to the surrounding structure.
  - g. The Contractor shall install all piping, fittings, and couplings used to connect the power drive to the cylinder and plunger in such a way that these may be removed and replaced at a future date. When Victaulic is used, there shall be access for inspection and maintenance. Destruction of portions of these items in the process of removal is acceptable but efforts shall be made in the designs to minimize the necessity to destroy items.
5. Valves
- a. Valves shall be of the unitized manifold type with no more than four solenoids and arranged so that all adjustments are individually adjustable without the need for sequential readjustment. Valve shall be designed to ensure that oil flow will be controlled in a positive and gradual manner, thereby ensuring smooth starts, operation, and stops of the elevator car.
  - b. Valves shall be designed for quiet operation and shall be mounted above the storage tank in a manner that allows leakage to drain back to the tank.
  - c. A safety check valve shall be provided which will function to hold the elevator car with rated load at any point when the pump stops or the maintained pressure drops below the minimum operating pressure required holding the car in place.

- d. A manually operated lowering valve shall be provided, which shall permit the manual lowering of the elevator car in the event of power failure. The location of the lowering valve and access to it shall be described in white stenciled lettering on the front panel of the pump unit. The lowering valve operating means shall be easily and readily accessible and unobstructed by the valve wiring, conduits or other equipment. A tank shut-off valve shall be provided to permit isolating the oil in the tank during maintenance operations. The location and orientation of the valve shall allow for safe operation of the handle throughout its range of travel.
  - e. All additional pump relief valves and other auxiliary valves required by the ASME Code or necessary to provide smooth, safe and satisfactory operation of the elevator shall be furnished and installed.
  - f. Any relief valves having exposed pressure adjustment shall have their adjustment sealed after being set to the correct pressure.
  - g. Manual shut-off valves shall be provided in the hydraulic oil line in the elevator pit and in the elevator machine room. In any portion of its travel, the machine room shutoff valve handle shall not intrude in the walk space or work space or obstruct access to other equipment.
6. Storage Tank
- a. The storage tank shall be constructed of steel and shall be provided with a steel cover, protected vent opening, overflow connection and a valved drain connection. Tank shall act as a storage tank only. Suitable gauge glasses shall be provided if the top of the tank is over 4 feet above the floor. An initial supply of oil sufficient for proper operation of the elevator shall be provided. The tank shall have a capacity equal to the volume of oil required to lift the elevator to the top terminal plus a reserve of not less than 10 gallons.
  - b. The oil storage tank cover shall be arranged for easy unobstructed access. Clearance of 24 inches vertical and 18 inches horizontal from tank cover shall be maintained for ease of service.
  - c. The permissible minimum liquid level shall be clearly indicated. The manufacturer's recommendation of type of oil to be used shall be included in the written instruction for the care, adjustment, and maintenance of the equipment. The flash point of oil used shall be not less than 400 degrees F.
  - d. Provide an oil filtering system that removes contaminants that can clog valves and settle in the bottom of the tank.
7. Blowout-proof foil-hydraulic muffler of an approved make shall be furnished and installed in the oil line near the power unit to reduce noise to a minimum.

8. Oil Temperature Control/Tank Heater: Hydraulic oil viscosity/temperature control shall be provided by the application of an internally mounted, thermostatically controlled, tank heater. The oil temperature shall be maintained at a maximum 110 degrees Fahrenheit with the use of a 120 VAC powered tank heater. Unit shall be permanently mounted, integral with oil reservoir, and with a lighted switch/indicator to visually confirm unit is powered. Tank heater shall include the switch for disconnection of power during maintenance/repair operations. Unit shall be hard wired to electrical source per ASME A17.1.
9. Elevator Car Buffers: Heavy-duty spring buffers shall be provided, mounted on the supporting channel or block on the pit floor. The buffers shall comply with the requirements of the ASME Code. Buffer anchorage at pit floor shall be arranged to avoid damaging the waterproofing.
10. Car guides consist of a guide rail and guide-rollers. Guide rails for the elevator cars shall be of planed steel standard T-section. Guide rails shall be erected plumb and parallel with a maximum deviation of 1/8 inch and shall be securely fastened to the bracket or other supports by approved heavy rail clamps.
11. Car Roller Guides:
  - a. The elevator car shall be provided with roller guides.
  - b. Roller guides shall be spring-loaded and allow rail-to-rail and front-back adjustment of the rollers.
  - c. Three or more rollers per guide and shall have 4-inch minimum sound-deadening wheels.

B. Operation:

1. Operation shall be automatic. Automatic operation by means of car and landing buttons. Stops registered by momentary actuation of car buttons to be made irrespective of number of buttons actuated or of sequence in which buttons are actuated.
2. Operating station in car containing bank of buttons numbered to correspond to landing served position indicators. EMERGENCY CALL button, keyed EMERGENCY STOP button, DOOR OPEN/DOOR CLOSE buttons, independent maintenance key switch, and key-operated light and fan switches, with legends as specified. Identification as specified for emergency telephone. Emergency call button connected to bell that serves as emergency signal. Panel finish: Stainless Steel.
3. Landing: Single push-button fixture at each terminal landing. Button fixture having push buttons with UP and DOWN legends at intermediate landing. Button identification as specified for Person with disabilities per latest ADA regulation (ADA rule 4.10.3).
4. Momentary pressure on car button or landing button illuminates that button, which remains illuminated until call is answered. Illuminated buttons serve as visual indication that call has been registered and that car will stop at that landing. The Push Buttons shall be flush, round, have a Metalized Halo and center jewel. The metalized halo shall be from different color and approved by ELES Engineer.

5. Stops, registered by momentary actuation of landing buttons. All stops subject to respective car or landing button being actuated sufficiently in advance of arrival of car at that landing to enable stop to be made. Direction of travel for idle car established by first car or landing button actuated.
6. UP landing calls answered while car is traveling in up direction and DOWN landing calls answered while car is traveling down, car reversing after uppermost or lowermost car or landing call has been answered and proceed to answer car calls and landing calls registered in opposite direction of travel.
7. Elevators to park at the secure landing level selected by the Engineer.
8. Push-button units to be Dupar US85 or approved equal with button identification as specified by latest ADA regulation.
9. Emergency-stop shall be key operated rather than push-pull arrangement with key removal only in off position.
10. All elevator car control panel operating devices shall be designated by Braille and by raised standard alphabet characters for letters, Arabic characters for numerals, and standard symbols as required by the Code and ADAAG.
11. Lettering shall have a highly visible coloring, such as white, that is permanently affixed.
12. Independent Service: Provide a key switch in the car operating panel which, when actuated, shall cancel previously registered car calls, disconnect the elevator from the hall buttons and allow operation from the car buttons only. Car door shall remain open unless closed fully by the door close button.
13. Two-Stop Collective Simplex Automatic Operation:  
The two-stop collective simplex automatic operation shall be used and checked for the following:
  - a. System shall be designed so that when the car is standing at either terminal landing, pressure on car button for the other terminal shall automatically dispatch car to that landing. Pressure of landing button at either terminal landing shall call car automatically to that landing. If a landing call is registered while the car is making its trip, that call shall remain registered until the car responds to that call. If no car calls are registered car shall start automatically and respond to hall calls. Provide time limit relay arranged to hold car at landing at which it has stopped for predetermined time after car stops. After all car landing calls have been answered, car shall remain parked at landing where last used with car and hoistway doors closed until another call is registered. Pressing the landing button at floor at which car is parked shall automatically open car and hoistway doors. In all normal operations, the starting of the car shall be contingent upon establishment of hoistway door interlock and car door circuits.

- b. Automatic dispatching operation: all two stop elevators shall include "Step-in-and-Go" feature. Calls for the opposite landing will be automatically set when the elevator opens its doors for a hall call. This feature shall be provided for all elevators that have public access for two stops (i.e., any elevators with key operated service landings will be included).

C Position Indicators:

1. Car indicator: In accordance with ADA requirements. Mounted in vertical row in car-operating panel to show position of car in hoistway by illumination of indicators corresponding to landing at which the car is stopped or passing. Finish for exposed-to-view metal components: Stainless Steel.
2. Landing indicator: In accordance with ADA requirements. Two-element direction-of-travel indicator mounted above call station or hoistway entrance as shown, including one red and one white indicator. Direction of car's operation shown by illumination of red indicator for DOWN and white indicator for UP.
3. In-car signals: Audible signal indicating car's direction of travel, signal sounding once for UP direction and twice for DOWN direction.
4. Landing signals: Audible signal at each hoistway entrance indicating car's direction of travel, signal sounding once for UP direction and twice for DOWN direction.

D. Lighting:

1. Machine Room Emergency Lighting: Emergency lighting shall be provided in each elevator machine room.
  - a) There shall be a minimum of one lighting fixture.
2. Car interior: LED fixture, 120-volt operation, with clear prismatic glass diffuser, flush mounted in ceiling, cool white bulbs. Illumination level shall be 15-foot candles minimum at car operating panel.
3. Car top and underside of car floor: Medium-base porcelain lamp receptacles, with wire lamp guards.
4. Car Emergency Lighting:
  - a. Fixture: Recess mounted, with stainless steel frame, location as shown.
  - b. Diffuser: Prismatic polycarbonate plastic.
  - c. Lamps: Two, size 16-51
  - d. Remote power supply:
    - 1) Power pack: Sealed gel cell battery with integral regulating charger and an alarm bell.
    - 2) Capable of operating bell for one-hour minimum and light at car-operating panel at 0.2 low candles minimum for four hours minimum.

- 3) Location: in top of car or COP with easy access provided.
- E. Inspection Operation: Key switch in car to nullify car and landing buttons permitting operation of elevator from top of car for inspection purposes:
1. Top of Car Inspection Station: The Inspection Station contains continuous pressure UP and DOWN buttons, emergency stop button and toggle switch to activate inspection devices. The device shall also have an 110v ac outlet for extension cord and provided with a light and guard.
- F. Leveling: Automatic leveling device to stop car within 1/8 inch of landing level regardless of load or direction of travel. Landing level maintained within leveling zone irrespective of hoistway doors being open or closed.
- G. Emergency Service:
1. Controls to return elevator to designated floor by means of key-operated switch outside street or ground floor hoistway entrance in compliance with ANSI/ASME A17.1.
  2. In-car control during emergency operation by means of key switch in compliance with ANSI/ASME A17.1.
  3. Terminals on elevators controllers for connection of circuit from heat and smoke sensing devices, with wiring from sensing devices to elevator controller.
- H. Telephone Facilities:
1. Provide all audio/visual communication, signaling, and monitoring in accordance with ADA and ANSI. "Hands-free" phone integral with control panel, mounted in accordance with ADA requirements; having inscription EMERGENCY TELEPHONE as specified for Person with disabilities; finish exposed-to-view components to match stainless steel control panel; color of letters to contrast with panel.
    - a. Provide emergency communicators in accordance with ADA requirements to include auxiliary push button to summon help and visual feedback indicating that the call has been responded to.
  2. Provide wiring and jacks for a portable self-contained battery-powered maintenance telephone system. Jacks shall be located on car top, inside car, and in machine room. Furnish three telephone instruments for use of maintenance personnel.
- I. Electrical Equipment:
1. Electric equipment for elevator shall be designed, selected, and fabricated in accordance with NEC, NEMA, IEEE, ANSI Standards, applicable jurisdictional codes, and additional specified requirements. All equipment including motors, controllers, service cabinets, circuit breakers, switches, panelboards, indicators, lighting, wiring, conduit, boxes and other appurtenances for proper installation and operation of the elevator shall be furnished and installed by the Contractor.

2. Cable and wire for external circuits between the various items of elevator equipment, exclusive of the traveling cable, shall comply with the requirements specified below. The talk pair of the voice communications intercom system shall be shielded with 0.008-inch, minimum, copper shield.
  - a. General Requirements for Single-Conductor and Multiple-Conductor Cable:
    1. Type and size: As shown or as required by code.
    2. Rated voltage: 600 volts.
    3. Conductors:
      - a) ASTM B3 or ASTM B8 annealed copper
      - b) Size 10 AWG and smaller: Solid or Class B or Class C stranded.
      - c) Size 8 AWG and larger: Class B stranded.
      - d) Other constructions as specified.
    4. Standards: Except as modified, wires and cable complying with the following:
      - a) Cross-linked polyethylene (XLPE) insulated cable: NEMA WC 70.
      - b) Other cable: NEMA WC 70.
    5. Nonmetallic jacket for single-conductor cable and individual conductors of multiple-conductor cable and as overall covering on multiple-conductor cable:
      - a) Chlorosulfonated polyethylene, or cross-linked polyolefin.
      - b) Cross-linked polyolefin complying with the following physical requirements.
    6. Properties tested in accordance with NEMA WC 70 if ethylene-propylene-rubber (EPR) insulation is used, or with NEMA WC 70 if cross-linked polyethylene insulation is used. Jacket material free of PVC and PVC-based compounds.
      - a) Tensile strength, minimum pounds per square inch: 1,800.
      - b) Elongation at rupture, minimum percent: 150.
      - c) Aging requirement: After 168 hours in air oven test at 100EC, plus or minus one degree C:
        - a) Tensile strength, minimum percentage of unaged value: 100.
        - b) Elongation at rupture, minimum percentage of unaged value: 80.

- d) Oil immersion: 18 hours at 121EC, plus or minus one degree C, ASTM D471, Table 1, No. 2 oil:
    - a) Tensile strength, minimum percentage of unaged value: 80.
    - b) Elongation at rupture, minimum percentage of unaged value: 80.
    - c) Jacket materials other than cross-linked polyolefin complying with NEMA WC 70. Jacket material free of PVC and PVC-based compounds.
  - e) Flame retardancy: Single-conductor and multiple-conductor cable demonstrating flame retardancy in accordance with the following:
    - a) Single-conductor cable and individual conductors of multiple-conductor cable passing vertical flame test in accordance with UL 1591 or NEMA WC 70. Cable size for testing: 14 AWG.
    - b) Single-conductor and individual conductors of multiple-conductor cable passing vertical tray flame test using ribbon gas burner in accordance with IEEE 1202.
    - c) Multiple-conductor cable passing vertical tray flame test, using ribbon gas burner in accordance with IEEE 1202.
  - f) Applied voltage testing:
    - a) Single-conductor cable and individual conductors of multiple-conductor cable to be given applied ac voltage dielectric strength test, i.e., six-hour water-immersion test.
    - b) For single conductors of multiple-conductor cable, conduct tests prior to assembly as multiple-conductor cable.
    - c) Test procedures:
      - (a) Polyethylene insulated conductors: In accordance with NEMA WC 70
      - (b) Other conductors: In accordance with NEMA WC 70.
- b. Single-Conductor Cable:
- 1. Insulated with ethylene-propylene-rubber with non-metallic jacket or unjacketed filled cross-linked polyethylene. UL-labeled Type RHW or XHHW.

2. Color coding: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.
- c. Multiple-Conductor Cable:
1. Individual conductors:
    - a) Number of conductors: As shown or as required by code.
    - b) Construction: Complying with one of the following:
      - a) Insulated with ethylene-propylene-rubber, with or without nonmetallic jacket as specified.
      - b) Insulated with composite compound of ethylene-propylene-rubber and polyethylene, UL Class EPCV, without outer jacket.
      - c) Insulated with filled cross-linked polyethylene without jacket.
    - c) Phase and neutral conductors: Individually insulated.
    - d) Neutral conductors: Same size as phase conductors.
    - e) Bare ground conductors: Sized in accordance with the NEC, unless otherwise shown.
    - f) UL-listed as Type RHW or XHHW.
  2. Conductors assembled with nonwicking, flame-retardant filler to form cable of circular cross section.
  3. Metallic-sheath: Provide one of the following
    - a) Continuous smooth aluminum sheath in accordance with NEMA WC 70.
    - b) Continuous corrugated aluminum sheath in accordance with NEMA WC 70.
    - c) Interlocked aluminum tape armor.
    - d) Multiple-conductor cable provided with overall nonmetallic jacket as specified.
    - e) Cable UL-listed as follows: Metallic-sheathed cable: Type MC, suitable for wet and dry locations.
  4. Color coding:
    - a) Power cables: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.
    - b) Control cables: In accordance with NEMA WC 70
- d. Fixture Wire: UL 62, with the following additional requirements:

1. Type: Suit temperature rating of lighting fixture, minimum 194EF.
  2. Conductor: Stranded copper conductor 16 AWG or larger as shown.
- e. Bare Conductor: ASTM B3 or B8, annealed copper conductor; 8 AWG and larger, class B stranded.
3. Traveling Cable
  - a. The elevator car traveling cable shall be type ETT conforming with the requirements of the NEC with minimum conductor sizes as specified in the NEC. Individual conductors in the cable shall have a distinctive color code for identification. Each traveling cable shall have one two-conductor stranded 18 AWG, twisted shielded pair for elevator intercom and a minimum of ten spare conductors. Traveling cable exceeding 100 feet in length shall have steel supporting fillers. Traveling cable 100 feet or less in length shall have steel or non-metallic fillers.
  - b. For surface elevators only, the traveling cable shall be provided in addition to the above requirements, with one RG-6u coaxial cable, and one two-conductor, twisted shielded pair, stranded 18 AWG power cable for CCTV camera.
4. Connector, Terminal Lugs and Fittings
  - a. In accordance with UL 486.
  - b. For 10 AWG and smaller conductor cable: Tin-plated copper pressure connectors with nonflammable, self-extinguishing insulation grip with temperature rating equal to that of conductor insulation.
  - c. For 8 AWG to 4/0 AWG conductor cable: Tin-plated copper compression connectors and terminal lugs with insulating sleeve or heat shrinkable insulator for insulation grip.
  - d. For multiple-conductor cable: Watertight aluminum fittings with stainless steel pressure ring and set screws or compression cone for grounding of aluminum sheath of Type MC cable.
  - e. Terminal lugs used for bonding connections to metallic structures shall be installed on bare/uncoated metallic surfaces to assure minimum contact resistance.
  - f. All wires shall run inside conduits. Wires and cables shall not be spliced inside or outside of conduit. Wire and cable shall only be connected at terminal strips or devices inside boxes, controller or approved enclosures.
5. Self-extinguishing nylon bundling straps having a temperature range of minus 65EF to plus 250EF shall be used for bundling or cabling of conductors where required. Strap shall have a hub complete with stainless steel locking barb on one end and a taper on the other.

6. Conduits and Fittings:
  - a. Rigid conduit and fittings shall be UL-Listed rigid galvanized steel conforming to the requirements of UL 6 and ANSI C80.1. The minimum diameter shall be 3/4 inch for power circuits, one inch for fire and intrusion circuits, and two inches for audio and control circuits.
  - b. Liquid-tight flexible conduit shall conform to the requirements of UL 360 and consist of a flexible galvanized steel core containing a copper bonding conductor spiral-wound between convolutions and a neoprene or PVC jacket overall. Fittings for liquid-tight flexible conduit shall be watertight and shall conform to the requirements of UL 514.
  - c. All conduits (rigid steel and liquid tight flexible) should be permanently secured with metallic clamps. Zip ties are not acceptable to use as permanent use.
7. Auxiliary gutters, wireways, and raceways shall be constructed of galvanized sheet steel conforming to the requirements of the NEC and shall be UL-listed. Raceway, conduit and wireways within the hoistway exposed to public view shall be concealed within steel cladding.
8. Electrical Boxes:
  - a. Outlet, junction and pull boxes shall be galvanized sheet steel or galvanized malleable iron, cast iron or ductile iron conforming to the requirements of UL 50, UL 514 and NEC paragraph 370-C. Pull boxes shall have screw cover with a liquid-tight gasket.
  - b. Junction boxes on car bottom and hoistway connecting the traveling cable shall contain approved terminal blocks for connection of traveling cable conductors. Terminal blocks shall have indelible identification numbers for each terminal connection.
  - c. All wire connection terminal blocks shall have the same identification number as labeled on the associated electrical wiring. All electrical wires shall use a labeling tube and heat shrink and match the terminal numbers.
  - d. During field installation of junction boxes or control boxes, the contractor/subcontractor shall not drill or cut into the top sides of the box for wiring.
  - e. All boxes shall be accessible without removal of other components.
  - f. All boxes in machine room or pit shall be mounted on strut channels in order to prevent future corrosion and water damage. The strut channels shall be mounted on the wall and has a minimum of 1-1/2 inches thickness and 18 inches above the floor.
  - g. All solid state and electrical components located on top of the car enclosure or in the hoistway shall be installed within NEMA 4X enclosures.

9. Disconnect Switches for Car Lights and Mainline Power
  - a. Disconnect switches shall be the following: UL 98, NEMA KS 1, heavy-duty, quick-make/quick-break switching mechanism with operating handle external to enclosure, with positions labeled ON and OFF, defeatable interlock to prevent opening of enclosure door when switch is ON. Enclosures shall be NEMA 250 Type 4x. Label disconnect switches in accordance with the NEC.
  - b. Mainline power disconnect switch shall be located in close proximity to the machine room entrance and shall be easily identifiable from other disconnect.
10. Circuit Breakers and Panelboards
  - a. Circuit breakers shall be the following: NEMA AB 1, UL 489, molded-case, bolt-on quick-make/quick-break, mechanically trip-free switching mechanism, with thermal trip for inverse time delay overcurrent protection and magnetic trip for instantaneous short-circuit protection. Designed to carry continuous rating in ambient temperature of 40°C.
  - b. Panelboards shall be the following: UL 50, NEMA PB 1, latch and handle in accordance with UL 50, minimum side gutter size of four inches, bus bar of 98-percent-conductivity copper with contact surfaces silver-plated or tin-plated, rating of neutral and ground buses equal to phase bus rating, neutral bus mounted on insulated block, neutral and ground buses equipped with integral mechanical connectors, one-inch high engraved plastic nameplate with 2-inch high letters on black and attached with stainless steel fasteners. Enclosures shall be NEMA 4.
11. Pit Receptacles and Lights
  - a. Electrical power receptacles shall be furnished and installed in the elevator hoistway, pit, and top of car as shown or required by code. Each receptacle shall be duplex, ground fault interrupter type, resettable at the receptacle; waterproof; grounded; rated for 120 volts at 20 amperes.
  - b. Maintenance lighting shall be furnished and installed in the elevator hoistway as shown or required by code. Lighting shall be vapor-tight service lights with quick start type PL compact fluorescent lamp. Furnish and install light switches; waterproof; grounded. The light switches shall be so located as to be accessible from the pit access door.
12. Drive Unit Motor
  - a. Motor shall be designed specifically for elevator service. The drive motor shall be of the alternating current, intermittent duty, 120 starts per hour, 1.15 service factor, squirrel cage induction type design adapted to the severe requirements of elevator service. Elevator drive motor shall be single-speed. The motor shall be suitable for operation on a 480-volt, three-phase, 60-Hertz supply and capable of developing the required starting torque.

- b. The motor shall be rated in accordance with NEMA Standard MG 1 for 60-minute rating motors and shall have sufficient capacity to operate the elevator with specified rated load at specified rated speed without overheating. The insulation and the starting and running torque of the motor shall be capable of permitting operation in accordance with NEMA MG 1. Standard factory motor test data and motor dimensions shall be submitted to the Contractor for approval. Each motor nameplate shall include the motor hp rating, voltage, full-load amperes, locked rotor amperes, full-load speed, design temperature rise, and NEMA design rating of the motor. Each motor shall be provided with ring or other suitable lifting means. The motor frame shall be tapped and drilled for a copper cable grounding connection.
- c. Insulation of windings shall be NEMA Class B, fully impregnated and baked to prevent the absorption of moisture and oil. The insulation resistance between motor frame and windings shall be greater than one megohm.
- d. Motor bearings shall be of the ball or roller type arranged for grease lubrication and fitted with grease gun connections and drain plugs or fitted with sealed-for-life bearings. The bearings shall incorporate dust-tight lubricant seals.
- e. Motor shall be provided with an electronic soft start feature and thermal overload protection for each phase.
- f. Connect motor and pump with multiple V-belt.
  - 1. Belts and sheaves shall be sized for duty involved and designed to prevent any metallic contact between motor and pump shaft.
  - 2. Furnish and install isolation units of rubber in shear to prevent transmission of pump and motor vibration to building.
  - 3. Furnish and install expanded metal sheave guard that can be easily removed for servicing and inspection.

13. Elevator Controller:

- 1. An Allen Bradley (or ELES Engineering approved equal) PLC-based controller shall be provided, governing starting and stopping as well as preventing damage to the motor from overload or excessive current. It shall automatically cut off the motor current and bring the car to rest in the event any of the safety devices are activated.
  - a. System shall coordinate the functioning of elevator drive unit relative to actual location and status of elevator. It shall interface with door control and all required safety circuits, switches and devices. The controller shall be mounted in a NEMA 4X stainless steel air-conditioned cabinet within the controller room.

- b. The diagnostic system shall be an integral part of the controller and provide user-friendly interaction between the service person and the controller system.
    - c. The supervisory logic shall be performed by a main controller or coordinated between the elevator controllers which will interface directly into the Allen Bradley DH485 protocol Remote Monitoring network, transmitting data from the elevator controller through a data concentrator to the Authority's AEMS RTU computer control and data system. The supervisory logic will coordinate dispatching assignments, interfacing operational demand data accumulated from car and corridor operating fixtures, selector and door control functions.
    - d. Controller shall be capable of operating with an operating temperature range of 32<sup>0</sup> F to 140<sup>0</sup> F with non-drip environment and no more than 90 percent relative humidity. However the air conditioner on controller cabinet shall maintain the operating temperature in range of 50<sup>0</sup> F to 90<sup>0</sup> F.
2. An Allen Bradley CompactLogix 1769-L32E (or ELES Engineering approved equal) based PLC control system shall be provided.
  - 1) The exclusive Allen Bradley DH485 protocol data port will transmit data from the elevator controller to the station or facility data concentrator. The contractor shall provide a controller data interface to a DH 485 network. Contractor shall provide Data cables to connect from the PLC controller to data concentrator in the station and available for connection to the controller DH485 interface. The contractor shall pull Belden 9842, or ELES Engineering approved equal, cables to connect the controller into the monitoring DH485 network. The DH 485 controller interface shall be programmable for data rates up to 115 Kbps. The interface shall allow other nodes such as other elevators and escalators to be readily incorporated into the DH 485 network.
  - 2) A data concentrator PLC shall be installed using an Allen Bradley MicroLogix 1400 or SLC5/05 per station to function as data concentrated or to consolidate data from all controllers in the station. The software for the data concentrator shall receive controller data over the local monitoring DH 485 network and provide formatted data to the AEMS RTU through an RS232 link. The data concentrator shall provide an Ethernet port for interfacing with the WMATA wide area network. A data concentrator connection to the WMATA wide area network shall be provided.
3. The PLC shall accommodate the following Signal List, as Applicable, and provide data to the data concentrator as specified in specification.

4. The PLC CPU module shall store the last 99 faults, accessible via laptop connection, controller fault/status display and remote communications. The contractor shall provide WMATA with a programming and monitoring unit, such as a laptop computer with the newest version of Allen Bradley RS-Logix and any other software required to setup and program all electronic items in the control system, for each elevator, for the purpose of troubleshooting and remote monitoring modifications. The laptop should allow uploading, editing, and downloading any software that is being used on this elevator for any operation
5. An Allen Bradley PanelView Plus 6, EZAutomation or ELES Engineering approved equal, fault/status display/interface shall be provided in the controller cabinet. Control system timers and other setup criteria shall be programmable through this unit. All fault, status and setup data shall be stored in the controller CPU module.
6. In cases where the programming is done by the supplier, the supplier shall provide a copy of all working programs, including labels for all inputs and outputs, data tables and internal logic points, on Flash Drives/CD-R disks as well as a printed program listing. The programs and setup data shall require a password for access and modification. The password shall be provided to ELES Engineering as part of the Submittal.
7. The main control of an elevator shall contain at least the following devices or electronic sensing: phase failure line voltage monitor, motor current and ground fault monitor.
8. The controller cabinet shall contain a permanently mounted fault indicator panel with LED indicator lights. Tripped safety devices, door position, door reversal, car running status, and control system status shall be indicated.
9. All terminals shall have identification markings and all wires, including field wires, shall be provided with permanent heat shrink sleeve cable markers. These wiring identifications shall be provided in the wiring diagram at each end of the circuit connections.
10. The controller shall be equipped with the AC vector drive installed in-line before the motor contactor and the motor.
11. The AC vector drive shall be capable of accelerating and decelerating the motor smoothly and gradually.
12. Adjustable settings for acceleration and deceleration ramps shall be provided.
13. The controller shall have, at least, one dedicated serial port for interface to the DH485 monitoring network and programming access without disconnecting any other port.
14. The Programmable Controller shall have, at least, one dedicated port to support the controller fault/status display.
15. The controller PLC shall provide the following Remote Monitoring and diagnostic network support:
  - a) All applicable faults, statuses and data listed in Table 1 shall be provided

- b) Fault indications shall remain until reset in the controller.
  - c) Status and analog data shall be provided for the duration of the condition.
  - d) Software in the controller PLC shall format monitoring data responses to data concentrator polling as specified in the specification.
  - e) The monitoring data port in the controller shall be setup for DH485 protocol with the port network identification number programmed for the particular elevator identification. For instance, identification number 11 applies to elevator 1, 12 to elevator 2, etc.
  - f) All faults, statuses and data shall be held by the controller CPU and sent from the CPU when polled by the data concentrator.
16. Provide sufficient non-volatile CPU memory, for non-volatile retention of program memory, system status and operating parameters.
17. Diagnostics
- a) The processor shall have built-in diagnostics and self-test, such that each time power is cycled, the processor does a complete CPU and RAM memory test. Additionally the power-up test will momentarily light up all diagnostic LEDs to be sure they are working. A power up test will not be performed if the internal flag (bit) for Firemans Service Phase I is latched. The processor shall be capable of reporting major and minor fault codes and processor status information back to the data concentrator, provided the fault is not a catastrophic hardware failure where the processor is unable to power up.
  - b) The processor shall have a built-in watchdog timer to ensure that all processor program scans occur within the time limit set by the watchdog timer.
  - c) The processor shall have individual LED indicators that are clearly visible and labeled for easy identification. At a minimum the following indicators must be provided:
    - (1) CPU is in RUN mode
    - (2) CPU is FAULTED
    - (3) CPU battery is LOW
    - (4) I/O points are FORCED and are not under program control  
COMMUNICATION channels are active.
18. Input/Output Modules
- a) The Input/Output modules shall be compatible with the PLC processor I/O structure. Each module shall be provided with a detachable terminal strip to connect wiring to the module. Each wire on the terminals shall be identified by the module terminal.
  - b) Discrete Input Modules: Suitable for the input voltage and compatible with the Allen Bradley system.
  - c) Discrete Output Modules: Suitable for the voltage and load and

compatible with the Allen Bradley system.

- d) Analog Input Modules: Converts analog signals to proportional twelve-bit binary values. The module shall accept 4 to 20 mA signals. Provide modules compatible with the Allen-Bradley system.

19. I/O Chassis and Power Supply

- a) The controller chassis shall have an additional three spare modules
- b) Power supplies shall provide power to the PLC processors, I/O and other function modules. The power supply shall be suitable for operation of 120 VAC, single phase power. Power supply capacity shall be a minimum of 150% of the connected load.

20. Air Conditioning

Provide an independent air conditioning unit for each controller to maintain manufacturers' recommended operating temperatures. Condensate from the air conditioning unit must be piped to a suitable drain.

21. Selective Collective Operating: As defined by ASME A17.1 and shall be the pressure upon one or more car buttons to correspond to landings in the order in which the landings are reached by the car, irrespective of the sequence in which the buttons are pressed, provided the hoistway door interlock and car door switch circuits are completed. During this operation, the car shall also answer calls from the landings, which are in the prevailing direction of travel. Each landing call shall be canceled when answered
- a. Momentary pressure on car button or landing button illuminates that button, which remains illuminated until call is answered. Illuminated buttons serve as visual indication that call has been registered and that car will stop at that landing.
  - b. Operation shall be automatic by means of the car and landing buttons. Stops registered by the momentary actuation of the car or landing buttons shall be made in the order in which the landings are reached in each direction of travel after the buttons have been actuated.
  - c. UP landing calls answered while car is traveling in up direction and DOWN landing calls answered while car is traveling down, car reversing after uppermost or lowermost car or landing call has been answered and proceed to answer car calls and landing calls registered in opposite direction of travel.
  - d. Should both an up and a down call be registered at an intermediate landing, only the call responding to the direction in which the car is traveling shall be canceled upon the stopping of the car at the landing.

22. Supervisory Control: A processor based system to coordinate dispatching assignments, interfacing operational demand data accumulated from car and corridor operating fixtures and other special feature commands issuing from computer processing, selector and door control functions. Incorporate in the system specific operational features as herein described.
- a. Allocate service to demand, make decisions to prevent crowding, save energy, and provide efficient coverage throughout the building. Respond in real time to prevailing traffic conditions as well as historical traffic patterns.
  - b. Constantly compare passenger demand, car load, anticipated demand, car motion status, machine status and other prevailing conditions and evaluate this information in the context of the following dispatching approaches:
    - 1) Give priority to contiguous calls, assigning calls on adjacent floor to the same car if other criteria is satisfied.
    - 2) Give priority to coincident calls, having the same car let a riding passenger off and a waiting passenger on at the same floor.
    - 3) Anticipate demand based on hall calls and car calls already registered and floors with a high possibility of demand.
    - 4) Evaluate relative system response time for each car in the group, weighing all of the above factors.
    - 5) Allocate calls and position cars to minimize waiting time, response time and travel time. The other elevator shall respond for hall calls without any delay after the first elevator leaved the door zone.
    - 6) When there is a hall call registered and an elevator left the landing, the other elevator shall run toward opposite landing.
  - c. Provide the capability to make both car to call or call to car assignments.
  - d. During light traffic conditions, assign cars without demand to specific parking areas until requested for a hall call. Continuously evaluate dispatching assignment and immediately release a car from its assigned area to meet heavy demand elsewhere in the building.
  - e. In determining relative system response time for a car to answer a hall call, factor in round-trip calculations for each car as well as other system parameters before deciding which car shall respond to a hall call.

23. Other Features:
    - a. Independent Operation: Provide TWO-position keyed switch (ChicagoLock 7500) marked Independent Service, OFF and ON in the lower portion of the car operating panel of all cars. The switch shall be spring loaded type. When placed in ON position, car will be removed from the automatic operating system and will not respond to demands registered at the hall push buttons. It will respond only to floor with doors open until another demand is registered in the car. Demands registered at the landing will remain registered until answered by another elevator. The car only responds to car calls and that the doors remain open after a stop until closed by continuous pressure on the door close button.
    - b. The controller shall be designed to operate automatically on standby power.
  24. Control Room Two Way Communication Device: Provide within each controller/machine room a two way communication device that will interface with any type of ADA compliant telephone. The device shall be mounted directly on or within hands distance proximity to the elevator controller.
  25. Any junction boxes installed in the machine room or hoistway shall be accessible for Maintenance.
    - a. Drilling or opening top end of enclosure is not acceptable
    - b. Wire nuts or splicing without terminal strips is prohibited.
    - c. All openings shall be properly sized for the conduits.
- J. Emergency Lowering
6. Provide a separate battery powered unit that senses loss of power and which shall operate as follows:
    - a. Elevator automatically descends to bottom landing.
    - b. Doors open automatically when car arrives at bottom landing and remain open until power is restored.
    - c. Elevator shall remain inoperative until normal power is restored.
  7. The system shall differentiate between actual power failure and manual operation of disconnect switch.
  8. Failure protection (operational/power) battery shall be a 12 volt minimum, sealed, lead-acid, or approved alternative. The separate box shall be used for battery and not stored within the main controller.
    - a. Unit shall be connected to a power source
    - b. Unit shall automatically maintain the battery at its proper charge.
  9. Provide a manual lowering valve to allow the car to return to the lowest landing. The manual lowering shall be easily accessible and reachable.
  10. Provide all wiring, sensors and associated connections to the main line power and disconnect.
- K. Elevator Hoistway Entrances and Doors

1. Doors of elevators shall be of the horizontal sliding type, single-speed, center-opening. All elevator door openings shall be a minimum of 42-inches wide per the Americans with Disabilities Act.
2. Entrance frames shall be of welded or bolted construction for complete one-piece unit assembly. All frames shall be securely fastened to fixing angles mounted in the hoistway and shall be type 316 stainless steel. Provide an additional type 316 stainless steel sill angle support. The landing sills shall be extruded stainless steel with a mill finish.
3. All materials and finished surfaces exposed to public view shall be stainless steel with embossed finish and/or glass panels as indicated on Contract drawings. Glass panels (if provided) to be completely flush with door assembly. In a glass hoistway the struts or any brackets should not be visible to public.
4. Fascia and Dust Cover in the hoistway shall be galvanized or type 316 stainless steel and extend at least the full width of door opening on each side. Toe guard shall be fastened to the sill at the lowest landing.
5. Hoistway doors are to be stainless steel and provided with keyways as required for operating mechanisms and door hangers. Provide glass panels that are completely flush with door, as indicated in A17.1. Each door panel shall have stainless steel bottom guides that run in landing sill slots. Guides shall be replaceable without removing door panels. All doors shall have fixed fire gibs.
6. Interlocks and Contacts:
  - a. The doors at each hoistway entrance shall be equipped with approved hoistway door interlocks of the hoistway unit system type tested as required by the Code. Interlock shall prevent operation of the car away from a landing until doors are locked in the closed position. Interlock shall prevent doors from opening at any landing from the corridor side unless car is at rest at that landing, or is in the leveling zone and stopping at that landing.
  - b. Provide key-operated hoistway door unlocking devices. A device shall conform to the requirements of the Code and shall permit authorized persons to open the hoistway doors from the landing when car is away from landing. The key for emergency use shall be mounted in a receptacle with a breakable transparent cover clearly marked in letter at least 1/8 inch high ELEVATOR DOOR KEY FOR FIRE DEPARTMENT AND EMERGENCY USE ONLY. The location of the receptacle shall be as directed by the Engineer.
7. Provide raised floor/level designations in characters and Braille on each jamb at 60 inches from floor to centerline. Characters shall be two inches high and in accordance with ADA requirements.

- a. Sills shall be stainless steel and shall be supported on and attached to galvanized steel anchors securely fastened to the sill plate support. The sill and its assembly shall be capable of supporting 1260-pound service load for the transfer cart used by WMATA. Grooves for the door guides shall be machined with minimum clearance for the guides. The Contractor shall provide sill plates. Sill plates and all other sill support structure including shims and jack bolts shall be hot-dipped galvanized.
  - b. Struts and closer angles shall be hot-dipped galvanized structural steel angles of sufficient size to accommodate and support the hoistway door header plate. Angles shall be continuous and securely bolted to the sills and building beams or structure above.
8. Hanger supports shall be 1/8-inch minimum thickness formed sections securely bolted to the strut angles.
  9. Fascia Plates: Galvanized Steel cladding reinforced to ensure a flat, even surface throughout, and shall be securely fastened to hanger supports and sills above.
  10. Dust Covers: galvanized or stainless steel cladding which shall extend over the hanger support the width of the jamb opening plus the jamb flanges, at the top landing for which fascia plates are not supplied.
  11. Hanger cover plate sections above the door openings shall be arranged for opening or removal from within the car.
  12. Sill guards: Sill guards (galvanized steel cladding) shall be supplied for the lowest landing. On glass hoistways, they shall extend the full width of the hoistway and to bottom of pit.
  13. Door hangers and tracks shall be provided for each hoistway, sliding door sheave type, two-point suspension hangers and tracks, complete. Sheaves shall not be less than 2-1/4 inch diameter with ball bearings properly sealed to retain grease lubrication and shall be mounted on stands arranged for attaching to the doors by two capscrews. Hangers shall be equipped with adjustable ball bearing rollers to take the up-thrust of the doors.
  14. The tracks shall be high-carbon steel or formed steel with nylon inserts, shaped to permit free movement of the sheaves.
  15. All inside surfaces of doors shall have baked-enamel finish as shown on the finish schedule.
- L. Elevator Components
1. The elevator car and car components shall conform to the requirements of the Code, and shall operate without squeaks or metallic sounds.  
  
Entire car assembly, including car frame and platform, shall be free from warps, buckles, and squeaks and rattles. Joints shall be lightproof.

2. Frame and Platform
  - a. The car frame shall be constructed of structural steel members. The platform shall consist of a steel frame with necessary steel stringers all welded together. The frame and platform shall be braced and reinforced to prevent the transmission of strain to the elevator car. Steel framing shall conform to the requirements of ASTM A500, Grade B, modified to minimum yield strength if required. The variation in straightness of individual members and the frame as a whole shall not exceed 1/8 inch. Secondary straightening may be performed if necessary. The car enclosure shall be securely fastened to the car platform and so supported that it cannot loosen or become displaced during ordinary service, on the application of the car safety or on buffer engagement.
  - b. Platform shall be provided with a steel floor designed for specified loading and sealed watertight. The platform shall be isolated from the cylinder by suitable rubber pads or other equally effective platen isolation.
  - c. All structural steel in the frame and platform shall be hot-dipped galvanized.
3. Car enclosure walls shall be structural steel tubing with stainless steel cladding, in-filled with aluminum framed laminated fully tempered safety glass. Stainless steel cladding shall be #4 satin finish.
4. Railings and Handrails: Car handrails shall be 1/2 inch by 6 inch stainless steel #4 satin finished tube suitably mounted.
5. Car threshold shall be stainless steel with a non-slip surface.
6. Toe Guard Aprons:
  - a. The toe guard apron (cladding) at entrance side of elevator cab shall be not less than 16 U.S. Standard Gauge (USSG) galvanized steel or stainless steel, and shall extend at least three inches beyond entrance jambs at each side. Toe guard shall have a straight vertical face, extending below the level of finished car floor, of not less than the depth of leveling zone plus three inches. The bottom of guard shall extend three inches below vertical face and be beveled at a 15-degree angle from the vertical. The toe guard shall be secured to car platform construction and be reinforced and braced to withstand a constant force of 150 pounds on its face without permanent deformation or deflection exceeding 1/4 inch.
  - b. On glass elevators, the toe guard shall extend full width of cab.
7. Suspended Ceiling:
  - a. The suspended ceiling shall be faced and edged with solid stainless steel panels, 0.075-inch thick with a fully adhered 3/4-inch thick core of noncombustible, sound-absorbent material and backed with galvanized sheet steel. ASTM A653M, G90 coating or better.

- b. Mounting brackets and any necessary holes for the CCTV camera shall be provided on the top of the ceiling, as further specified. Coordinate bracket configuration and location with the CCTV subcontractor.
  - c. Mounting brackets and any necessary holes for the smoke and fire detection sensors shall be provided on the top of the ceiling, as further specified. Coordinate bracket configuration and location with the fire and intrusion system subcontractor
8. Glass shall be laminated fully tempered safety glass conforming to ANSI Z97.1 and the requirements of Specification Section 08\_81\_00.
- a. Glass shall be laminated. Heat-strengthened, safety glass conforming to requirements of ASTM C 1048 and ANSI Standard Z97.1 and shall consist of two pieces of ¼ inch thick glass and a 0.060 inch thick polyvinyl butyryl interlayer, laminated together.
  - b. Color: Tint by Globe-Amerada Co., used as a standard of quality, or comparable and approved equal.
  - c. Weatherproof tape for field installation of final edge seating shall be compatible with the interlayer.
9. Dry Pressure Glazing Materials:
- a. The setting blocks, edge blocks, and face gaskets shall be ozone-resistant, virgin neoprene.
  - b. Setting blocks for installation at each quarter point of the sill shall be 90 durometer, shore A hardness, approximately full channel width, four inches long, and high enough to afford correct cover and 3/8-inch edge clearance for the glass.
  - c. Edge blocks, for vertical installation at the bottom of each joint channel, shall be 50 durometer, shore. hardness approximately full channel width, three inches long, and provide 3/8-inch edge clearance for the glass.
  - d. Face gaskets shall be continuous, 50 durometer hardness, and provide 3/16-inch face clearance both inside and outside.
10. Sub floor material to be nominal ¼" stainless steel to prevent water infiltration between finished floor, cab and platform base.
- Floor covering: Poured Acrylic Epoxy, polymer system or approved equal, color selection and samples to be submitted to the Authority for approval by the Engineer, with slip-resistant surface, ¼ inch thickness, covering elevator car floor area. Flooring shall be non-shrinking, manufactured of prime quality compound, free of calendaring and curing defects, resistant to grease, oil, chemicals, aging, and ozone. Flooring shall be poured incorporating a full membrane system for the entire cab floor width and depth.
11. Emergency exit: Car shall have a top emergency exit conforming to the requirement of the ASME Code, and the applicable jurisdictional requirements. The door shall open toward the top of elevator and shall have a latching mechanism to keep it in place.

12. Ventilation: A 350-cfm two-speed exhaust fan for continuous car ventilation shall be provided and located above the car ceiling or outside the enclosure.
  - a. Ventilating fans shall be securely mounted in place.
  - b. Ventilation openings shall comply with the ASME and local codes, and shall be suitably sized and distributed to provide uniform airflow within the car.
  - c. Connect continuous ventilation fan to emergency power system. Provide battery backup for fan operation of at least 1 hour in the event of power loss.
  - d. The exhaust fan shall be controlled from the car operating panel with Chicago Lock 7500 (similar to existing WMATA Elevators keys).
13. Cab air conditioning (if applicable), in addition to the exhaust fan, shall be installed as specified in the contract and shall be a self-contained, packaged design for easy mounting, maintenance, and replacement.
  - a. Packaged air conditioners shall be installed on the top of the elevator car.
    1. If not installed in original scope, space provisions shall be made for future installation of packaged air conditioning units.
    2. Installation area shall be coordinated with electrical, structural, and other trades to ensure no interferences with current or future installation.
    3. Electrical power of the proper voltage and capacity shall be available for the air conditioning unit installation current or future.
14. Lighting Fixtures and Plug Receptacles:
  - a. Car lighting shall provide a minimum of 15-foot candles measured at any point on the cab floor and shall be of the LED type. Car lighting shall be provided with emergency battery backup upon failure or interruption of normal car lighting. Emergency lighting unit shall provide required lighting for a minimum of four (4) hours. Battery charger shall be capable of restoring battery to full charge within sixteen (16) hours after resumption of normal power.
  - b. Exterior car lighting shall be as specified. On glass-enclosed elevators they shall be concealed under access panels flush with cab top or bottom surfaces, respectively. A duplex plug receptacle shall be provided in the pit and on top and bottom of each car. The lighting fixtures and receptacles on exterior of car shall be controlled by a switch adjacent to each fixture.

- c. Provide 115 volt ac plug receptacle (GFCI) within 12 inches of CCTV camera location. Coordinate the installation of CCTV equipment within the design of the elevator cab as the elevator contractor is responsible for the installation of the camera and wiring to the control room.
15. Car Doors and Door Equipment:
- a. Car doors and door frames shall be suitably reinforced and provided with a laminated stainless steel #4 finish on cab side and baked enamel finish on hoistway side. Doors shall protect the full width and height of car entrance opening when in the fully closed position. Car door frame shall be integral with front wall of cab.
  - b. Hanger cover plate sections above the door opening shall be removable from the hoistway. Doors shall be guided at the bottom by composition gibs engaging threshold grooves with minimum clearance.
  - c. Car/Hoistway Door Operator: Car and hoistway doors at each landing shall be opened and closed quietly and smoothly by a direct current electric operator.
  - d. Door operation automatic at each landing with door opening being initiated as car arrives at landing and closing taking place after expiration of specified time interval, with electric contact to prevent starting elevator away from landing unless car door is in its fully closed position.
    - 1. Time door closing to start 5 seconds minimum from notification that car is answering landing call.
    - 2. Time doors to remain open five seconds minimum.
    - 3. Time shall be adjustable to 20 seconds.
    - 4. The interval of time that the doors remain open at intermediate landings shall be less for a stop made in response to a landing call. Door open time at a dispatching terminal shall be longer than the time for a stop in response to an intermediate landing call.
    - 5. All door timers shall be adjustable from the controller display panel.
16. Capacity Plate:
- a. The car capacity plate shall be of plain stainless steel and, in addition to data required by the ASME Code, but shall not bear the name of elevator manufacturer.
17. Door Operator Equipment:
- a. Provide a water resistant heavy-duty GAL MOVFR- or ELES Engineering approved equal door operator with encoderless VVVF drive. Closed loop door operator designed to operate car and hoistway doors simultaneously at the speed specified. Door shall open automatically when car stops at landing to discharge

passengers or to answer valid calls and close automatically after predetermined time interval has elapsed. The doors shall be capable of smooth and quiet operation without slam or shock. Door operator to have the following features:

1. ½ hp motor and heavy-duty sprocket, chain, belt, and sheaves.
  2. Closed loop regulated speed performance.
  3. Hand-held keypad programming.
  4. Adjustments can be stored in the keypad and downloaded to another operator.
  5. Adjustable door obstruction reversal.
  6. Optical cams with LED indicators.
  7. Test switches for open, close, nudging and speed zone set up.
  8. Universal inputs for open, close, and nudging.
  9. Reversing switch to back up the door reversal device.
  10. Designed for interior and exterior applications.
- b. Provide a non-contact door reversal device with light immunity: The Door Reopening Device shall cause both the car and hoistway doors to reverse, should they detect an obstruction in the elevator entrance. The device electrical wiring shall be supplied with quick disconnects terminals to facilitate replacement. The infrared curtain detector shall include the following:
- a. A protective infrared detector field extending from 1 1/2" above the car sill to a height of 68".
  - b. A fail-safe control system to prevent the doors from closing in case of power loss to the detector.
  - c. A one-piece full door height protective lens cover designed to be completely waterproof and to withstand impact, abrasion and vandalism.
- M. Normal and final terminal stopping devices shall be provided for elevator conforming to the ASME Code requirements.
6. Final terminal stopping devices, located in hoistway or on the car and operated by cams, shall be fitted with rollers having a rubber or other approved composition tread to provide silent operation when actuated by the cam.
  7. Normal terminal stopping device may be mounted in hoistway, on top of the car, or in the machine room.
- N. Signal Devices and Fixtures:
- 1) Car Operating Station:

- a. Provide one (1) main station in the front and one (1) auxiliary station. The COP shall be a vertical type.
- b. General: Provide signal fixtures and control devices for each elevator. Buttons and signals shall be tamper resistant of the illuminated type that light-up when activated and remain lit until call or other function has been fulfilled. All signal fixture and control device faceplates shall be of Type 316L, nominal 0.135 inch thick stainless steel with No. 4 finish, unless otherwise shown on the Contract Drawings.
- c. Car operating stations shall contain Braille plates adjacent to each call button. Contractor to coordinate proper landing call outs based on maximum characters as indicated on Contract drawings. Buttons for DOOR-OPEN, DOOR-CLOSE, ALARM, EMERGENCY PHONE call functions are to be supplied. Buttons are to be vandal resistant and of the positive stop type.
- d. Station shall have a locked service cabinet for keyed switches of the car light; exhaust fan, independent operation, GFI duplex outlet as indicated on the Contract drawings.
- e. Provide Emergency Communication: "Hands-free" ADA compliant telephone/intercom.
  - 2) Hall Station: Riser of hall stations of the push-button, call acknowledging, stainless steel, tamper resistant type shall be mounted at all elevator landings. Highest landing shall have a single DOWN button. Lowest landing shall have a single UP button. Incorporate ADA compliant telephone with each hall station. Braille Indicator Plate shall be provided. Faceplate finish shall be Type 316L stainless steel #4 finish. The Hall Station shall be flush to the surface and shall not be projected out.
  - 3) Hall Lanterns:
    - a. Tamper resistant hall lanterns shall be equipped with illuminated (LED type) UP and DOWN signal arrows, but provide single arrow where only one direction is possible. Provided units projecting from faceplate for ease of angular viewing. Match materials, finishes and mounting method with hall stations.
    - b. In conjunction with each hall lantern, provide an adjustable electronic chime signal to indicate that a car is arriving in response to a hall call and to indicate direction of car travel. Signal shall sound one for up direction of travel and twice for down direction.
  - 4) Bell Alarm System: Bell alarm system for each elevator shall be properly located within building and audible outside hoistway when activated by the EMERGENCY ALARM call button on each car control building/station. When emergency stop switch is activated inside fire service box, the bell alarm system should not be activated.

- 5) Firefighters' Service System: Firefighters' service system shall be provided in compliance with code requirements.
- O. Drip pans constructed of 26 USSG galvanized sheet steel shall be provided below all bearings to catch lubricant drippings, except for bearings that are fitted with effective approved grease seals.
- P. Metal parts visible to the public shall be field painted.
- Q. A metal cabinet of suitable size shall be provided in each machine room for the storage of special tools and necessary spare parts. The cabinet shall be mounted on legs or a pedestal, a minimum of 4 inches off the floor. A Mobile Tool Storage Cabinet with wheels is not allowed.
- R. A complete set of special tools or wrenches that are designed specifically for tasks associated with elevator inspection, maintenance and repair shall be provided with a case or suitably mounted in the storage cabinet.
- S. At the expiration of the warranty requirements, the Contractor shall provide a spare parts and service facility in the United States at no additional cost to the Authority from which all manufactured parts and components of the equipment furnished and installed can be obtained for an additional three years.

#### **2.04 KIOSK SURVEILLANCE CONTROL AND COMMUNICATION:**

- A. Surveillance Camera Provisions (Surface Elevators). All requirements for CCTV shall comply with the WMATA SMNT Department.
  1. Space provisions and mounting holes shall be provided for closed-circuit television (CCTV) cameras to be furnished and install by CCTV subcontractor.
    - a. The Contractor shall coordinate with the CCTV subcontractor and install wiring from the CCTV location within the elevator cab to an interface terminal and video transmitter located on the elevator car. Final equipment selection has not been performed and is subject to change. Coordinate model, configuration, and location with the CCTV subcontractor.
      - 1) Power will be required by the video transmitter and CCTV camera and shall be provided.
      - 2) Equipment: Fiber Optic Video Transmitters (Elevator Cameras)
    - b. The Contractor shall work with the CCTV subcontractor to install CCTV subcontractor-provided fiber-optic cable and transmitter to a terminal location specified by the CCTV subcontractor. The Contractor shall tag the cables appropriately, indicating that they are for future use by others.

B. Supply the following status indication, control, and communication functions for each elevator car and landing at an annunciator panel in the kiosk: indication, control, and communication functions in each elevator and landing; and all interconnecting wiring required to provide a complete and operable system. Systems to be provided and installed include the following:

1. Kiosk annunciator panel: Panel shall be a single panel approximately 7-½ by 19 inches. Coordinate design to ensure that the panel is compatible with the mounting provisions, previous designs, and human factors. The panels shall contain:
  - a. Indicators:
    - 1) Visual display of elevator car status, to include landing stopped at or being approached and direction of travel:
      - a) Designate elevator by functional name, e.g., Garage 1.
      - b) For garage elevators designate landing by garage floor level.
    - 2) Out of service because of malfunction.
    - 3) In-Car stop switch is actuated.
    - 4) Continuous audible alarm activated when emergency alarm switch in car is initiated.
    - 5) Indicator lamps shall be LEDs, with life expectancy of 50,000 average rated hours.
  - b. Controls:
    - 1) Out of service.
    - 2) Override control.
    - 3) Door open.
    - 4) Landing selection.
    - 5) Push button switches shall have limited over-travel to prevent damage due to abuse and shall be equipped with lift-up covers to avoid inadvertent operation, have mechanical and electrical life of 25,000 cycles, with integral or isolated illumination circuit and be normally open with momentary action or alternate action circuitry.
    - 6) When the override control switch is OFF, the kiosk controls shall function in parallel with the car and landing controls, i.e., the selective/collective control system shall respond to a kiosk-initiated landing selection with the normal priority afforded the remaining system landing selection and call buttons.
    - 7) When the override control switch is ON, the following actions shall take place:
      - a) If the car is stationary at a landing, it shall remain at the landing and the doors, if open, shall close and remain closed.

- b) If the car is in motion, it shall stop at the first landing reached and the doors shall remain closed.
  - c) The elevator control system shall then respond only to the kiosk controls and car station.
  - d) The car shall park at the designate landing.
- 8) When the OUT OF SERVICE switch is actuated, the elevator shall return to the lowest landing before shutting off.
2. Elevator fire detection sensor: Provide space and mounting holes for smoke and fire detection sensors to be furnished and installed as required by building, electrical, elevator and local codes. Install wiring from the sensor location in the car to interface terminal cabinet in the machine room, for connection from the sensors to the smoke and fire detection system. Coordinate with installers to allow installation of sensors and operational checkout of the system.
3. Passenger - Kiosk communications (VIOP) system:
- a. Communications signal button in elevator car momentary contact to illuminate back-lighted signal button in car and latch on a continuous audible signal and illuminated indicator in the kiosk.
  - b. Communications buttons at landings, momentary contact, to illuminate back lighted signal button at the landing and latch on a continuous audible signal and illuminated indicator in the kiosk.
  - c. Push button in kiosk to activate intercom system and reset indicator lamps and audible alarm.
  - d. Each passenger operated device shall have identification markings as specified for car operating devices.
  - e. The voice communication intercom system shall function as a master remote network. The master station shall be located in the kiosk annunciator panel and shall include a speaker-microphone, audio amplifier, on-off indicator lamp, audible signal device control and push button lamp for the operations. A remote station shall include a speaker-microphone and a communications signal button shall light the signal button and cause a continuous audible signal at the master station and light indicator lamp corresponding to the calling remote station. Communications between master and remote station shall be established upon the actuation of the master station push-button control corresponding to the calling remote station with the master station push to talk control determining the direction of transmission.
  - f. If successive calls are received from other remote stations while communication is in progress with one remote station, the audible signal shall sound the indicator lamps corresponding to the calling remote stations shall light and both shall remain on the indicate waiting calls.

- g. Means shall be provided to clear the indicating lamps independently. Communication initiated from the master station shall be established upon actuation of the push button control corresponding to the called remote station, with the master station push-to-talk control determining the direction of transmission.
- h. The audio amplifier at the master station shall be all solid state in construction and shall control incoming and outgoing volumes for all of the remote stations. The volume levels shall be preset during installation and shall be adjustable to provide a maximum of five watts rms at the speaker-microphones.
- i. The power supply shall supply all ac and dc voltages necessary for all circuitry associated with the voice communications intercom system, and shall operate from the 120-volt ac, 60 Hertz emergency power supply located in the elevator machine room.
- j. The audio amplifier and the speaker-microphones shall have a frequency response of plus or minus three Db from 300 Hertz to 5,000 Hertz. Power consumption shall be 5 watts maximum in standby and 50 watts maximum under load.
- k. The Contractor shall be responsible for shielding, grounding and other measures necessary to protect the voice communications intercom system from interference from other electrical systems.
- l. Speaker grilles shall have a minimum of 35 percent open area over the entire surface of the speaker cone.
- m. Switches and relays used with this system shall have an operating life exceeding 5,000,000 cycles. Documentation shall be provided by the Contractor to the Engineer, for his approval, to substantiate this life cycle level.
- n. The system shall perform adequately, as approved by the Engineer, with both the remote and the master station test personnel speaking from three feet away from the speaker-microphones.
- o. Communication in the car shall also rollover to a 24-hour manned site (Rail Operations Control Center) in the event that the kiosk does not respond to the call.
- p. Each passenger-operated device shall be identified in accordance with ADA/ADAAG requirements.
  - 1. ADA requirement for providing emergency two-way communications between an elevator and a point outside the hoistway (the Kiosk).
  - 2. Device mounting heights shall comply with:
    - a) ADAAG requirements.
    - b) ASME A17.1-2007. The highest operable part of the two-way communication system shall be a maximum of 48 inches from the floor.

- 3. A Braille Instruction Plate shall be permanently affixed on each remote intercom unit.
  - a) ADA Standards: Raised symbol and lettering (Signage) located adjacent to the device.

**PART 3 – EXECUTION**

**3.01 EXAMINATION**

- A. Prior to beginning installation of elevator equipment, examine the following and verify that no irregularities exist that would affect quality or execution of work as specified.
  - 1. Hoistway size and plumbness.
  - 2. Sill pockets.
  - 3. Anchor brackets
  - 4. Sill supports.
  - 5. Spreader/Divided beams.
  - 6. Machine beams and any other supplied by others.
  - 7. Pit Depth
  - 8. Overhead clearance
- B. Do not proceed with installation until previous work conforms to project requirements.

**3.02 INSTALLATION**

- A. Electrical Installation:
  - 6. The Contractor shall install all raceways and wiring necessary for the proper connection and operation of all equipment. The installation shall comply with the applicable requirements of the NEC and local codes.
  - 7. Raceway:
    - a. Rigid conduit connecting the various items of elevator equipment and electrical boxes in the machine room and hoistway shall be run parallel to the ceilings and walls. Metal wireway and auxiliary gutters in the machine room shall run exposed in readily accessible locations and shall not protrude into the working space around equipment.
    - b. Liquid-tight flexible conduit shall be used for connections to motor, limit switch, interlock push-button box, door operator motor, and similar devices. A length of liquid-tight flexible conduit 18 to 24 inches long shall be used for connection to the elevator drive motor.
    - c. Raceway terminal fittings shall be free from burrs, shoulders, or other projections that will reduce internal passage area or cause abrasion of conductors.
    - d. Electrical boxes shall be installed in accordance with the requirements of NEC paragraph 370.

8. Wiring:
  - a. All wiring shall be run in conduit, metal wireway, or auxiliary gutter, with the following exceptions:
    1. Flexible hard-service cord, type SO, used between fixed car wiring and switches on car doors.
    2. The traveling cable connection to the elevator car.
  - b. Wire and cable shall be sized for their respective duty so that the maximum current carried shall not exceed limits prescribed by the NEC and local codes. The minimum sizes of conductor shall be 12 AWG for lighting and receptacle circuits and 16 AWG for operating, control and signal circuits, except for traveling cable, where 14 AWG shall be the minimum size for elevator lighting circuit conductors.
  - c. In glass hoistways, wiring shall be installed only in the locations shown with the requirement that wiring and conduit be hidden from public view.
  - d. The traveling cable shall run from a junction box on the bottom of car to a junction box approximately midway in the hoistway. The cable shall be anchored and suspended to minimize any strain on individual cable conductors. The cable shall be free from contact with the hoistway construction, car, or other equipment. The overall covering of cable shall remain intact between junction boxes. The Contractor shall ensure that the cable shall not bend to a radius less than 12 times the outer diameter at any position of elevator travel.
  - e. Traveling cable shall be suspended by the wire rope center or self-gripping devices where cable weight will not cause excessive crushing forces.
9. Splices and terminations of conductors shall be made only in outlet, junction. Splices in conduit or raceways will not be permitted. Splices and terminal connections shall be made only by means of solderless connectors and terminal lugs as specified. Splices shall be covered with electrical insulating tape to an insulation level equivalent to that of the conductors. Terminal lugs used for bonding connections to metallic structures shall be installed on bare/uncoated metallic surfaces to assure minimum contact resistance.
10. Grounding:
  - a. The Contractor shall be responsible for grounding and bonding all parts of the elevator metallic structure, equipment and raceway in accordance with the applicable requirements of the NEC and the codes and regulations of the jurisdictional authorities. An equipment grounding conductor will be furnished and installed by other trades in each feeder to the elevator machine room and terminated in a disconnect device or junction box.

- b. The Contractor shall provide equipment grounding conductors from the disconnect devices or junction boxes for all feeders and branch circuits as shown and required. Electrical equipment shall be provided with a minimum of two ground paths. One path shall be a green insulated equipment grounding conductor. The second path shall be a connection to grounded metallic structure using metallic fasteners, metallic conduit and/or bonding jumper. In elevator car, bond exposed metallic structures, ac equipment enclosures and lighting fixtures to grounded elevator metallic structure with metallic fasteners as shown.
  - 11. Each device, each terminal, and each wire on the controller panels shall be properly identified by name, letter, or standard symbol in an approved indelible manner, on the device, panel, or wire. The identification markings shall be identical to markings used on the wiring diagrams.
- B. Machine Room Equipment:
- Machine room shall be 168 sq.ft minimum.
- 1. Machine Room Emergency Lighting: Maintained Emergency lighting fittings shall be provided in each elevator machine room.
    - a. There shall be a minimum of one maintained lighting fixture.
  - 2. Clearance around equipment in each machine room shall comply with provisions of all applicable codes. Clear distance for the maintenance purposes shall be at least 18". In no case shall this clearance supersede minimum Code requirements.
  - 3. Equipment in elevator machine room shall be so arranged that replaceable items can be removed for repair or replacement either by overhead hoist and dolly, or other conventional means, without dismantling or removing other equipment components in the same machine room.
  - 4. Machine rooms must be air conditioned and heated to maintain an ambient temperature of 50<sup>0</sup> F to 90<sup>0</sup> F degrees and a relative humidity between 35% and 50%. The Air Conditioner shall be Split System. The heating system for the machine room is also a built in system. A forced removal should be done by moving the air from the room to the outside of the building to another part of the building to keep an air exchange through the equipment room. Intake and exhaust vent should not be located close to each other.
  - 5. Any component attached to the controller shall have a minimum clearance of 18 inches from the side(s) of the component requiring access for maintenance and free air circulation.
  - 6. One set of approved electrical and hydraulic diagrams of elevator shall be mounted in an aluminum channel frame with lucite cover and waterproof fiberglass backing and installed adjacent to the appropriate drive machine.

7. Provide Mats of insulating rubber or other suitable floor insulation in the front of the Controllers.
  - a. The Resistance range shall be  $1 \times 10^4 < 1 \times 10^6$  and shall meet ANSI/ESD requirements.
  - b. The rubber mat shall be the width of the controller plus 12".
  - c. The length of rubber mat shall be a minimum of 24".
  - d. The rubber mat shall be a 1/4" thickness and beveled at each end.
- C. Hydraulic Elevator Cylinder
  6. The Contractor shall set the hydraulic elevator cylinders true and plumb
    - a. Dielectric Insulation Installation
      1. Each cylinder shall be electrically isolated from the building steel and other earth ground sources
      2. The following are minimum requirements:
        - a) Install an insulating gasket between the platen plate and floor of the elevator cab. Use insulating sleeves and washers on the bolts.
        - b) Use insulating pads to insulate the cylinder support members (channels) from the guide rails and other structures at ground potential.
        - c) Use insulating sleeves and washers on the bolts that connect the cylinder to the support channels.
        - d) Install an insulating coupling on the oil supply line between the pump and cylinder, located as close to the cylinder as possible.
  7. Insulating gaskets shall be installed in the same manner as a normal gasket.
    - a. Sleeves shall not be forced through misaligned bolt holes. Where misalignment occurs, the holes shall be reamed true, and all metal, chips shall be carefully removed.
    - b. The sleeves shall extend into the plastic washer on both sides of the flange. Any sleeves or washer cracked during installation shall be replaced immediately.
    - c. After making up the flange, the resistance of each bolt to the flange shall be tested using a 500-volt megohmmeter. If the resistance of any bolt is less than 50 megohms, the sleeve and washer shall be checked and changed, if necessary, to provide the required resistance.

### 3.03 DEMONSTRATION

- A. Acceptance Tests:

1. The Contractor shall submit an operational test plan to the Authority for approval. When each elevator, furnished, installed, and tested, is ready to be placed in interim service, the Contractor, at no additional cost to the Authority, shall perform operational tests described below. The Authority shall be notified at least 48 hours prior to each scheduled test so that arrangements can be made for the presence of appropriate personnel to witness the tests. Acceptance Tests and inspections will be based upon the elevator meeting the requirements of the Specification and as evidenced by the operational test shall be witnessed by WMATA representative.

B. Elevator Tests

6. When the elevator work is fully completed, the Contractor shall demonstrate to the satisfaction of the Authority and Authorities Having Jurisdiction that the proper operation of every part of the equipment complies with all applicable requirements including the ASME Code.
  - a. The inspection procedure outlined in the ASME A17.2 will form a part of the final inspection.
  - b. No shop test of elevator motor and no certified test sheets will be required.
  - c. The heating, insulation and resistance of the motors will be determined under actual conditions after installation.
7. The Elevator Contractor shall furnish all test instruments and materials, required at the time of final inspection, to determine compliance of the work with the Contract requirements. Materials and instruments furnished shall include standard 50-pound test weights, megohmmeter, voltmeter and ammeter, Centigrade calibrated thermometers, spirit level, and stop watch. At the time of final inspection, tests shall include, but not be limited to, the following:
  - a. After installation, each elevator shall be tested without load by the Contractor. The elevator shall be subjected to a test for a period of eight-hours continuous run. During the test run, the car shall be stopped at top and bottom levels, in both directions of travel with a standing period of 10 seconds at each landing.
  - b. Full-Load Run Test
    1. The elevator shall be subjected to a test for a period of one-hours continuous run, with full specified rated load in the car. During the test run, the car shall be stopped at top and bottom levels, in both directions of travel with a standing period of 10 seconds at each landing.
  - c. Speed Test
    1. The actual speed of the elevator car shall be determined in both directions of travel, with full specified rated load and with no load in the elevator car.

2. Speed tests shall be made before and after the full-load run test.
  3. For hydraulic elevators, speed shall be determined with a temporarily mounted tachometer on the guide rail or stop.
  4. Car speed when ascending shall be not more than 10 percent above not more than 10 percent below the specified car speed.
  5. Car speed when descending shall be not more than 25 percent above not more than 10 percent below the specified car speed.
- d. Temperature Rise Test
1. The temperature rise of the drive unit motor shall be determined during the full-load test run. Temperatures shall be measured as specified in NEMA and IEEE Standards. Under these conditions the temperature rise of the motor shall not exceed NEMA and IEEE specified temperature rise. Test shall be started only when all parts of equipment are within 9 degrees Fahrenheit of the ambient temperature at time of starting test.
- e. Car Leveling Test
1. Elevator car leveling devices shall be tested for ¼-inch accuracy of landing at all floors with no load in car and with full load in car, in both directions of travel.
  2. One re-level operation is permitted when full load is in the car.
  3. Accuracy of floor leveling shall be determined both before and after the full-load run test.
- f. Insulation Resistance Test
1. The complete wiring system of elevator shall be free from short circuits and accidental grounds. The insulation resistance of the system shall be more than one megohm when tested by using a 500-volt megohmmeter. The elevator structure, equipment, and raceway shall be tested for continuity to ground.

### 3.04 ELEVATOR PROTECTION

1. The finished elevator installations shall be completely barricaded and enclosed to preclude their use without permission of the Contractor until Final Acceptance and release by the Contractor for general use. The enclosure shall be fabricated to allow easy access for maintenance, testing and adjustment.

2. The Contractor shall be responsible for the security of the contents of each machine room. The Contractor shall control access to that room, and ensure that it shall remain secure at all times until the completion of the Contractor's interim maintenance obligation.
3. Protection: During installation and until all elevator systems are fully operational and accepted by WMATA, make all necessary provisions to protect all elevator components from damage, deterioration, and adverse environmental conditions. Do not use or allow the use of the elevator for construction purposes such as hauling materials or worker transport during construction.
4. Security Of Machine Rooms: The Contractor shall be responsible for the security of the contents of each machine room. The Contractor shall control access to that room and ensure it shall remain locked and secure at all times.
5. Field Painting:
  - A. The pit, pit walls and machine room floor shall be painted. All machine room equipment shall be given two coats of approved machinery paint. All new iron work shall be given one coat of rust-inhibiting paint.
  - B. Metal parts visible to the public may be field painted where specifically shown or authorized by the Authority.

### 3.05 MAINTENANCE

The Contractor shall perform full maintenance service for a period of two years on each elevator in accordance with the manufacturer's maintenance manual and WMATA ELES maintenance program prior to WMATA providing permanent maintenance. The period of maintenance shall begin after test(s) and Provisional Acceptance of each elevator and shall extend to the scheduled date of Final Acceptance for all units in the same facility plus a period of two years. In no case shall the interval between inspections and testing be greater than one month. The maintenance service during the warranty period shall be provided by fully trained elevator mechanics. The maintenance tasks shall include, but not be limited to, the following:

- a. Inspection of completed installation and periodic testing to maintain the elevators in completely operable condition.
- b. Contractor shall provide support for periodic, accident and incident, PM compliance inspections.
- c. Lubrication of parts, and the protection of the equipment.
- d. Replacement of defective parts at no additional cost to the Authority.
- e. Annual clean down of the elevator and hoistway enclosure is required. Make necessary arrangements with Authority in order to minimize any inconvenience.
- f. Contractors performing maintenance are responsible for all service, repair work and emergency call. The contractors shall provide

unlimited service during revenue hours and twenty-four (24) hour emergency call back service at no additional cost.

- 1) Provide twenty (24) hour emergency service during the maintenance period consisting of a prompt response (within 1 hour) to emergency request by telephone or otherwise from Authority or designated representative if an elevator is inoperable or in case of injury, entrapment, or potential injury to persons.
  - 2) Unlimited service callbacks are included with a required response time of one (1) hour (including Holidays).
- g. Periodic maintenance (based on WMATA schedule) shall be performed off peak hours to minimize service interruption as long as the other elevator serving the same platform is operational.
  - h. Reporting: Detailed monthly records of tasks performed including names of individuals performing the tasks, date and time performed, and other pertinent data. In addition, the reports are to be provided in an electronic format acceptable to WMATA's needs.
  - i. Contractor performed maintenance shall follow the WMATA Office of Elevator and Escalator Operations procedures, schedules and check charts.

Within three (3) months prior to the termination of this contract, the Authority or his designated representative(s) shall make a thorough maintenance inspection of all equipment covered under this contract. The contractor shall provide personnel to remove, test, and operate equipment as necessary. All deficiencies found as a result of this inspection shall be corrected by the Contractor as required in this agreement with no additional cost for the Authority.

### **3.06 REMOTE MONITORING SPECIFICATIONS:**

- A. Allen Bradley DF1 or ELES Engineering approved equal industry standard Modbus protocol shall be provided to transmit data from the Elevator/Escalator controller to the Authority's AEMS RTU computer control and data system. The Design-Builder shall provide a controller data interface to a DH-485 network located in the Elevator /Escalator machine room. The DH-485 controller interface shall be programmable for data rates up to 115Kbps. The interface shall allow other nodes such as other Elevator or Escalators to be readily incorporated into the DH-485 network. The controller data interface shall include one Allen Bradley SLC PLC per station to function as a data concentrator to consolidate data from all the controllers in the station. The software for the data concentrator shall be as specified by the Authority. The data concentrator shall receive controller data over the DH-485 data network and provide formatted data to the AEMS RTU through a RS 232 link. This data transmission may be accomplished by a separate PLC controller integrated into the control system.

- B. The Elevator /Escalator control system shall automatically initiate the transmittal of data when data is requested by the Authority's AEMS system and continue until all data is received by the AEMS RTU in the station AC switchboard room. The Authority will perform final integration of the data in the AEMS system.
- C. The Contractor shall also provide the required hardware to download data from any fault finding annunciator panel to a supplied laptop PC being utilized at the Elevator/Escalator location. The provided software shall permit the downloading and storage of data on the supplied laptop PC from multiple fault finding annunciator panels.
- D. The Contractor shall install an Allen Bradley network interface module, (model 1761-NET-AIC, or approved alternative) beside the PLC in the controller and provide 24 VDC power to the module. The Allen Bradley PLC will be used for remote monitoring capabilities into WMATA established engineering monitoring network.
  - a) The Contractor shall provide all wiring and programming of the PLC to communicate with station data concentrators on the DH-485 network. Coordinate work with WMATA ELES Engineering.
  - b) The Contractor shall pull all remote monitoring cables to the interface in the elevator controller from the remote monitoring network going back to WMATA's Automated Energy Management System (AEMS) remote terminal unit (RTU).
  - c) Provide Ethernet communication between the elevator machine room and WMATA's communication room. The communication port shall be located less than 6' from the controller and shall have minimum of two ports for data communication.
- E. Terms and Definitions
  - 1. Boolean - A single bit data type.
  - 2. DF1 - A Rockwell Automation Company proprietary communications protocol.
  - 3. DH485 - An industrial communications network used by Allen Bradley programmable controllers.
  - 4. Integer - A data type 16 bit signed (range -32768 to 32767).
  - 5. PLC - Programmable Logic Controller.
  - 6. QEI - QEI Inc. Springfield NJ
  - 7. RTU - Remote Terminal Unit
- F. Elevator Remote Monitoring Data Specification
  - 1. Overview

The design of the WMATA escalator & elevator monitoring system shall include a data concentrator PLC to gather data from the elevator control PLC's over an Allen Bradley DH 485 network or ELES Engineering approved equal. The QEI RTU shall read data from the WMATA data concentrator PLC via an RS 232 serial connection to a 1746-BAST (or ELES Engineering approved equal) module

using Allen Bradley DF1 (or ELES Engineering approved equal) protocol. See figure 1.1 for reference. This specification defines data to be presented by the WMATA data concentrator PLC to the QEI RTU. The WMATA data concentrator PLC station shall pole the escalator & elevator controller(s) periodically for data and format the data into blocks within the WMATA data concentrator. An Ethernet TCP/IP connection is available at the Data concentrator PLC. The data concentrator PLC has been designed to collect data from up to (10) escalators and/or elevators. The data concentrator PLC is to be mounted into the existing QEI RTU enclosures and powered by a 120 VAC source from within the RTU. For Metro stations where more than (10) escalators and elevators are present additional data concentrator PLC's will be required.

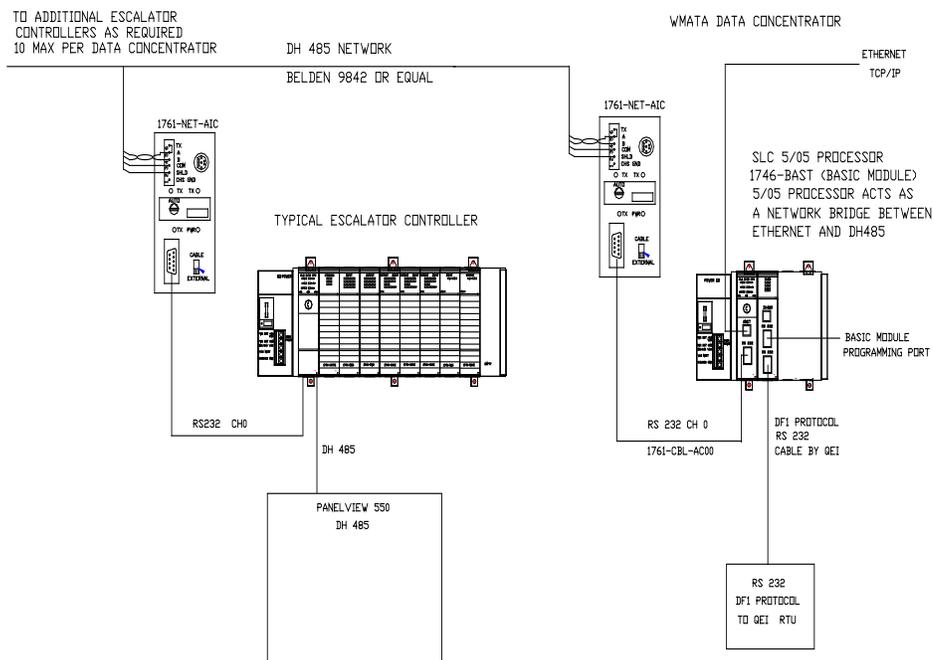


Figure 1.1

2. Data Concentrator PLC Data File Assignments.

The WMATA data concentrator PLC shall store data for up to (10) escalators and/or elevators in any combination as defined in table 2.1.

Table 1

Escalator DH485 node #	Elevator H485 node #	Status bits File	Analog Data File	DC PLC MSG file#	DC PLC MSG buffer file#
1		N20	N21	N81	N101
2		N22	N23	N82	N102
3		N24	N25	N83	N103
4		N26	N27	N84	N104
5		N28	N29	N85	N105
6		N30	N31	N86	N106
7		N32	N33	N87	N107
8		N34	N35	N88	N108
9		N36	N37	N89	N109
10		N38	N39	N90	N110
	11	N40	N41	N121	N141
	12	N42	N43	N122	N142
	13	N44	N45	N123	N143
	14	N46	N47	N124	N144
	15	N48	N49	N125	N145
	16	N50	N51	N126	N146
17		N52	N53	N127	N147
18		N54	N55	N128	N148
19		N56	N57	N129	N149
20		N58	N59	N130	N150
Concentrator PLC (DC)	25	N80	N79		

Each data file shall begin with word 1 (example: escalator #1 status bits begin with N20:1 and end at N20:20)

The data concentrator PLC communication ports shall be configured as follows.

**Channel 1**

Driver: Ethernet  
IP Address: TBD  
Subnet Mask: TBD  
Gateway Address: TBD

**Channel 2**

Driver: DH485  
Baud Rate: 19.2K  
Node Address: 25

1756-BAST basic module communication ports shall be configured as follows.

**Port 1:** Programming port

Settings -- 19,200 Baud, No parity, 8 bits, 1 stop bit, No handshaking

**Port 2:** DF1 port

Settings -- 19,200 Baud, No parity, 8 bits, 1 stop bit, No handshaking

DF1 – Op Code 19 (Full Duplex, NHS, ER, Enable DPD, CRC error checking,

Timeout = 50

Retries = 3

RTS on delay = 20 msec

RTS off delay = 20 msec

Module address = 10

**DH485 Port** – Not Available

**3. Data Format**

Data Concentrator status in File N80 per table 3.0

**Table 3.0 Data Concentrator Status Bits**

WORD	BIT	DATA TYPE	DESCRIPTION	"0" STATE	"1" STATE
1	0	BOOLEAN	Spare		
	1	BOOLEAN	Data Concentrator PLC Battery Status	FAULT	NORMAL
	2	BOOLEAN	Data Concentrator Basic Module Battery Status	FAULT	NORMAL
	3	BOOLEAN			
	4	BOOLEAN			
	5	BOOLEAN			
	6	BOOLEAN			
	7	BOOLEAN			
	8	BOOLEAN			
	9	BOOLEAN			
	10	BOOLEAN			
	11	BOOLEAN			
	12	BOOLEAN			
	13	BOOLEAN			
	14	BOOLEAN			
	15	BOOLEAN			

WORD	BIT	DATA TYPE	DESCRIPTION	"0" STATE	"1" STATE
2		BYTE	Data Concentrator checksum byte1		

3		BYTE	Data Concentrator checksum byte2		
---	--	------	----------------------------------	--	--

Words 4 through 20 of the Data Concentrator status file (N80) are unused.

The Data Concentrator Analog data file (N79) is unused.

#### Elevator data:

Two 20 word (40 BYTE) blocks of data shall be developed for each elevator one block for status bits and one block for analog data. Table 3.3 defines the format of data for status bits. Table 3.4 defines the format for analog data.

**Table 3.3 Elevator Status Bits**

WORD	BIT	FAULT TYPE	DESCRIPTION	"0" STATE	"1" STATE
1	0	FAULT	24 VDC POWER SUPPLY	FAULT	NORMAL
	1	FAULT	SAFETY CIRCUIT GOOD	FAULT	NORMAL
	2	FAULT	TOP FINAL LIMIT TRIPPED	FAULT	NORMAL
	3	FAULT	BOTTOM FINAL LIMIT TRIPPED	FAULT	NORMAL
	4	FAULT	DRIVE FAULTED	FAULT	NORMAL
	5	FAULT	OVERLOAD TRIPPED	FAULT	NORMAL
	6	FAULT	STOP BUTTON ACTIVATED	FAULT	NORMAL
	7	STATUS	IN-CAR ALARM BUTTON PRESSED	ALARM	NORMAL
	8	FAULT	OUT OF SERVICE BY DELAY	FAULT	NORMAL
	9	FAULT	MOTOR LIMIT TIMER TRIPPED	FAULT	NORMAL
	10	FAULT	VALVE LIMIT TIMER TRIPPED	FAULT	NORMAL
	11	STATUS	INSPECTION OPERATION ON	ON	OFF
	12	STATUS	INDEEDENDANT SERVICE ON	ON	OFF
	13	STATUS	VISCOSITY CONTROL ON	ON	OFF

	14	STATUS	CONTROLLER TEST SWITCH ON	ON	OFF
	15	STATUS	FIRE SERVICE PHASE 1 ON	ON	OFF

WORD	BIT	FAULT TYPE	DESCRIPTION	"0" STATE	"1" STATE
2	0	STATUS	FIRE SERVICE PHASE 2 ON	ON	OFF
	1	FAULT	SMOKE SENSOR @ MAIN ON	ON	OFF
	2	FAULT	SMOKE SENSOR @ OTHERS ON	ON	OFF
	3	STATUS	EMERGENCY POWER OPERATION	ON	OFF
	4	STATUS	OVERRIDE ON	ON	OFF
	5	STATUS	CAR IS RUNNING UP	NOT-RUN	RUNNING
	6	STATUS	CAR IS RUNNING DOWN	NOT-RUN	RUNNING
	7	STATUS	BRAKE LIFTED	LIFTED	NORMAL
	8	STATUS	CAR IS IN DOOR ZONE	IN ZONE	IN ZONE
	9	STATUS	INTERLOCKS ARE MADE	OPEN	NORMAL
	10	STATUS	FRONT DOOR GATE SWITCH MADE	OPEN	NORMAL
	11	STATUS	FRONT DOOR FULLY CLOSED	OPEN	CLOSED
	12	STATUS	FRONT DOOR FULLY OPEN	CLOSED	OPEN
	13	STATUS	FRONT DOOR REVERSAL ACTIVATED	OFF	ACTIVE
	14	STATUS	FRONT DOOR PROTECTION ACTIVATED	OFF	ACTIVE
	15	STATUS	REAR DOOR GATE SWITCH MADE	OPEN	NORMAL

WORD	BIT	FAULT TYPE	DESCRIPTION	"0" STATE	"1" STATE
3	0	STATUS	REAR DOOR FULLY CLOSED	OPEN	CLOSED
	1	STATUS	REAR DOOR FULLY OPEN	CLOSED	OPEN

	2	STATUS	REAR DOOR REVERSAL ACTIVATED	OFF	ACTIVE
	3	STATUS	REAR DOOR PROTECTION ACTIVATED	OFF	ACTIVE
	4	FAULT	DOOR REVERSAL DEVICE FAILURE	FAULT	NORMAL
	5	FAULT	ROPE BRAKE SET	FAULT	NORMAL
	6	FAULT	LEVELING SYSTEM FAILURE	FAULT	NORMAL
	7	FAULT	WATER INTRUSION ALARM ACTIVE	FAULT	NORMAL
	8	STATUS	ELEVATOR SLC 5/03 LOW BATTERY	FAULT	NORMAL
	9	STATUS	ELEVATOR SLC 5/03 COMM. ACTIVE	FAULT	NORMAL
	10	STATUS	ELEVATOR SLC 5/03 LOCAL/REMOTE	REMOTE	LOCAL
	11	STATUS	ELEVATOR SLC 5/03 RUN/PROG	PROG	RUN
	12	FAULT	FAULTED	FAULT	NORMAL
	13	STATUS	Out of Service	FAULT	NORMAL
	14		SPARE		
	15		SPARE		

WORD	BIT	FAULT TYPE	DESCRIPTION	"0" STATE	"1"STATE
4	0	STATUS	CAR POSITION 1	NOT AT POSITION	AT POSITION
	1	STATUS	CAR POSITION 2	NOT AT POSITION	AT POSITION
	2	STATUS	CAR POSITION 3	NOT AT POSITION	AT POSITION
	3	STATUS	CAR POSITION 4	NOT AT POSITION	AT POSITION
	4	STATUS	CAR POSITION 5	NOT AT POSITION	AT POSITION
	5	STATUS	CAR POSITION 6	NOT AT POSITION	AT POSITION
	6	STATUS	CAR POSITION 7	NOT AT POSITION	AT POSITION
	7	STATUS	CAR POSITION 8	NOT AT POSITION	AT POSITION
	8				

	9				
	10				
	11				
	12				
	13				
	14				
	15				

Words 5 through 20 are unused.

**Table 3.4 Elevator Analog Data**

WORD	DATA TYPE	MIN VALUE	MAX VALUE	UNITS	SCALE FACTOR	DESCRIPTION
1	INTEGER			AMPS	X10	DRIVE MOTOR AMPS
2	INTEGER			KWH	X1	PRE DAY KWH
3	INTEGER				X1	PRE DAY UP COUNT
4	INTEGER				X1	PRE DAY DOWN COUNT
5	INTEGER				X1	PRE DAY FRONT DOOR CYCLES
6	INTEGER				X1	FAULT CODE
7	INTEGER				X1	PRE DAY REAR DOOR CYCLES
8	INTEGER					
9	INTEGER					
10	INTEGER					
11	INTEGER					
12	INTEGER					
13	INTEGER					
14	INTEGER					

15	INTEGER					
16	INTEGER					
17	INTEGER					
18	INTEGER					
19	INTEGER					
20	INTEGER					

Note: All analog values are multiplied by 16 in the data concentrator to bit shift left 4 bits to align with QEI's 12 bit analog data types.

A note on communication loss

A 60 second watchdog timer is coded into each escalator file. If communications are lost between the data concentrator and the escalator controller for more than 60 seconds the watchdog timer will timeout. When the timer has timed out the communications loss bit will be reset (0) to indicate the communications loss condition.

**3. Time and date sync**

The QEI RTU shall provide clock synchronization to the WMATA data concentrator PLC every 5 minutes. Table 4.1 defines the address and data format of the clock registers in the WMATA data concentrator PLC. The data concentrator PLC shall set the escalator controller date and time every day at 3 AM.

**Table 4.1**

FUNCTION	ADDRESS	FORMAT
YEAR	N13:10	4 DIGITS
MONTH	N13:11	2 DIGITS
DAY	N13:12	2 DIGITS
HOUR	N13:13	2 DIGITS 24 HOUR

MINUTE	N13:14	2 DIGITS
SECOND	N13:15	2 DIGITS

#### 4. Data Concentrator PLC Program

The data concentrator PLC includes code to monitor up to 10 escalators and 5 elevators. Each escalators and elevators has an independent code file and a configuration bit. If an elevator is to be monitored the configuration bit must be set corresponding to the DH485 station address of the elevator controller. If the configuration bit is reset (0), the status and analog data table values for the elevator or escalator will be set to 0.

The configuration bits are as follows.

Escalator Configuration Bit	DH485 Address of Escalator Controller	Elevator Configuration Bit	DH485 Address of Elevator Controller
B9:0/1	1	B9:1/1	11
B9:0/2	2	B9:1/2	12
B9:0/3	3	B9:1/3	13
B9:0/4	4	B9:1/4	14
B9:0/5	5	B9:1/5	15
B9:0/6	6	B9:1/6	16
B9:0/7	7	B9:1/7	17
B9:0/8	8	B9:1/8	18

B9:0/9	9	B9:1/9	19
B9:0/10	10	B9:1/10	20

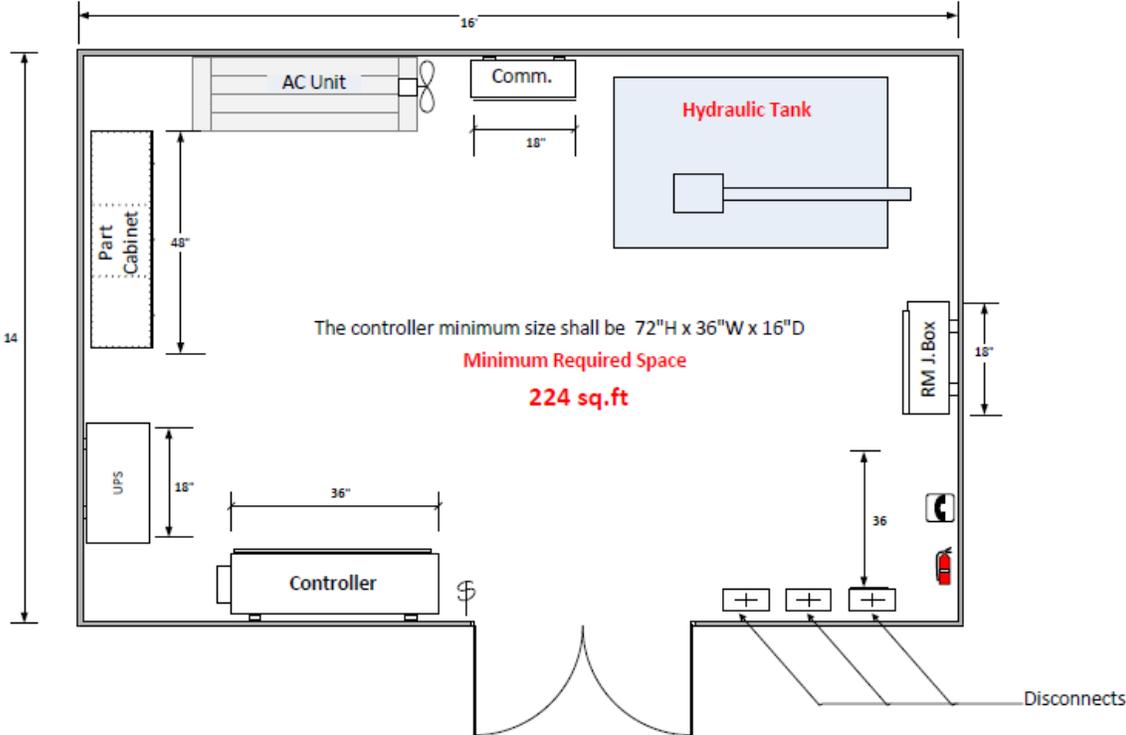
**3. Data Concentrator Gateway IP addresses.**

The Data concentrator PLC acts as a gateway between the Ethernet and DH485 networks. The PLC contains a list of IP addresses, known as the routing table which will be allowed access to the DH485 network. The routing table will contain 20 addresses.

Station	IP Address
1	TBD
2	
3	
4	
5	
6	
7	
8	
9	
10	

11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

3.07 EXHIBIT 1. Hydraulic Single Elevator Macine Room



END OF SECTION

**SECTION 14240  
GEARLESS TRACTION PASSENGER ELEVATORS**

**PART 1 - GENERAL**

**1.01 DESCRIPTION**

- A. This provides guidelines for the fabrication, installation and testing of the heavy-duty gearless traction passenger elevators, signs and Kiosk information system.
- B. The following sections include related requirements and are performed by other trades:
  - 1. Specifications Section 02000 – Site Construction
  - 2. Specifications Section 05000 – Metal Fabrication
  - 3. Specifications Section 08800 – Glass and Glazing
  - 4. Specifications Section 09920 – Painting
  - 5. Division 7 Section “Waterproofing” for water proofing of elevator pit
  - 6. Division 15 Sections for heating, ventilating and/or air conditioning of elevator machine room.
  - 7. Division 16 Sections for electrical service to elevator equipment, fire alarm systems and communications systems.
- C. Definitions:
  - 1. Heavy duty elevator: An elevator designed specifically for the harsh environment and duty load cycles common to transportation system usage.
  - 2. Elevator - a hoisting and lowering mechanism, equipped with a car or platform, which moves in guide rails or racks and serves two or more landings
  - 3. Elevator, passenger - an elevator used primarily to carry persons other than the operator and persons necessary for loading and unloading.
  - 4. Gearless: a traction machine, without intermediate gearing, that has the traction sheave and the brake drum mounted directly on the motor shaft.
  - 5. Contractor: The General Contractor.
  - 6. Installer: The responsible party who installs the elevator.
  - 7. OEM: Original Equipment Manufacturer.
  - 8. Dwell time: The period of time the elevator is at a landing while the doors open, passengers transfer and doors close.

9. Substantial completion: The point at which the elevator is ready for use, whether the site is finished or not. This is where the jurisdictional inspection usually takes place.
10. Final Acceptance: The point at which the owner accepts the elevator project as being complete including all submittal requirements. This may be a different point in time than substantial completion.
11. Interim Maintenance: Maintenance from the point of substantial completion, but prior to Revenue Service.
12. Beneficial Use: When the elevator is placed into service, may be prior to the site being ready for public use.
13. Revenue Service: The station or facility opening date.
14. Notice to Proceed (NTP): within this document shall mean the date which the elevator installer is notified to proceed with the project.
15. Override Switch – A switch located in a kiosk panel, which disables the Hall Call Buttons.
16. MSDS - Material Safety Data Sheet.
17. BOM - Bill of Material
18. SMNT - Systems Maintenance (WMATA)
19. WMATA: Washington Metropolitan Area Transit Authority.

## **1.02 REFERENCES AND QUALITY ASSURANCE**

### **A. Codes, Regulations, Reference Standards and Specifications:**

1. Codes and regulations. of the jurisdictional authorities.
2. ANSI/ME: A17.1, A17.1a, A17.1b, A117.1.
3. ASTM: A123, A153, A525, A568, C1048.
4. Uniform Federal Accessibility Standard,
5. Americans with Disabilities Act.
6. FS: RR-W-410.
7. American Institute of Steel Construction (AISC).
8. American Iron and Steel Institute (AISI).
9. American National Standards Institute (ANSI): C80.1
10. American Welding Society (AWS): D1.1.
11. Environmental Protection Agency (EPA).
12. Federal Transit Administration (FTA).

13. Institute of Electrical and Electronic Engineers (IEEE): 1202.
  14. International Code Council (ICC) – International Building Code (IBC).
  15. National Association of Architectural Metal Manufacturers. (NAAMM): C54, C55.
  16. National Institute of Standards and Technology (NIST).
  17. National Electrical Code (NEC).
  18. National Electrical Manufacturers' Association (NEMA): WC 70, KS 1, AB 1, 250, PB 1, MG 1.
  19. National Electrical Safety Code (NESC)
  20. National Elevator Industry, Inc. (NEII)
  21. National Fire Protection Association (NFPA): NFPA-130-2003.
  22. Occupational Safety and Health Act (OSHA).
  23. Society of the Plastics Industry (SPI).
  24. Underwriters' Laboratories, Inc. (UL), UL-94HB, 6, 50, 62, 98, 360, 486, 489, 514, 1591.
  25. United States Department of Transportation (DOT).
  26. Any additional requirements imposed by local agencies and/or codes having jurisdiction shall be incorporated into elevator installation.
  27. In the event of a conflict between codes, regulations or standards, the most stringent requirement as determined by the Contractor and approved by the Authority shall take precedence unless specifically addressed herein.
- B. Elevator Manufacturer and/or Installer's Qualification:
1. Manufacturer Qualification: : Shall provide documents stating that their firm has successfully produced elevators for transit system applications for a minimum of ten (10) years and regularly engaged for the past five (5) years in the manufacture of major components for gearless traction passenger elevators. As a standard of quality the elevator equipment design and installation shall comply with the Code.
  2. Installer's Qualifications: Shall be the original manufacturer of elevator equipment or manufacturer's authorized agent who is trained and approved for installation of units required for this Project.
  3. The Contractor shall obtain and pay for all permits and licenses and perform all required inspections.
- C. Quality Assurance:
1. The elevator contractor shall guarantee the materials and workmanship of the apparatus furnished under these specifications and will make good any defects not due to ordinary wear and tear or improper use or carelessness, which may develop within two (2) years from date of completion of each elevator, inclusive of labor and

- traveling expenses. Defective work shall be repaired or replaced at no additional cost to the Authority.
2. Welding: Welding shall be performed in accordance with the requirements of AWS or CWB Welders shall produce evidence of current certification by AWS or CWB.
  3. Labeling Requirements: Every elevator shall be clearly marked with rated load and speed, manufacture serial number and the designated Authority identification.
    - a. All elevators shall be permanently numbered with number designations corresponding to the indications on the kiosk annunciator panel. A station sketch showing the elevator numbers shall be submitted for WMATA ELES Engineering. The elevators shall be numbered in sequence, starting at the north entrance left to right facing to the elevator at each station and proceeding clockwise around the station. The numbering shall proceed into the station toward the end of the platform. Corresponding numerical identification shall be affixed to the equipment in the machine rooms. The elevator numbering shall be approved by the ELES Engineer.

### **1.03 SUBMITTALS**

Submit the following for approval in accordance with the General Requirements and the additional requirements as specified for each to WMATA/ELES.

A. Shop Drawings:

The contractor to provide detailed drawings that shows the dimensions, tolerance and specification that may include the material specification, hardness or electrical rating for each component that is being used. In regards to assemblies, they must provide a top level drawing with BOM and quantities with detailed material specifications and drawings with dimensional tolerances. The contractor also to provide as-built CAD models of all elevator components.

The name of the manufacturer and type or style designation shall be listed on the equipment shop drawings. Drawings submitted shall include, but not be limited to, the following. Submit six sets include the following:

1. Fully dimensioned layout in plan and elevation, showing the arrangement of equipment and all pertinent details of each specified elevator unit, including as appropriate:
  - a. All equipment located in machine rooms.
  - b. Location of circuit breaker, switchboard panel, disconnect switches, light switch, and feeder extension points in machine rooms,
  - c. Location in hoistway of outlets for connection of traveling cables for car light, fire detectors, communication, and control systems.
  - d. Car, drive and motors, safeties governors, supporting beams, guide rails, buffers, and other components located in the hoistways for each elevator.

- e. Maximum Rail bracket spacing and maximum horizontal forces on guide rails in accordance with Part 2.23 of the ANSI/ASME Code.
  - f. Reactions at points of supports.
  - g. Weight of principal parts.
  - h. Loads on hoist beams.
  - i. Loads imposed on racks requiring transfer to building structure.
  - j. Top and bottom clearance and travel of car and counterweight runby.
  - k. Refuge space on top of car and pit.
  - l. Cab design, dimensions and layout.
  - m. Color/material schedule and selection chart for cab and entrance features.
2. Complete wiring diagram of the elevator system and subsystems. Complete data regarding electrical characteristics and connection requirements.
  3. Drawings of the hoistway entrances and doors showing their method of operation, details of construction, and fastenings to the structural members of the station structure.
  4. Drawings of the car for each design specified, showing details of construction, and fastenings to platform car floor covering, car-lighting, ventilation, communication, provision for closed circuit television monitor, and location of equipment.
  5. Cuts or drawings showing details of all signal and operating devices, identifying graphics and kiosk interface where applicable.
  6. Electrical characteristics and connection requirements.
  7. Complete assembly detail of machine, machine mounting, machine beam assembly, dead end hitch and beam assemblies.
  8. Machine performance data sheets.
  9. Elevator controller, including manufacturer's technical data and catalog cuts, and interface hardware and software requirements.
  10. Power door operator.
  11. Door interlocks and electrical contacts including test reports showing that hoistway door interlocks, car door contacts, and car top emergency contacts meet the requirements of the ANSI/ASME Code and certification by the NBS or other approved laboratory.
  12. Car ventilation.
  13. Car lighting.
  14. Cabling.

15. Hall and car fixtures at each landing including the car operating panel (COP).
16. Buffer, including stroke and certified maximum striking speed for car.
17. Mechanical, electrical, and architectural design details of communication systems and intrusion systems for both elevator and kiosk systems. Provide diagram and schematic of kiosk annunciator panel.
18. Design and architectural details of electrical protective device for car doors.
19. Where use of adjoining dissimilar metals is required, descriptions of protective measures to be employed to avoid corrosive damage.
20. Certification from independent testing laboratory that glazing gaskets meet the specified requirements.
21. Conduit and wireway cladding configuration configuration from the point of origin to the final destination. .
22. Interface wiring diagrams with other systems showing terminal board location and identification.
23. Expected heat dissipation of elevator equipment in machine room and control areas (i.e. BTU's/hr.) based on 240 round cycles per hour.

**B. Samples:**

Three of each of the following samples shall be submitted for approval.

1. Stainless Steel: One of stainless steel sheet of thickness and finish specified, 6 inches square.
2. Glass: One, 12 inches square.
3. Floor covering: One, 12 inches square in the color and finish to be supplied.
4. Neoprene gasket: One of each type.
5. Landing selector button mounted in cover plate with identity marking along side button.
6. Ceiling material.
7. Signs: One of each type.

**C. Certification:**

1. Certificates of inspection and acceptance issued by jurisdictional authority.
2. The Acceptance Inspection (Specifications and Code) by Office of Elevator and Escalator (ELES) shall take place prior to the Final Acceptance Inspection by the Jurisdictional Authority, and the elevators and associated equipment shall be free of defective material, imperfect work and faulty operation.

All defective work identified by ELES representatives shall be repaired or replaced at no additional cost to the Authority prior to the Final Acceptance Inspection by the Jurisdictional Authority.

D. Operation and Maintenance Manuals:

Six sets of the approved manuals, elevator installation, operation instructions, troubleshooting techniques and related equipment drawings and software (all publication must be in English) – two copies of which to be delivered to the WMATA/ELES Engineer representing of the Authority prior to installation. Each binder shall has the Binder Cover and Spine Insert which contain the Station Name and Unit ID.

Submit an additional electronic copy on Flash Drive(s)/CD(s). The Information shall be saved/presented as follows:

- a. Graphic images in “.dwg” AutoCad and “.pdf” formats. All revisions shall be made by using computer software. Hand written changes are not acceptable.
- b. Text in Microsoft Word .doc, “.pdf” or approved equal format.

The manuals shall include the following:

- 1. Complete operation and maintenance Instructions of the elevator equipment included complete illustrated, exploded views of all assemblies and a complete illustrated, exploded view for identification all system parts.
- 2. Complete nomenclature of replaceable parts, part numbers, current cost, and warehouse location. If product source is another vendor, Contractor shall include name and address of other vendor.
- 3. Furnish a summation, in tabular form, of all parts incorporated in the elevators supplied under the Contract. Include but not be limited to the following:
  - a. Nomenclature of part.
  - b. Contractor's part number.
  - c. Nomenclature of next higher assembly in which used.
  - d. Manufacturer and part number.
  - e. Model number of elevator on which used.
  - f. Total quantity.
  - g. Current unit price to the Authority.
  - h. Serial numbers of all serialized assemblies, subassemblies, motors, and other major components supplied and installed.
- 4. Control and schematic electrical wiring diagrams of controller including wiring of safety devices.

- a. Wiring Diagrams shall be full size, ladder type, complete "as-built" wiring and single line diagrams showing the electrical connections, functions and sequence of operation of apparatus connected with each elevator, using standard symbols or proprietary symbols defined on the diagram, both in the machine room and in the hoistway, shall be furnished in duplicate for each elevator.
  - b. Wiring diagrams shall incorporate the wiring identification labeling to identify the controller and field wiring used for each circuit. Wiring diagrams shall have sheets numbered with an indication of the total number of sheets in the diagram set. Each page should include unit number where the diagram belongs to.
  - c. After approval, a copy of each print shall be laminated and mounted in each elevator machine room. A reproducible .003 mil Mylar set of wiring diagrams for each elevator shall be delivered to ELES Engineering.
  - d. Coded diagrams are not acceptable.
5. Complete detailed drawings and wiring diagram of elevator system.
  6. Lubricants, sealers, paints and any other potentially hazardous substances are subject to review and approval by the Authority.
  7. Detailed lubrication and cleaning schedule.
  8. Procedures for adjusting all elevator components.
  9. Complete set of contract software including operating control software.
  10. Detailed, record and as-built layout drawings.
  11. The entire manual, all software upgrades and service tools for elevators shall be provided in an electronic format on CD-ROM that is acceptable to the WMATA Engineering and Maintenance Department.
  12. All hard copy publications shall be in loose-leaf form, on 30-pound paper and with punch holes reinforced with plastic, cloth or metallic material.
- a. The O&M manual shall only contain information related to equipment installed under this contract. Generic information that does not pertain to the equipment installed shall not be included. Scanned documents are not allowed. The fonts should be standard format.
  - b. All covers shall be resistant to oil, moisture, and wear commensurate with their intended use. Diagrams and illustrations shall not be loose or in pockets. All printed material shall be capable of being reproduced on dry copying machines.

13. Each elevator shall be treated as a whole and not as a grouping of disassociated parts. The material in the Wiring Diagram Manual shall be organized and indexed by the elevator classifications included in this Specification. All manual sections shall be sub-divided, to the extent required by the subject matter, and shall include, but not necessarily limited to the following topics:
  - a. General system or sub-system description and operation.
  - b. Sequence of operation.
  - c. Replacement and step by step adjustment procedure for all components and systems.
  - d. Block diagrams.
  - e. Functional schematics.
  - f. Functional as-built wiring diagram.
  - g. Lubrication and cleaning, including frequency, methods, and trade identifications of recommended materials.
  - h. Component location and description.
  - i. Inspection and maintenance standards including wear limits, settings, and tolerances.
  - j. Installation and removal sequence.
  - k. Test and evaluation procedures.
  - l. Spare parts lists and special tools.
14. The contractor shall provide all information: manuals, drawings, design changes, modifications, techniques, procedures and any other documents related to maintenance, safety, operations which relate to any part, component, system, subsystem or material and applicable to the elevator equipment. All operating, programming, control software and licensing keys (if applicable) to the PLC control system for the installation.
15. All of the above referenced shall be provided as it pertains to the original installation and for a period of ten (10) years after final acceptance of the elevator. During a ten (10) years period, In case of any items are obsolete or no longer available from the manufacturer the Elevator Contractor shall provide the alternative products.

**1.04 PRODUCT DELIVERY, STORAGE AND HANDLING**

- A. Ship equipment and accessories securely packaged and labeled for safe handling and to prevent damage.
- B. Protect equipment exposed finishes during transportation storage and erection against damage and stains.

- C. Deliver components with factory-installed wooden skids and lifting lugs; pack components in factory-fabricated protective containers.
- D. Store in clean, dry and secure areas and protect them from weather and damage.

**1.05 WORK BY OTHER TRADES**

The following will be provided in accordance with other sections of the Contract Specifications or by separate contracts; coordination is the Contractor's responsibility:

- A. Hoistway conforming to code and specified requirements, plumb to within ¼ inch, including machine beams, pit, and pit ladders.
- B. Intermediate rail bracket supports.
- C. Grouting around hoistway entrances and sills.
- D. Temporary and Permanent Electrical Power Services:  
Contractor shall provide and coordinate the following:
  - 1. For the elevator drive systems: 480 (460) volts, 3 phase, 3 wire, 60 Hertz terminating in a disconnect switch within sight of the controller. The disconnect shall be free on any obstruction for a total of 36" from any part of the disconnect.
  - 2. For lighting and GFCI receptacles: 120 volts, 1 phase, 3 wire, 60 Hertz terminating at the elevator controller location.
  - 3. Separate disconnect for cab lighting and wiring to cab. This disconnect shall be located close to the main line disconnect.
  - 4. Separate service for sill heaters where required.
- E. Cutouts in hoistway walls for fixtures.
- F. Smoke and/or heat sensors in machine room, in car and above each hoistway entrance.
- G. Closed circuit television camera (CCTV) in elevator car.
- H. Intrusion detectors on machine room doors.
- I. Space in kiosk for elevator annunciator panels.
- J. All embedded electrical conduit between elevator hoistway, machine room and kiosk.
- K. Pit Drainage means to prevent water from accumulating in the pit for outdoor and indoor elevators. If pumps are used, they shall have a backup power source.
- L. Lock and Key Requirements: Contractor shall coordinate with WMATA. The keys for all elevators except of Code requirements shall be keyed the same. Each station shall have a key and a master key shall be furnished which will operate all elevator locks in the Metro System, including previously installed elevators.

- M. Contractor shall coordinate any alterations required to accommodate elevators with the Authority.
- N. Contractor shall attend appropriate safety training programs provided by WMATA at no extra cost.
- O. As-Built Drawings: Contractor is responsible to provide revised Contract Drawings to reflect the actual as built condition including all structural, architectural, electrical, mechanical and plumbing connections to the elevators.

**1.06 COORDINATION WITH OTHERS**

- A. The elevator installer shall install all elevator wiring in the embedded conduit provided by other trades including that to the kiosk. Other trades will bring wiring for their services to either the elevator machine room or the elevator pit, terminated on a terminal block. The elevator installer shall extend wires from the terminal blocks to the appropriate location or device within the elevator enclosure or hoistway. Some of these circuits shall require shielded wires or separate isolated circuits.

**1.07 OPERATION AND MAINTENANCE TRAINING**

- A. Training: The Contractor shall develop and provide operation, troubleshooting and maintenance training in accordance with the General Requirements and as follows:
  - 1. Three days of classroom plus two days hands on training on the field shall be provided for 10 students per class. Six training session for a total of 60 students is required.
  - 2. Time and place of training will be determined by the Authority, but must be completed no later than 30 days prior to the Final Completion.
  - 3. Training shall be organized to make optimum use of the required maintenance and operation manuals including training for replacement of all parts contained in the Parts Inventory list.
  - 4. At the completion of the first training session, a narrated and properly edited training video shall be submitted for the authority on DVD or flash drive. The video shall be taken by the professional camera operator with quality image and sound track and will be used for the future trainings. The video shall cover operation of the elevator, function of the devices, maintenance, adjustment procedures and troubleshooting. The following items shall be included as minimum requirements:
    - 1) Step by step adjustment procedure on the followings:
      - 1.1 Door operators, DCL, DOL, full door opening, and so on...

- 1.2 Car Leveling and adjustment of leveling sensors and vans
  - 1.3 Door: door interlock, proper pressure, restrictors ...
  - 2) General overview of major items:
    - 2.1 Controller:
    - 2.2 Controller display:
    - 2.3 Door sills
    - 2.4 Guide rails
  - 3) Daily operation and sequence of operation
  - 4) Replacement and Installation of components:
    - 4.1 door photo eye
    - 4.2 Door clutch
    - 4.3 Door pickup rollers
  - 5) Proper guide roller adjustment
  - 6) Verification of safety circuit
  - 7) Maintenance procedure and Frequency of maintenance
  - 8) Proper access of pit and top of car for inspection
  - 9) Proper test of fire service operation
  - 10) Proper lubrication of components
  - 11) Troubleshooting techniques
  - 12) How to use proper communication device, machine room, car top, and kiosk
  - 13) Proper adjustment of shaft and drive encoders
  - 14) Proper run learn adjustment
  - 15) Operation of Governor and adjustment procedure
  - 16) How to perform governor tripping test
  - 17) Function of Rope gripper
  - 18) Lubricate rope and check for wear
  - 19) Maintenance and inspection of buffer
  - 20) Test and inspection of safety plunk
  - 21) Overview of car and counterweight run-by
  - 22) Operation of brake and proper adjustment procedure.
  - 23) Check Gear box for wear and oil check
  - 24) Inspect Sheave for wear and bearings lubrication
- 5. Provide one additional copy of all required submittals to the Engineer for Authority use.
  - 6. Provide two copies in DVD format of training materials along with visuals and handouts to the Engineer for Authority use.
    - a. Video shall be narrative.
    - b. Video shall be separated by major components Sections

- c. Equipment Identification shall be as a part of the section title.
- 7. Separate training manual shall be submitted for approval prior the scheduling of the training. The O&M manual shall not be used as a training manual.

**B. Scope of Work**

- 1. All training, as described below, shall take place prior to Final Acceptance of equipment or materials by the Authority. The contractor shall video tape all training sessions and provide WMATA/ELES with edited copy of the recording.
- 2. The training shall be tailored specifically to the furnished and installed equipment, and designed to teach the day-to-day operation of all equipment. The training shall be sufficient to bring personnel to a level of operating proficiency such that routine vendor support is not needed.
- 3. Maintenance Training shall be tailored specifically to the furnished and installed equipment, and designed to develop the knowledge and skills required to maintain all item(s) delivered.
- 4. The training shall be subdivided into two major levels as follows:
  - a. System Level Maintenance Training, covering:
    - i. Theory of operation of the system and its major components.
    - ii. System configuration.
    - iii. Preventative maintenance, consisting of written procedures and schedules for the periodic maintenance of all equipment.
    - iv. Written and validated inspection procedures and a system-level trouble-shooting guide (to the lowest field-replaceable unit).
  - b. Shop Level Maintenance Training, covering
    - i. Detailed theory of operation to module, board, and/or device level.
    - ii. Component level troubleshooting and component replacement and adjustment.
    - iii. Testing and alignment procedures of repaired units.

**C. Deliverables**

- 1. The following course materials shall be delivered by the Contractor, according to the following specifications:

- a. An Instructor's Guide containing all the information and direction necessary for the instructor to make an effective presentation. It shall include adequate guidelines to conduct a comprehensive training program. Individual lessons within the course shall be organized as separable blocks (or modules) which may be taught as a unit. The Instructor's Guide shall contain, as a minimum:
  1. Discussion of student prerequisites (if any).
  2. Program overview.
  3. A statement of overall program goals.
  4. Lesson plans (a session-by-session outline containing the following):
    - a. Student learning objectives, stated in measurable term
    - b. Overview of each lesson.
- b. A Student Manual including all materials for the student to interact in the learning situation. It shall contain, as a minimum:
  1. Program overview and introduction.
  2. Statement of overall program goals.
  3. Learning objectives, stated in measurable terms that specifically describe desired behaviors or knowledge to be gained.
  4. A fully developed prose treatment (not outline format) of content presentation, developed in the same modular format as the Instructor's Guide.
  5. Illustrations, charts, photos or other graphics of actual system components as needed to enhance content presentation.
  6. The training manuals shall be prepared and submitted for approval to WMATA/ELES prior to training. The training manuals shall include procedures for adjustment and replacement of all electrical and mechanical components, and a troubleshooting guide.
- c. Audio-visual Aids consisting of a narrated video of not less than 90 minutes duration to include, but not limited to, the following:
  1. General overview of major features.
  2. Daily operations.
  3. Maintenance procedures (lubrication, adjustments, critical measurements, etc.).
  4. Frequency of maintenance procedures.
  5. Parts replacement safety devices, lighting, etc.

6. Verification of safety circuits, methods of accessing and preserving computerized functional data if required.
  7. Step by step adjustment procedures and installation of components.
  8. Handouts, transparencies and/or slides as necessary to ensure clear and comprehensive presentations.
  9. The training video shall be taken from actual equipment installed under this contract.
- D. Supplemental Materials consisting of a functional mock-up or a functional representation is required of any equipment that requires theoretical discussion. This may be in the form of an animated schematic, a model of the equipment, an actual device, an interactive video training device, or an approved substitute. All mock-ups shall become the property of the Authority for eventual turn over to WMATA/ELES.
- E. The final copies shall be delivered to the Authority as follows:
1. One complete set of training materials that is completely camera-ready. Camera-ready copy is defined as typewritten or typeset originals or high-quality copies such that further copies can be made from them with no noticeable decrease in copy quality.
  2. Five copies of all student and instructor materials, to be used for archival purposes, in the WMATA ELES Technical Library.
  3. A set of complete student materials including training manuals for each participant enrolled in training classes. The O&M manual, training manuals and special tools shall be approved by WMATA prior to the training.
  4. The contractor shall video record all training sessions and provide WMATA/ELES with edited DVD copy of the recording to be used as training guide for other WMATA ELES employees.
- F. The following specifications shall be met in instructional delivery:
1. Instructor Qualifications. A description of instructor qualifications, a resume, curriculum vitae, or other description of instruction qualifications must be submitted at least 60 days prior to the presentation of training. The description shall document a thorough knowledge of the equipment being taught, an understanding of the adult learning process, and demonstrated experience in vocational instructional. The ELES Engineering Office will review and approve the Instructor candidacy.
  2. Course length. The length of the course shall be 5 working days with 3 days in the classroom and 2 days hands-on training.
  3. Student qualifications. For the purposes of course development and presentation, vendors shall assume all students are high school graduates (or equivalent), and that maintenance personnel will possess the ability to use basic hand tools and electronic test equipment.

4. Testing. Instructors must give written and/or practical tests as a measuring device to determine knowledge transference. Tests shall use a multiple-choice or short answer format, and have been validated in a pilot course or by some other means agreed to by the Authority and Contractor. Whenever possible, a practical hands-on test shall be developed to demonstrate the transference of operational/mechanical skills.

**1.08 SPARE PARTS AND SERVICE FACILITY**

- A. At the expiration of the warranty requirements of the General Provisions, the Contractor is responsible to provide a source for spare parts and service facility in the United States which can be obtained for an additional five years. If product source is another vendor, Contractor shall include name and address of other vendor.
- B. The Contractor shall propose and provide a spare parts inventory, to be approved by the Engineer and provided to the Authority not less than 90 days prior to scheduled completion, equal in value to seven percent of the cost of the each elevator.
- C. This provision requires the furnishing of a Recommended Spare Parts and Special Tools List based on manufacturer's recommendations, defines criteria to be used by the Contractor in developing spare parts recommendations; defines the manner of identifying spare parts on the list and the labeling and identification of spare parts upon delivery; and the timing of delivery of spare parts.

Elevator parts list, grouped by system and subsystem for stocking identification and the list shall contain the following information for each item listed:

- a. Component name and Part number(s)
  - b. Manufacturer's name
  - c. Model number(s)
  - d. A blank column for WMATA's part number
  - e. Manufacturer's recommended quantity
  - f. Anticipated annual usage
  - g. Unit price
  - h. Special storage and handling requirements
- D. The manufacturer's recommended quantities shall be based upon the following reliability, usage and lead time considerations:
    - a. Wear: Components which may be expected to require replacement under normal maintenance schedule and operations, such as mechanical parts subject to continuous operation within projected mean time between failure levels.

- b. Consumables or Expendables: Components which are consumed, used up, destroyed, or upon failure, are otherwise made usable for their intended purpose and are economically unrecoverable except for inherent scrap value.
- c. Recoverable or Repairable: Components which, upon failure, are capable of being repaired or remanufactured to a serviceable, operational condition and maintained available for use within their initial intended purpose.
- d. Long Lead: Components that are not available from commercial distributors or within 48 hours from the manufacturers such as specifically made or selected components.
- E. Cross referencing: Where replacement components are common to more than one system or subsystem, include a cross reference and indexing system in the replacement components list:
- F. Non-Unique parts: In all components lists, items that are not unique to the system and have been manufactured by others shall be identified by the manufacturer's name and part number.
- G. WMATA will provide the Elevator Contractor with shipping instructions, with WMATA part numbers for each item the Elevator Contractor is required to furnish.
- H. The parts shall be shipped to the locations as directed by the Authority, at the same time as the counterpart equipment delivery or acceptance by the Authority of installed equipment. Shipping documents shall identify the Contract number, manufacturer's part number, quantity, unit price and WMATA part number.
- I. Spare parts shall be properly packaged or crated so as to prevent damage during shipment and long-term storage.
- J. Spare parts shall be the same in all respects as their counterparts furnished as a part of the assembled equipment to be delivered.
- K. Parts furnished in accordance with this provision are WMATA spares, separate and distinct from any Contractor obligation to replace parts, components or assemblies under any warranty provision.
- L. Parts lists contained in Operations and Maintenance Manuals provided under the Contract shall include assigned WMATA part numbers.
- M. A Manufacturer's Recommended Spare Parts List shall be provided. Parts to be provided shall be based on the criteria described herein and require the Authority approval and shall be provided prior to Final Acceptance.
- N. Any Special Tool(s) used including, but not limited to, troubleshooting, maintaining the elevator, software and/or hardware shall be provided as part of the spare parts to ELES Engineering Office. Any tools provided shall be the same as those issued to the Adjuster and equivalent members of the subcontractor's staff.

**1.09 STORAGE CABINET**

- A. The contractor shall install a lockable metal cabinet of suitable size with a key specified by the WMATA Engineering and Maintenance Dept. in each elevator machine room for the storage of special tools and necessary spare parts. The cabinet shall be mounted on legs or a pedestal, a minimum of 4 inches off the floor.

**1.10 SPECIAL TOOLS**

- A. A complete set of special tools and instruments necessary for troubleshooting and making all adjustments on every part of the elevator installation, including software and hardware shall be furnished for each elevator machine room and delivered to the Engineer as part of the spare parts inventory. Tools that are designed specifically for tasks associated with elevator inspection, maintenance and repair or that are required for these tasks, and are not readily available through normal purchasing channels are defined as special tools.
- B. Any "Special Tool/ equipment" that is required to troubleshoot, maintain, adjust, and test the system; the tool/equipment shall remain operational for the life of the equipment.
  - a. Provide all special tools and equipment necessary for making all system adjustments to the signal and speed controller and door equipment. A programming unit, approved by the Original Equipment Manufacturer (OEM) such as a laptop with 4GB memory, 15-inch display and DVD drive, with all software packages required to setup and program all equipment in the elevator system shall be provided, one per station or location. Software shall be provided for the display unit, DeviceNet, hoist motor drive, if applicable, and any other programmable devices, as well as for the controller PLC. Any hardware or software required for configuring, programming and or communicating to controller or any parts of the elevator shall be submitted to ELES engineering. Using the provided laptop, the contractor shall demonstrate loading, downloading (programming) any and all software that is required for the elevator for all operating needs. This includes display, PLC and any I/O controls. No special tools with decaying circuits or clocks are permitted.
- C. Keys: Provide ten (10) sets of keys to operate all keyed switches and locks prior to completion of the first unit.

**1.11 AUTHORITY COORDINATION:**

The elevators shall not be in service for passenger/public use until all of the following requirements have been met.

- 1. The Operations and Maintenance Manuals have been approved and received by WMATA.

2. The Training and Student Manuals as well as video record of all training sessions have been approved and received by WMATA
3. The required training has been completed in accordance with this specification.
4. All field tests have been successfully completed.
5. The acceptance testing has been successfully completed.
6. All spare parts have been delivered and received by WMATA.
7. All Special Tools/Equipment and Software have been delivered and received by WMATA.
8. All discrepancies identified by the WMATA's CEI (Certified Elevator Inspector) representative shall be completed.

**PART 2 - PRODUCTS**

**2.01 DESIGN REQUIREMENTS**

A. General:

1. Elevators furnished under the Contract shall be Gearless Traction elevators type elevators as shown. All parts shall be built to standard dimensions, tolerances, and clearances so that similar machines and devices supplied under contract are completely interchangeable. The mechanical fastening used throughout the equipment on parts subject to wear and requiring replacement shall be key and seat, nut, screw, or other removable and replaceable type not requiring physical deformation or field positioning. The use of rivets or similar devices will not be acceptable as mechanical fastenings for such parts.
2. Hours of Operation: Elevator shall be designed for continuous operation seven (7) days per week, 24 hours per day.
3. Elevators shall be designed, installed, and tested to operate with full-specified performance while exposed to the climatic and environmental conditions specified. In addition, during installation and until the beginning of scheduled maintenance service, the elevators will be subject to more extreme environmental conditions. The Contractor shall furnish protection necessary to prevent damage to or deterioration of the elevators during this period.
  - a. Elevators shall be designed to operate in dry bulb temperature range of -10<sup>0</sup>F to 140<sup>0</sup>F and operate while exposed to the natural elements of weather, including sunlight, rain, snow, slush, salt; all condition of relative humidity, de-icing chemicals, debris, airborne dust, and corrosive elements.

- b. The elevators shall have a special winter operation. The elevators shall be designed to operate in the event the outside temperature falls below a pre-established minimum value. The elevator contractor shall furnish and install the necessary timers and thermostat to accommodate the desired function
  - 4. Make provision for and provide a closed circuit television camera (CCTV), in the elevator car(s) with the ability to monitor the CCTV from the Kiosk annunciator panel. Submit drawings for approval before fabrication.
    - a. Provide electrical connections, through shielded traveling cables, between camera and the communications terminal block in machine room or pit.
  - 5. Painting: The pit, pit walls and machine room floor shall be painted. All machine room equipment shall be given two coats of approved machinery paint. All new iron work shall be given one coat of rust- inhibiting paint.
- B. Fasteners
  - 1. Fasteners shall be compatible with materials being fastened.
  - 2. Fasteners shall be furnished with self-locking nuts or retaining rings (spring washers, toothed disks).
  - 3. Fasteners shall be equal to or of greater corrosion resistance than the most corrosion resistant metals being fastened.
  - 4. Fasteners securing removable sheet metal materials shall be operable with the aid of simple tools and concealed wherever possible. When the framework to which the metal is fastened is less than ¼ inch thick, steel backup plates ¼ inch thick shall be added with tapped holes and clearance holes where necessary.
- C. Capacity, Speed, Travel, Platform Size
  - 1. All parts of the elevator equipment shall be of such design, size, and material as to satisfactorily function under all conditions of loading and operation within its rated load and speed, all with a proper factor of safety, maximum mechanical and electrical efficiency, and minimum wear on parts. The elevators shall have sufficient capacity to lift the rated load at 350 feet per minute, minimum.
  - 2. Elevator shall be of size, arrangement, capacity and shall comply with design criteria and as shown on the Contract Drawings, and in accordance with the requirements of the ANSI/ASME A17.1
  - 3. The top enclosure shall be reinforced to support two men and be capable of sustaining, without damage or permanent deformation, a load of three hundred pounds on any area two feet square and 100 pounds applied at any point. An emergency exit shall be installed in the car top in conformance with the Code.

- 4. Travel, location terminal floors, number of stops and openings, and overall car platform size shall be as shown on the Contract Drawings.

D. General Environmental Operation Conditions:

- a. Operation Under Fire or Other Emergency Conditions: Elevator shall be equipped to function in accordance with the requirements of ANSI/ASME A 17.1 and applicable local codes.
- b. Sound Level: No elevator car or elevator power unit shall generate noise in excess of NC45 sound level. Measurement of noise shall be made at a point 36 inches from the hoistway, machine room entrances, and ventilation openings.

E.. Hoistway Movement:

- 1. Elevators shall be designed to sustain the load and operate with the following lateral movements of the hoistway structures:
  - a. In any individual glazed area. ¼ inch.
  - b. In total height of hoistway structure for aerial and surface structures: 5/8 inch.

F.. Reliability:

- 1. Each elevator shall be capable of operating at full load under any of the normal modes of operation at a level of availability of not less than 98 percent over a period of 365 days.
- 2. Availability (A) is defined as the percent of normal operational time during which the equipment is available for use. Or

$$A = \frac{MTBF}{MTBF + MTTR}$$

Where:

- MTBF* = Mean time between failure in days
- = Operating time, *t* (in days) /Number of failures in time *t*
- MTTR* = The average time in days required to restore an elevator to operation after a report of a failure.

G. Workmanship:

- 1. Joints shall be welded their full length and dressed smooth and flush on exposed surfaces. Spot welding shall be sued where practicable in preference to screw or rivet fasteners.

2. Sheet metal materials shall be accurately rolled and leveled, and have smooth finish and uniform color. Joints shall be formed to a tight fit, with abutting edges flush, and shall be securely welded or riveted together in such a manner as to give strength equivalent to the solid sheet. Riveted construction shall have heavy reinforcement on the back, and no rivets shall show on exposed surfaces, Welds shall be solid and dressed flush, and holes for screws or bolts shall be drilled and countersunk.
  3. Wrought work shall have joints milled to a tight even fit and, where possible, shall be made without screws. Square turns and comers shall be sharp, Curves and loops shall be true and without visible joints. Abutting members shall be welded, riveted or both. Similar bars shall be halved at intersections and wide bars shall be punched for the small bars to pass through.
  4. The finished work shall be strong, rigid and neat in appearance. Plane surfaces shall be smooth and free from warp or buckle. Molded members shall be clean cut, straight, and true. Miters shall be well formed and in true alignment. Fastenings shall be concealed from face side of the material.
- H. Corrosion Protection: The contractor shall design the elevator assembly in such a manner to avoid corrosion and galvanic action due to physical contact between dissimilar metals or due to other causes.

**2.02 MANUFACTURERS**

- A. The major elevator components shall be the products of one of the three manufacturers of established reputation, except they may be the products, either wholly or in part, of another manufacturer of established reputation provided such items are capably engineered and produced under coordinated specifications to ensure a high grade, safe reliable, and smooth operating system.
- B. Major components to be furnished for this project shall be of a make or makes that have performed satisfactorily together under conditions of normal use for not less than one year in at least two other elevator installations of equal or greater capacity and speed.

**2.03 PRODUCTS AND MATERIALS**

- A. Elevator Car Characteristics:
  1. Rated load. Minimum rated load for the car will be as determined by the inside net platform area per ANSI/ASME A17.1 formula rules-rule 1300.1.
  2. Rated speed: as per Contract Drawings
  3. Inside dimensions: As shown.
  4. Landings served: As shown.
  5. Number of openings: As shown.
  6. Travel: As shown.

7. Operation: Selective/Collective. Drive Type: AC – VVVF
  8. Car and landing operating buttons: Illuminated type, vandal resistant, in accordance with ADA requirements.
  9. Car door and hoistway entrances: High-Speed, Heavy-Duty Master Door Operator GAL – MOVFR. Door Type: per Contract Drawings. Door Size: per Contract Drawings
- B. Operation:
1. Operation shall be automatic. Automatic operation by means of car and landing buttons. Stops registered by momentary actuation of car buttons to be made irrespective of number of buttons actuated or of sequence in which buttons are actuated.
  2. Operating station in car containing bank of buttons numbered to correspond to landing served position indicators. EMERGENCY CALL button, keyed EMERGENCY STOP button, DOOR OPEN/DOOR CLOSE buttons, independent maintenance key switch, and key-operated light and fan switches, with legends as specified. Identification as specified for emergency telephone. Emergency call button connected to bell that serves as emergency signal. Panel finish: Stainless Steel.
  3. Landing: Single push-button fixture at each terminal landing. Button fixture having push buttons with UP and DOWN legends at intermediate landing. Button identification as specified for Person with disabilities per latest ADA regulation (ADA rule 4.10.3).
  4. Momentary pressure on car button or landing button illuminates that button, which remains illuminated until call is answered. Illuminated buttons serve as visual indication that call has been registered and that car will stop at that landing. The Push Buttons shall be flush, round, have a Metalized Halo and center jewel. The metalized halo shall be from different color and approved by ELES Engineer.
  5. Stops, registered by momentary actuation of landing buttons. All stops subject to respective car or landing button being actuated sufficiently in advance of arrival of car at that landing to enable stop to be made. Direction of travel for idle car established by first car or landing button actuated.
  6. UP landing calls answered while car is traveling in up direction and DOWN landing calls answered while car is traveling down, car reversing after uppermost or lowermost car or landing call has been answered and proceed to answer car calls and landing calls registered in opposite direction of travel.
  7. Elevators to park at the secure landing level selected by the Engineer.
  8. Push-button units to be Dupar US85 or approved equal with button identification as specified by latest ADA regulation.

9. Emergency-stop button shall be key operated rather than push-pull arrangement with key removal only in off position.
10. All elevator car control panel operating devices shall be designated by Braille and by raised standard alphabet characters for letters, Arabic characters for numerals, and standard symbols as required by the Code and ADAAG.
11. Lettering shall have a highly visible coloring, such as white, that is permanently affixed.
12. Independent Service: Provide a key switch in the car operating panel which, when actuated, shall cancel previously registered car calls, disconnect the elevator from the hall buttons and allow operation from the car buttons only. Car door shall remain open unless closed fully by the door close button.
13. Two-Stop Collective Simplex Automatic Operation:  
The existing two-stop collective simplex automatic operation shall be reused and checked for the following:
  1. System shall be designed so that when the car is standing at either terminal landing, pressure on car button for the other terminal shall automatically dispatch car to that landing. Pressure of landing button at either terminal landing shall call car automatically to that landing. If a landing call is registered while the car is making its trip, that call shall remain registered until the car responds to that call. If no car calls are registered car shall start automatically and respond to hall calls. Provide time limit relay arranged to hold car at landing at which it has stopped for predetermined time after car stops. After all car landing calls have been answered, car shall remain parked at landing where last used with car and hoistway doors closed until another call is registered. Pressing the landing button at floor at which car is parked shall automatically open car and hoistway doors. In all normal operations, the starting of the car shall be contingent upon establishment of hoistway door interlock and car door circuits.
  2. Automatic dispatching operation: all two stop elevators shall include "Step-in-and-Go" feature. Calls for the opposite landing will be automatically set when the elevator opens its doors for a hall call. This feature shall be provided for all elevators that have public access for two stops (i.e., any elevators with key operated service landings will be included).

C Position Indicators:

1. Car indicator: In accordance with ADA requirements. Mounted in vertical row in car-operating panel to show position of car in hoistway by illumination of indicators corresponding to landing at which the car is stopped or passing. Finish for exposed-to-view metal components: Stainless Steel.
  2. Landing indicator: In accordance with ADA requirements. Two-element direction-of-travel indicator mounted above call station or hoistway entrance as shown, including one red and one white indicator. Direction of car's operation shown by illumination of red indicator for DOWN and white indicator for UP.
  3. In-car signals: Audible signal indicating car's direction of travel, signal sounding once for UP direction and twice for DOWN direction.
  4. Landing signals: Audible signal at each hoistway entrance indicating car's direction of travel, signal sounding once for UP direction and twice for DOWN direction.
- D. Lighting:
1. Machine Room Emergency Lighting: Maintained Emergency lighting fittings shall be provided in each elevator machine room.
    - a) There shall be a minimum of one maintained lighting fixture.
  2. Car interior: LED fixture, 120-volt operation, with clear prismatic glass diffuser, flush mounted in ceiling, cool white bulbs. Illumination level shall be 15-foot candles minimum at car operating panel.
  3. Car top and underside of car floor: Medium-base porcelain lamp receptacles, with wire lamp guards.
  4. Car emergency lighting:
    - a. Fixture: Recess mounted, with stainless steel frame, location as shown.
    - b. Diffuser: Prismatic polycarbonate plastic.
    - c. Lamps: Two, size 16-51
    - d. Remote power supply:
      - 1) Power pack: Sealed gel cell battery with integral regulating charger and an alarm bell.
      - 2) Capable of operating bell for one-hour minimum and light at car-operating panel at 0.2 low candles minimum for four hours minimum.
      - 3) Location: on top of car or in COP with easy access provided.
- E. Inspection Operation: Key switch in car to nullify car and landing buttons permitting operation of elevator from top of car for inspection purposes:

1. Top of Car Inspection Station: controls on roof of car containing continuous pressure UP and DOWN buttons, emergency stop button and toggle switch to activate inspection devices. The device shall also have an 110v ac outlet for extension cord and provided with a light and guard.
- F. Leveling: Automatic leveling device to stop car within 1/8 inch of landing level regardless of load or direction of travel. Landing level maintained within leveling zone irrespective of hoistway doors being open or closed.
- G. Emergency Service:
  1. Controls to return elevator to designated floor by means of key-operated switch outside street or ground floor hoistway entrance in compliance with ANSI/ASME A17.1.
  2. In-car control during emergency operation by means of key switch in compliance with ANSI/ASME A17.1.
  3. Terminals on elevators controllers for connection of circuit from heat and smoke sensing devices, with wiring from sensing devices to elevator controller.
- H. Telephone Facilities:
  1. Provide all audio/visual communication, signaling, and monitoring in accordance with ADA and ANSI. "Hands-free" phone integral with control panel, mounted in accordance with ADA requirements; having inscription EMERGENCY TELEPHONE as specified for Person with disabilities; finish exposed-to-view components to match stainless steel control panel; color of letters to contrast with panel.
    - a. Provide emergency communicators in accordance with ADA requirements to include auxiliary push button to summon help and visual feedback indicating that the call has been responded to.
  2. Provide wiring and jacks for a portable self-contained battery-powered maintenance telephone system. Jacks shall be located on car top, inside car, and in machine room. Furnish three telephone instruments for use of maintenance personnel.
- I. Elevator Components:

Provide and install, Gearless Traction elevators with machine unit, roping, governors, safeties, counterweight, and related equipment. Provide for locating and installing the machine units and associated control equipment in the machine rooms. Provide and install any and all necessary auxiliary beams, structural members or other such devices needed to assure proper and safe operation of all elevator equipment. Vibration isolating machine foundation shall be of approved type which shall effectively prevent transmission of machine vibration to the building structure.

1. Guide Rails:
  - a. Guides shall be steel T-section rails. Rail surfaces shall be machined smooth to insure proper operation of guides. Rail ends shall be accurately machined with tongue and matching groove centrally located on web. Non wearing rail surfaces are to be painted at the completion of the elevator in color selected by the Engineer.
  - b. Guides shall be joined and installed in accordance with Section 2.23 of the Code.
  - c. Rail bracket spacing and maximum horizontal forces and guide rails in accordance with ASME A17.1.
2. Roller Guides: Roller guides shall be mounted on top and bottom of the car and counterweight frames to engage the guide rails and provide a smooth ride.
3. Machine: Provide AC gearless machine, with permanent magnet synchronous motor, direct current electro-mechanical disc brakes and integral traction drive sheave.
  - a. The motors shall be of the alternating current reversible asynchronous or synchronous type of a design adapted to the severe requirements of elevator service. Motor shall be capable of developing the torque required to meet or exceed an acceleration rate of 2 ft/sec<sup>2</sup> for the elevator car.
  - b. A means to protect the windings and bearings from airborne dust shall be provided.
  - c. Insulation of all windings shall be impregnated and baked to prevent absorption of moisture and oil. The insulation resistance between motor frame and windings shall not be less than one megohm. The motor windings shall stand a dielectric test of twice the normal voltage plus 1000 RMS volts of 60 Hertz, alternating current for one minute.
  - d. Motor leads in the conduit box shall have the same insulation class as the windings. Motor lead wire shall be rated 125 C and shall be sized for 105 C at the motor nameplate amperes at 1.0 Power Factor per Electrical Apparatus Service Association (EASA) recommendations. Leads are to be numbered for clockwise rotation when facing opposite the shaft end.
  - e. The motor shall be designed to stand the severe loads encountered in elevator service and the windings shall have a minimum insulation temperature rating two ratings higher than the actual temperature rise of the motor, with a minimum rating of NEMA class F.
  - f. The motor shall be designed to the ASME A17.1 rated load requirements.
4. Brake: The brake(s) shall be of the self-adjusting fail-safe (spring

applied and electrically released) type provided with an external manual brake release and designed to meet the service factor demand of its intended use. Dual brakes shall operate independent of each other for ascending car over speed and unintended car movement. Disc type brake shall be securely mounted to the shaft and shall run concentric to the shaft. Disc shall be machined to obtain a smooth and accurate face. The brake shall be spring actuated, direct current, electrically released, heavy construction with proper braking area for the load and speed specified. The brake shall be provided with sufficient power to stop and hold the car with full contract load.

5. Elevator Drive System: Variable Voltage Variable Frequency (VVVF) Drive: The drive shall be microprocessor and IGBT based using vector control algorithms. The algorithms shall incorporate a motor model to determine the electromagnetic state of the motor. The motor model shall also encompass a temperature compensation algorithm which is essential for speed accuracy.
  - a. Velocity shall be controlled by a feedback loop to within +/- 2% of contract speed and speed shall be independently supervised.
  - b. Position of floors in the building shall be learned during a slow speed setup run. Once learned, floor locations shall be stored in non-volatile memory. Power loss shall not require the floors to be re-learned. Stopping accuracy shall be +/- 5 mm or less. Re-leveling shall be automatic.
  - c. Resistors shall be provided to absorb the power regenerated by the motor. They shall dissipate power only when the motor is regenerating. Control shall be by IGBT.
  - d. Maximum total harmonic distortion shall not exceed IEEE Std. 519 to be measured at the elevator disconnect.
  - e. For hoist motors 50Hp and above, the drive shall be regenerative feeding the three-phase power supply of the controller.
6. Hoistway Operating Devices: Normal terminal stopping devices. Emergency terminal stopping device as required, controller switches and circuitry arranged in accordance with ANSI/ASME requirements. All switches to be compatible with control system.
7. Stop Switch: Emergency stop switch mounted in the pit of each elevator in accordance with Section 2.2.6 of the Code, shall prevent operation of elevator when switch is activated. Switch shall be of the type described in Section 2.2.6 of the Code.
8. Automatic Terminal Stopping Device: Terminal stopping devices shall be provided at the top and bottom of the elevator hoistway and shall be operated by a fixed cam attached to the elevator. The switches shall be

- independent of any other stopping device and shall cut off power from the driving machine motor and brake.
9. MOUNTING: Anti-vibration Mounts: For machines that are support beam mounted, an anti-vibration mounting pad is to be provided.
  10. Car Safety. The car safety shall be Type B, as specified in the ANSI/ASME Code, mounted under the car platform and securely bolted to the car sling. It shall be sized for the capacity and speed noted on the Contract Drawings. The car safety shall be actuated by the speed governor upon a predetermined overspeed downward. When tripped, the safety mechanism shall engage the rails with sufficient force to stop a fully loaded car with an average rate of retardation within the limits given by the ASME A17.1 Code for the capacity. The safety shall stop the elevator whenever excessive descending speed is experienced and means shall be provided to cut off power from the motor and apply brake prior to application of the safety. The safety shall be modified and adjusted as necessary so that its operation complies with Code requirements and requirement of all authorities having jurisdiction.
  11. Governor: Friction type over-speed governor rated for the duty of the elevator specified and to operate the car safety. The governors shall be located where the car or the counterweight in case of overtravel cannot strike it, and where there is adequate space for full movement of governor parts and driven by a governor rope suitably connected to the governor rope-releasing carrier.
    - a. An electrical governor overspeed protective switch that, where operated, shall remove from the driving machine motor and brake before or at the time of application of the safety.
    - b. The governor shall be sealed and tagged with the running speed, tripping speed, and date last tested as required by Code.
  12. Tension Sheave: A tension sheave shall be provided in accordance with governor and car safety loading requirements.
  13. Life Safety Provisions: Provide Life safety hooks and/or other life safety devices for fall protection in accordance with OSHA standards/guidelines. Life safety hooks and/or other life safety devices locations to be coordinated and installed by the Installer.
  14. Counterweight: A counterweight shall be provided for the elevator equal to the weight of the complete car and 40 percent of the rated car. Tie rods shall pass through holes in each subweight and through holes in frame members above and below subweights in such a manner as to securely hold subweights in place. The bottom of the counterweight shall have a buffer striking plate and means to attach knock-off blocks during rope stretch. Roller guides shall be mounted on top and bottom of the counterweight frames to engage the guide rails. Submit paint finish of counterweights for approval.

- a. Idler Sheave: To be located directly above the counterweight frame and integral with counterweight frame. The sheave material shall be accurately machined as per manufacturers requirements.
  - b. Counterweight guides shall be of the roller type; each guide shall consist of a set of at least three (3) large diameter polyurethane rollers equipped with sealed preloaded ball bearings. Each roller shall automatically adjust itself to guide rail misalignment and prevent excessive lateral car movement.
15. Compensation for the weight of hoisting ropes and unbalanced portion of traveling cables shall be provided where required to produce proper operation of elevator for car travel of 50 to 100 feet. All elevators requiring compensation shall have rope compensation.
- a. Rope compensation shall consist of an appropriate number and size of iron steel wire ropes attached to the underside of car frame and counterweight frame and passing under a weighted idler sheave in pit. A metal data tag giving the number, diameter, type, month and year installed, and names of manufacturer and installer of compensating ropes shall be securely attached to one of the compensating rope fastenings.
  - b. The weighted idler shall be provided to equalize tension in the compensating rope. The idler sheave shall be provided with bearing of anti-friction bearing metal, ball or roller-type similar to those specified for hoisting machine. Suitable metal guards shall be provided for, or be incorporated in, the design of the equipment, to prevent rope jumping off sheave.
16. Buffers: Provide and install car and counterweight buffers of the oil type as indicated by Code with blocking and support, mounted on the supporting channel or block on the pit floor. Buffers shall comply with all applicable codes. Buffer anchorage at pit floor to be designed and installed without damage to pit floor.
17. Car Frame: A suitable car frame shall be provided with adequate bracing to support the platform and car enclosure. Provide welded or bolted type 316 stainless steel channel uprights affixed to crosshead and plank channels with welded or bolted bracing members and gusset plates which will remove strain from car enclosure.
18. Platform: Havy Loading Type. The car platform shall be designed to accommodate one-piece loads weighing up to 25% of the APTA rated load, such as wheeled food carts, hand trucks, etc. The platform shall be type 316 stainless steel.

19. Provide and install all necessary accessory beams, auxiliary beams or other devices needed for safe and normal operation and installation of all elevator equipment and devices. It is the elevators installer's responsibility to ensure provided elevator equipment will function as designed in the available space and with the steel beams, steel members or other such equipment in the machine rooms and hoistways in place at the time of installation.

J. Controller-System:

1. An Allen Bradley PLC-based controller shall be provided, governing starting and stopping as well as preventing damage to the motor from overload or excessive current. It shall automatically cut off the motor current and bring the car to rest in the event any of the safety devices are activated.
  - a. System shall coordinate the functioning of elevator drive unit relative to actual location and status of elevator. It shall interface with door control and all required safety circuits, switches and devices. The controller shall be mounted in a NEMA 4X stainless steel air-conditioned cabinet within the controller room.
  - b. The diagnostic system shall be an integral part of the controller and provide user-friendly interaction between the service person and the controller system.
  - c. The supervisory logic shall be performed by a main controller or coordinated between the elevator controllers which will interface directly into the Allen Bradley DH485 protocol Remote Monitoring network, transmitting data from the elevator controller through a data concentrator to the Authority's AEMS RTU computer control and data system. The supervisory logic will coordinate dispatching assignments, interfacing operational demand data accumulated from car and corridor operating fixtures, selector and door control functions.
  - d. Controller shall be capable of operating with an operating temperature range of 320F to 140F with non-drip environment and no more than 90 percent relative humidity. However the air conditioner on controller cabinet shall maintain the operating temperature in range of 50<sup>0</sup> F to 90<sup>0</sup> F.
2. An Allen Bradley CompactLogix 1769-L32E based PLC control system shall be provided.
  - 1) The exclusive Allen Bradley DH485 protocol data port will transmit data from the elevator controller to the station or facility data concentrator. The contractor shall provide a controller data interface to a DH 485 network. Contractor

shall provide Data cables to connect from the PLC controller to data concentrator in the station and available for connection to the controller DH485 interface. The contractor shall pull Belden 9842, or ELES Engineering approved equal, cables to connect the controller into the monitoring DH485 network. The DH 485 controller interface shall be programmable for data rates up to 115 Kbps. The interface shall allow other nodes such as other elevators and escalators to be readily incorporated into the DH 485 network.

- 2) A data concentrator PLC shall be installed using an Allen Bradley MicroLogix 1400 or SLC5/05 PLC per station to function as data concentrated or to consolidate data from all controllers in the station. The software for the data concentrator shall receive controller data over the local monitoring DH 485 network and provide formatted data to the AEMS RTU through an RS232 link. The data concentrator shall provide an Ethernet port for interfacing with the WMATA wide area network. A data concentrator connection to the WMATA wide area network shall be provided.
3. The PLC power shall come from 120VAC provided by the car lighting supply in the elevator controller.
4. The PLC shall accommodate the following Signal List, as Applicable, and provide data to the data concentrator as specified in specification.

5. The PLC CPU module shall store the last 99 faults, accessible via laptop connection, controller fault/status display and remote communications. The contractor shall provide WMATA with a programming and monitoring unit, such as a laptop computer with the newest version of Allen Bradley RS-Logix and any other software required to setup and program all electronic items in the control system, for each elevator that this system is installed, for the purpose of troubleshooting and remote monitoring modifications. The laptop should allow uploading, editing, and downloading any software that is being used on this elevator for any operation.
6. An Allen Bradley PanelView Plus 6, EZAutomation or ELES Engineering approved equal, fault/status display/interface shall be provided in the controller cabinet. Control system timers and other setup criteria shall be programmable through this unit. All fault, status and setup data shall be stored in the controller CPU module.
7. In cases where the programming is done by the supplier, the supplier shall provide a copy of all working programs, including labels for all inputs and outputs, data tables and internal logic points, on Flash Drives/CD-R disks as well as a printed program listing. The programs and setup data shall require a password for access and modification. The password shall be provided to ELES Engineering as part of the Submittal.
8. The main control of an elevator shall contain at least the following devices or electronic sensing: phase failure line voltage monitor, motor current and ground fault monitor.
9. The controller cabinet shall contain a permanently mounted fault indicator panel with LED indicator lights. Tripped safety devices, door position, door reversal, car running status, and control system status shall be indicated.
10. All terminals shall have identification markings and all wires, including field wires, shall be provided with permanent heat shrink sleeve cable markers. These wiring identifications shall be provided in the wiring diagram at each end of the circuit connections.
11. The controller shall be equipped with the AC vector drive installed in-line before the hoist motor contactor and the hoist motor.
12. The AC vector drive shall be capable of accelerating and decelerating the hoist motor smoothly and gradually.
13. Adjustable settings for acceleration and deceleration ramps shall be provided.
14. The controller shall have, at least, one dedicated serial port for interface to the DH485 monitoring network and programming access without disconnecting any other port.

15. The Programmable Controller shall have, at least, one dedicated port to support the controller fault/status display.
16. The controller PLC shall provide the following Remote Monitoring and diagnostic network support:
  - a) All applicable faults, statuses and data listed in Table 1 shall be provided
  - b) Fault indications shall remain until reset in the controller.
  - c) Status and analog data shall be provided for the duration of the condition.
  - d) Software in the controller PLC shall format monitoring data responses to data concentrator polling as specified in the specification.
  - e) The monitoring data port in the controller shall be setup for DH485 protocol with the port network identification number programmed for the particular elevator identification. For instance, identification number 11 applies to elevator 1, 12 to elevator 2, etc.
  - f) All faults, statuses and data shall be held by the controller CPU and sent from the CPU when polled by the data concentrator.
17. Provide sufficient non-volatile CPU memory, for non-volatile retention of program memory, system status and operating parameters.
18. Diagnostics
  - a) The processor shall have built-in diagnostics and self-test, such that each time power is cycled, the processor does a complete CPU and RAM memory test. Additionally the power-up test will momentarily light up all diagnostic LED's to be sure they are working. A power up test will not reset fire-service status signals if the internal flag (bit) for Firemans Service Phase I is latched. The processor shall be capable of reporting major and minor fault codes and processor status information back to the data concentrator provided the fault is not a catastrophic hardware failure where the processor is unable to power up.
  - b) The processor shall have a built-in watchdog timer to ensure that all processor program scans occur within the time limit set by the watchdog timer.
  - c) The processor shall have individual LED indicators that are clearly visible and labeled for easy identification. At a minimum the following indicators must be provided:
    - (1) CPU is in RUN mode
    - (2) CPU is FAULTED
    - (3) CPU battery is LOW
    - (4) I/O points are FORCED and are not under program control  
COMMUNICATION channels are active.

19. Input/Output Modules
- a. The Input/Output Modules shall be compatible with the PLC processor I/O structure. Each module shall be provided with a detachable terminal strip to connect wiring to the module. Each wire on the terminals shall be identified by the module terminal.
  - b. Discrete Input Modules: Suitable for the input voltage and compatible with the Allen Bradley system.
  - c. Discrete Output Modules: Suitable for the voltage and load and compatible with the Allen Bradley system.
  - d. Analog Input Modules: Converts analog signals to optional twelve-bit binary values. The module shall accept ~~4~~ four 20 Ma signals. Provide modules compatible with the Allen-Bradley system.
20. I/O Mounting and Power Supply
- a) The controller chassis shall have an additional three spare modules.
  - b) Power supplies shall provide power to the PLC processors, I/O and other function modules. The power supply shall be suitable for operation of 120 VAC, single phase power. Power supply capacity shall be a minimum of 150% of the connected load.
21. Air Conditioning:
- Provide an independent air conditioning unit for each new controller to maintain manufacturers recommended operating temperatures. Condensate from the air conditioning unit must be piped to a suitable drain.
22. Selective Collective Operating: As defined by ASME A17.1 and shall be the pressure upon one or more car buttons to correspond to landings in the order in which the landings are reached by the car, irrespective of the sequence in which the buttons are pressed, provided the hoistway door interlock and car door switch circuits are completed. During this operation, the car shall also answer calls from the landings, which are in the prevailing direction of travel. Each landing call shall be canceled when answered
- a. Momentary pressure on car button or landing button illuminates that button, which remains illuminated until call is answered. Illuminated buttons serve as visual indication that call has been registered and that car will stop at that landing.
  - b. Operation shall be automatic by means of the car and landing buttons. Stops registered by the momentary actuation of the car or landing buttons shall be made in the order in which the landings are reached in each direction of travel after the buttons have been actuated.
  - c. UP landing calls answered while car is traveling in up direction and DOWN landing calls answered while car is traveling down, car reversing after uppermost or lowermost car or landing call has

- been answered and proceed to answer car calls and landing calls registered in opposite direction of travel.
- d. Should both an up and a down call be registered at an intermediate landing, only the call responding to the direction in which the car is traveling shall be canceled upon the stopping of the car at the landing.
23. Supervisory Control: A processor based system to coordinate dispatching assignments, interfacing operational demand data accumulated from car and corridor operating fixtures and other special feature commands issuing from computer processing, selector and door control functions. Incorporate in the system specific operational features as herein described.
- a. Allocate service to demand, make decisions to prevent crowding, save energy, and provide efficient coverage throughout the building. Respond in real time to prevailing traffic conditions as well as historical traffic patterns.
  - b. Constantly compare passenger demand, car load, anticipated demand, car motion status, machine status and other prevailing conditions and evaluate this information in the context of the following dispatching approaches:
    - 1) Give priority to contiguous calls, assigning calls on adjacent floor to the same car if other criteria is satisfied.
    - 2) Give priority to coincident calls, having the same car let a riding passenger off and a waiting passenger on at the same floor.
    - 3) Anticipate demand based on hall calls and car calls already registered and floors with a high possibility of demand.
    - 4) Evaluate relative system response time for each car in the group, weighing all of the above factors.
    - 5) Allocate calls and position cars to minimize waiting time, response time and travel time. The other elevator shall respond for hall calls without any delay after the first elevator leaved the door zone.
    - 6) When there is a hall call registered and an elevator left the landing, the other elevator shall run toward opposite landing.
  - c. Provide the capability to make both car to call or call to car assignments.
  - d. During light traffic conditions, assign cars without demand to specific parking areas until requested for a hall call. Continuously evaluate dispatching assignment and immediately release a car from its assigned area to meet heavy demand elsewhere in the building.

- e. In determining relative system response time for a car to answer a hall call, factor in round-trip calculations for each car as well as other system parameters before deciding which car shall respond to a hall call.
24. Other Features:
- a. Independent Operation: Provide TWO-position keyed switch (ChicagoLock 7500) marked Independent Service, OFF and ON in the lower portion of the car operating panel of all cars. The switch shall be spring loaded type. When placed in ON position, car will be removed from the automatic operating system and will not respond to demands registered at the hall push buttons. It will respond only to floor with doors open until another demand is registered in the car. Demands registered at the landing will remain registered until answered by another elevator. The car only responds to car calls and that the doors remain open after a stop until closed by continuous pressure on the door close button.
  - b. The controller shall be designed to operate automatically on standby power.
25. Machine Room Two Way Communication Device: Provide within each controller/machine room a two way communication device that will interface with any type of ADA compliant telephone. The device shall be mounted directly on or within hands distance proximity to the elevator controller.
26. Any junction boxes installed in the machine room or hoistway shall be accessible for Maintenance.
- a. Drilling or opening top end of enclosure is not acceptable
  - b. Wire nuts or splicing without terminal strips is prohibited.
  - c. All openings shall be properly sized for the conduits.
- K. Door Operator Equipment:
- 1. Provide a water resistant heavy-duty GAL MOVFR or ELES Engineering approved equal door operator with encoderless VVVF drive. Closed loop door operator designed to operate car and hoistway doors simultaneously at the speed specified. Door shall open automatically when car stops at landing to discharge passengers or to answer valid calls and close automatically after predetermined time interval has elapsed. The doors shall be capable of smooth and quiet operation without slam or shock. Door operator to have the following features:
    - a) ½ hp motor and heavy duty sprocket, chain, belt, and sheaves.
    - b) Closed loop regulated speed performance.
    - c) Hand-held keypad programming.
    - d) Adjustments can be stored in the keypad and downloaded to another operator.
    - e) Adjustable door obstruction reversal.

- f) Optical cams with LED indicators.
  - g) Test switches for open, close, nudging and speed zone set up.
  - h) Universal inputs for open, close, and nudging.
  - i) Reversing switch to back up the door reversal device.
  - j) Designed for interior and exterior applications.
2. Provide a non-contact door reversal device with light immunity: The Door Reopening Device shall cause both the car and hoistway doors to reverse, should they detect an obstruction in the elevator entrance. The device electrical wiring shall be supplied with quick disconnects terminals to facilitate replacement. The infrared curtain detector shall include the following:
- a. A protective infrared detector field extending from 1 1/2" above the car sill to a height of 68".
  - b. A fail-safe control system to prevent the doors from closing in case of power loss to the detector.
  - c. A one-piece full door height protective lens cover designed to be completely waterproof and to withstand impact, abrasion and vandalism.
- L. Hoistway Entrances:
- 1. Doors of elevators shall be of the horizontal sliding type, single-speed, center-opening. All elevator door openings shall be a minimum of 42-inches wide per the Americans with Disabilities Act.
  - 2. Entrance frames shall be of welded or bolted construction for complete one-piece unit assembly. All frames shall be securely fastened to fixing angles mounted in the hoistway and shall be type 316 stainless steel. Provide an additional type 316 stainless steel sill angle support. The landing sills shall be extruded stainless steel with a mill finish.
  - 3. All materials and finished surfaces exposed to public view shall be stainless steel with embossed finish and/or glass panels as indicated on Contract drawings. Glass panels (if provided) to be completely flush with door assembly. In a glass hoistway the struts or any brackets should not be visible to public.
  - 4. Fascia and Dust Cover in the hoistway shall be galvanized or type 316 stainless steel and extend at least the full width of door opening on each side. Toe guard shall be fastened to the sill at the lowest landing.
  - 5. Hoistway doors are to be stainless steel and provided with keyways as required for operating mechanisms and door hangers. Provide glass panels that are completely flush with door, as indicated. Each door panel shall have stainless steel bottom guides that run in landing sill slots. Guides shall be replaceable without removing door panels. All doors shall have fixed fire gibs.
  - 6. Interlocks and Contacts:

- a. The doors at each hoistway entrance shall be equipped with approved hoistway door interlocks of the hoistway unit system type tested as required by the Code. Interlock shall prevent operation of the car away from a landing until doors are locked in the closed position. Interlock shall prevent doors from opening at any landing from the corridor side unless car is at rest at that landing, or is in the leveling zone and stopping at that landing.
  - b. Provide key-operated hoistway door unlocking devices. A device shall conform to the requirements of the Code and shall permit authorized persons to open the hoistway doors from the landing when car is away from landing. The key for emergency use shall be mounted in a receptacle with a breakable transparent cover clearly marked in letter at least 1/8 inch high ELEVATOR DOOR KEY FOR FIRE DEPARTMENT AND EMERGENCY USE ONLY. The location of the receptacle shall be as directed by the Engineer.
7. Provide raised floor/level designations in characters and Braille on each jamb at 60 inches from floor to centerline. Characters shall be two inches high and in accordance with ADA requirements.
- M. Wiring and Cable: Division 16, except elevator traveling cable.
1. Elevator Traveling Cable.
    - a. NEC Type ETT, size and number of conductors to suit service, 14AWG minimum, each conductor with different color insulation.
    - b. Cable exceeding 100 feet in length to have steel supporting fillers, cable 100 feet or less with steel or nonmetallic fillers.
    - c. Conductors for electrical, signal, control telephone and sensing devices.
    - d. Ten feet of additional telephone, communications and sensing-device conductors in elevator machine room for connection to future interface panel by others.
    - e. Each traveling cable shall have a minimum of 10 percent spare conductors, but not less than 6 spare conductors in each traveling cable.
    - f. A separate coax cable or a shielded twisted pair should be added to accommodate the security video cameras inside the elevator.
    - g. Provide separate traveling cables for car lighting and fan control circuits and 14 AWG minimum size for elevator lighting circuit.
    - h. All insulated wiring, control wiring and wiring in traveling cables shall be tag coded at their terminals in the motor/controller room, and hoistway junction box, elevator cab junction box, and push-button stations within the cab, and shall agree with the approved wiring diagrams.

- i. Cables shall be free from any possible contact with hoistway structure, car or other equipment. Furnish and install shields or pads to protect the cables.

**N. Conduit Raceways and Boxes: Division 16.**

- 1. Rigid conduit and fittings shall be UL-Listed rigid galvanized steel conforming to the requirements of UL 6 and ANSII C80.1. Minimum diameter shall be  $\frac{3}{4}$  inch for power circuits, one inch for fire and intrusion circuits, and two inches for audio and control circuits. Liquid-tight flexible conduit shall conform to the requirements of UL 360 and consist of a flexible galvanized steel core containing a copper bonding conductor spiral-wound between convolutions and a neoprene or outer jacket overall. Fittings for liquid-tight flexible conduit shall be watertight and shall conform to the requirements of UL 514.
  - a. All conduit terminating in steel cabinets, junction boxes, wireways, switch boxes, outlet boxes and similar locations shall have approved insulation bushings. If the bushings are constructed completely of insulation material, a steel locknut shall be installed under the bushing. At ends of conduits not terminating in steel cabinets or boxes, the conductors shall be protected by terminal fittings having an insulated opening for the conductors.
  - b. The Contractor shall furnish all materials and completely wire all parts of the electrical equipment of the elevators including electrical devices on hatch doors.
- 2. Auxiliary gutters, wireways, and raceways shall be constructed of galvanized sheet steel conforming to the requirement of the NEC and shall be UL listed. Raceway, conduit and wireways within the hoistway exposed to public view shall be concealed within steel cladding.
- 3. Electrical boxes:
  - a. Outlet, junction and pull boxes shall be galvanized sheet steel or galvanized malleable iron, cast iron or ductile iron conforming to the requirement of UL 50, UL 514, and NEC 370-C. Pull boxes shall have screw cover with a liquid-tight gasket.
  - b. Junction boxes on car bottom and hoistway connecting the traveling cable shall contain approved terminal blocks for connection of traveling cable conductors. Terminal blocks shall have indelible identification numbers for each terminal connection.
  - c. All wire connection terminal blocks shall have the same identification number as labeled on the associated electrical wiring. All electrical wires shall use a labeling tube and heat shrink and match the terminal numbers.
  - d. During field installation of junction boxes or control boxes, the contractor/subcontractor shall not drill or cut into the top sides of the box for wiring.

- e. All boxes in machine room or pit shall be mounted on strut channels in order to prevent future corrosion and water damage. The strut channels shall be mounted to the wall and has a minimum of 1-1/2 inches thickness and a minimum of 18 inches above the floor.
  - f. All solid state and electrical components located on top of the car enclosure or in the hoistway shall be installed within NEMA 4X enclosures.
4. Disconnect Switches for Car Lights and Mainline Power
- a. Disconnect switches shall be the following: UL 98, NEMA KS 1, heavy-duty, quick-make/quick-break switching mechanism with operating handle external to enclosure, with positions labeled ON and OFF, defeatable interlock to prevent opening of enclosure door when switch is ON. Enclosures shall be NEMA 250 Type 4x. Label disconnect switches in accordance with the NEC.
  - b. Mainline power disconnect switch shall be located in close proximity to the machine room entrance and shall be easily identifiable from other disconnect.
- O. Metal Work:
- 1. Steel sheet and steel fabrications:
    - a. Stainless steel sheet for cladding shall be minimum 16-gauge, best grade cold-rolled furniture steel. Stainless steel sheet for top enclosure shall be minimum 12-gauge. Stainless steel sheet for hoistway door frame shall be minimum 12-gauge.
    - b. Steel sheet for corrugated floor decking shall be minimum 10-gauge.
    - c. Steel shed for subfloor shall be minimum 3/8-inch thick.
    - d. Stainless steel for screws, bolts and nuts shall be AISI Alloy 303.
    - e. Galvanized steel material shall comply with ASTM A123, ASTM A153, ASTM A525 (G90 coating) and ASTM A568, as applicable. Steel sheet and steel fabrications, except stainless and lubricated machinery parts, which are not shown or specified to have other applied finishes, shall be galvanized.
  - 2. Steel Finishes:

Provide protection for all metal parts, fittings, and accessories by painting or galvanizing, except for stainless steel or anodized aluminum.

    - a. Where visible to the public, cladding and related steel surfaces shall be 316 stainless steel satin finish.
    - b. Paint finish, where shown, shall be aliphatic polyester polyurethane as follows:
      - 1) Primer shall be high-build epoxy-polyamide type, Tnemec Series 66-1211 or equal.

- 2) Finish coat shall be aliphatic polyester polyurethane, Tnemec 71 Endura-shield or equal.
  - 3) Total dry film thickness shall be not less than six mils.
- P. Cab Enclosure:
1. The elevator car and car components shall conform to the requirements of the Code, and shall operate without squeaks or metallic sounds.
  2. Entire car assembly, including car frame and platform, shall be free from warps, buckles, and squeaks and rattles. Joints shall be lightproof.
  3. Handrails: Handrails shall be ½ inch by 6 inch stainless steel #4 satin finished tube suitably mounted.
  4. Car threshold: Car threshold shall be stainless steel with non-slip surface.
  5. Toe guard aprons:
    - a. The toe guard aprons (cladding) at entrance side of elevator car shall be not less than 16 U.S. Standard Gauge (USSG), galvanized or stainless steel and shall extend at least three inches beyond entrance jambs at each side. Toe guard shall have a straight vertical face, extending below the level of finished car floor, of not less than the depth of leveling zone plus three inches. The bottom of guard shall extend 3 inches below vertical face and be beveled at a 15-degree angle from the vertical. The toe guard shall be secured to car platform construction and be reinforced and braced to withstand a constant force of 150 pounds on its face without permanent deformation or deflection exceeding ¼ inch.
    - b. On glass elevators, the toe guard shall extend full width of cab.
  6. Suspended Ceiling:
    - b. The suspended ceiling shall be faced and edged with solid stainless steel panels, 0.075-inch thick with a fully adhered ¾-inch thick core of noncombustible, sound-absorbent material and backed with galvanized sheet steel. ASTM A653M, G90 coating or better.
    - c. Mounting brackets and any necessary holes for the CCTV camera shall be provided on the top of the ceiling. The CCTV 360 degree camera shall be provided that will cover the entire car area. Coordinate bracket configuration and location with the CCTV subcontractor.
    - d. Mounting brackets and any necessary holes for the smoke and fire detection sensors shall be provided on the top of the ceiling, as further specified. Coordinate bracket configuration and location with the fire and intrusion system subcontractor.
  7. Laminated tempered safety glass: Glass shall be laminated fully tempered safety glass conforming to ANSI Z97.1 and the requirements of Specification Section 088000.

- a. Glass shall be laminated. Heat-strengthened, safety glass conforming to requirements of ASTM C 1048 and ANSI Standard Z97.1 and shall consist of two pieces of ¼ inch thick glass and a 0.060 inch thick polyvinyl butyryl interlayer, laminated together.
  - b. Color: Tint by Globe-Amerada Co., used as a standard of quality, or comparable and approved equal.
  - c. Weatherproof tape for field installation of final edge seating shall be compatible with the interlayer.
8. Dry pressure glazing materials:
- a. The setting blocks, edge blocks, and face gaskets shall be ozone resistant, virgin neoprene.
  - b. Setting blocks for installation at each quarter point of the sill shall be 90 durometer, shore A hardness approximately full channel width, 4 inches long, and high enough to afford correct cover and provide 3/8 inch edge clearance for the glass.
  - c. Edge blocks, for vertical insulation at the bottom of each joint channel, shall be 50 durometer, shore A hardness approximately full channel width, three inches long, and provide 3/8 inch edge clearance for the glass.
  - d. Face gaskets shall be continuous, 50 durometer hardness, and provide 3/16 inch face clearance both inside and outside.
9. Sub floor material to be nominal ¼" stainless steel to prevent water infiltration between finished floor, cab and platform base.
- Floor covering: Poured Acrylic Epoxy, polymer system or approved equal color selection and samples to be submitted to the Authority for approval by the Engineer, with slip-resistant surface, ¼ inch thickness, covering elevator car floor area. Flooring shall be non-shrinking, manufactured of prime quality compound, free of calendaring and curing defects, resistant to grease, oil, chemicals, aging, and ozone. Flooring shall be poured incorporating a full membrane system for the entire cab floor width and depth.
10. Emergency exit: Car shall have a top emergency exit conforming to requirements of the ANSI/ASME Code, the applicable jurisdictional requirements. The door shall open toward the top of elevator and shall have a latching mechanism to keep it in place.
11. Ventilation: A 350 cfm exhaust fan for continuous car ventilation shall be provided. Connect continuous ventilation fan to emergency power system. The exhaust fan shall be controlled from the car operating panel with Chicago Lock 7500. Provide sixty (60) minute backup battery power for fan.
12. Lighting fixtures and plug receptacles:

- a. Car lighting shall provide a minimum of 15-foot candles measured at any point on the cab floor and shall be of the LED type. Car lighting shall be provided with emergency battery backup upon failure or interruption of normal car lighting. Emergency lighting unit shall provide required lighting for a minimum of four (4) hours. Battery charger shall be capable of restoring battery to full charge within sixteen (16) hours after resumption of normal power.
  - b. Exterior car lighting shall be as specified. On glass-enclosed elevators they shall be concealed under access panels flush with cab top or bottom surfaces, respectively. A duplex plug receptacle shall be provided in the pit and on top and bottom of each car. The lighting fixtures and receptacles on exterior of car shall be controlled by a switch adjacent to each fixture.
  - c. Provide 115 volt ac plug receptacle (GFCI) within 12 inches of CCTV camera location. Coordinate the installation of CCTV equipment within the design of the elevator cab as the elevator contractor is responsible for the installation of the camera and wiring to the control room.
13. Car Doors and Door Equipment:
- a. Car doors and door frames shall be suitably reinforced and provided with a laminated stainless steel #4 finish on cab side and baked enamel finish on hoistway side. Doors shall protect the full width and height of car entrance opening when in the fully closed position. Car door frame shall be integral with front wall of cab.
  - b. Hanger cover plate sections above the door opening shall be removable from the hoistway. Doors shall be guided at the bottom by composition gibs engaging threshold grooves with minimum clearance.
  - c. Car/Hoistway Door Operator: Car and hoistway doors at each landing shall be opened and closed quietly and smoothly by a direct current electric operator.
  - d. Door operation automatic at each landing with door opening being initiated as car arrives at landing and closing taking place after expiration of specified time interval, with electric contact to prevent starting elevator away from landing unless car door is in its fully closed position.
    - a. Time door closing to start 5 seconds minimum from notification that car is answering landing call.
    - b. Time doors to remain open five seconds minimum.
    - c. Time shall be adjustable to 20 seconds.
    - d. The interval of time that the doors remain open at intermediate landings shall be less for a stop made in response to a landing call. Door open time at a dispatching terminal shall be longer than the time for a stop in response to an intermediate landing call.

- e. All door timers shall be adjustable from the controller display panel.
- 14. Capacity plate: The car capacity plate shall be of plain stainless steel and contain the data required by the ANSI/ASME Code but shall not bear the name of the elevator manufacturer.
- 15. Signal Devices and Fixtures:
  - 1) Car Operating Station:
    - a. Provide one (1) main station in the front and one (1) auxiliary station. The COP shall be a vertical type.
    - b. General: Provide signal fixtures and control devices for each elevator. Buttons and signals shall be tamper resistant of the illuminated type that light-up when activated and remain lit until call or other function has been fulfilled. All signal fixture and control device faceplates shall be of Type 316L, nominal 0.135 inch thick stainless steel with No. 4 finish, unless otherwise shown on the Contract Drawings.
    - c. Car operating stations shall contain Braille plates adjacent to each call button. Contractor to coordinate proper landing call outs based on maximum characters as indicated on Contract drawings. Buttons for DOOR-OPEN, DOOR-CLOSE, ALARM, EMERGENCY PHONE call functions are to be supplied. Buttons are to be vandal resistant and of the positive stop type.
    - d. Station shall have a locked service cabinet for keyed switches of the car light; exhaust fan, independent operation, GFI duplex outlet as indicated on the Contract drawings.
    - e. Provide Emergency Communication: "Hands-free" ADA compliant telephone/intercom.
  - 2) Hall Station: Riser of hall stations of the push-button, call acknowledging, stainless steel, tamper resistant type shall be mounted at all elevator landings. Highest landing shall have a single DOWN button. Lowest landing shall have a single UP button. Incorporate ADA compliant telephone with each hall station. Braille Indicator Plate shall be provided. Faceplate finish shall be Type 316L stainless steel #4 finish. The Hall Station shall be flush to the surface and shall not be projected out.
  - 3) Hall Lanterns:
    - a. Tamper resistant hall lanterns shall be equipped with illuminated (LED type) UP and DOWN signal arrows, but provide single arrow where only one direction is possible. Provided units projecting from faceplate for ease of angular viewing. Match materials, finishes and mounting method with hall stations.
    - b. In conjunction with each hall lantern, provide an adjustable electronic chime signal to indicate that a car is arriving in response to a hall call and to indicate direction of car

travel. Signal shall sound one for up direction of travel and twice for down direction.

- 4) Bell Alarm System: Bell alarm system for each elevator shall be properly located within building and audible outside hoistway when activated by the EMERGENCY ALARM call button on each car control building/station. When emergency stop switch is activated inside fire service box, the bell alarm system should not be activated.
- 5) Firefighters' Service System: Firefighters' service system shall be provided in compliance with code requirements.

R. Machine Room Equipment:

1. Machine Room Emergency Lighting:  
Emergency lighting fittings shall be provided in each elevator machine room.
  - a. There shall be a minimum of one maintained lighting fixture.
2. Clearance around equipment in each machine room shall comply with provisions of all applicable codes. Clear distance for the maintenance purposes shall be at least 18". In no case shall this clearance supersede minimum Code requirements.
3. Equipment in the elevator machine room and hoistway sheaves area shall be so arranged that replaceable items can be removed for repair or replacement either by overhead hoist and dolly, or other conventional means, without dismantling or removing other equipment components in the same machine room.
4. Machine rooms must be air conditioned and heated to maintain an ambient temperature of 50F to 90 degrees F and a relative humidity between 35% to 50%. The Air Conditioner shall be Split System. The heating system for the machine room is also a built in system. A forced removal should be done by moving the air from the room to the outside of the building to another part of the building to keep an air exchange through the equipment room. Intake and exhaust vent should not be located close to each other.
5. Any component attached to the controller shall have a minimum clearance of 18 inches from the side(s) of the component requiring access for maintenance and free air circulation.
6. Provide Mats of insulating rubber or other suitable floor insulation in the front of the Controllers.
  - a. The Resistance range shall be  $1 \times 10^4 < 1 \times 10^6$  and shall meet ANSI/ESD requirements.
  - b. The rubber mat shall be the width of the controller plus 12".
  - c. The length of rubber mat shall be a minimum of 24".
  - d. The rubber mat shall be a ¼" thickness and beveled at each end.

**2.04 KIOSK SURVEILLANCE CONTROL AND COMMUNICATION:**

A. Surveillance Camera Provisions (Surface Elevators). All requirements for CCTV shall comply with the WMATA SMNT Department.

1. Space provisions and mounting holes shall be provided for closed-circuit television (CCTV) cameras to be furnished and install by CCTV subcontractor.

1. The Contractor shall coordinate with the CCTV subcontractor and install wiring from the CCTV location within the elevator cab to an interface terminal and video transmitter located on the elevator car. Final equipment selection has not been performed and is subject to change. Coordinate model, configuration, and location with the CCTV subcontractor.

1) Power will be required by the video transmitter and CCTV camera and shall be provided.

2) Equipment: Fiber Optic Video Transmitters (Elevator Cameras)

2. The Contractor shall work with the CCTV subcontractor to install CCTV subcontractor-provided fiber-optic cable and transmitter to a terminal location specified by the CCTV subcontractor. The Contractor shall tag the cables appropriately, indicating that they are for future use by others.

B. Supply the following status indication, control, and communication functions for each elevator car and landing at an annunciator panel in the kiosk: indication, control, and communication functions in each elevator and landing; and all interconnecting wiring required to provide a complete and operable system. Systems to be provided and installed include the following:

1. Kiosk annunciator panel: Panel shall be a single panel approximately 7-½ by 19 inches. Coordinate design to ensure that the panel is compatible with the mounting provisions, previous designs, and human factors. The panels shall contain:

a. Indicators:

1) Visual display of elevator car status, to include landing stopped at or being approached and direction of travel:

a) Designate elevator by functional name, e.g., Garage 1.

b) For garage elevators designate landing by garage floor level.

2) Out of service because of malfunction.

3) In-Car stop switch is actuated.

4) Continuous audible alarm activated when emergency alarm switch in car is anitiated.

5) Indicator lamps shall be LEDs, with life expectancy of 50,000 average rated hours.

- b. Controls:
  - 1) Out of service.
  - 2) Override control.
  - 3) Door open.
  - 4) Landing selection.
  - 5) Push button switches shall have limited over-travel to prevent damage due to abuse and shall be equipped with lift-up covers to avoid inadvertent operation, have mechanical and electrical life of 25,000 cycles, with integral or isolated illumination circuit and be normally open with momentary action or alternate action circuitry.
  - 6) When the override control switch is OFF, the kiosk controls shall function in parallel with the car and landing controls, i.e., the selective/collective control system shall respond to a kiosk-initiated landing selection with the normal priority afforded the remaining system landing selection and call buttons.
  - 7) When the override control switch is ON, the following actions shall take place:
    - a) If the car is stationary at a landing, it shall remain at the landing and the doors, if open, shall close and remain closed.
    - b) If the car is in motion, it shall stop at the first landing reached and the doors shall remain closed.
    - c) The elevator control system shall then respond only to the kiosk controls and car station.
    - d) The car shall park at the designate landing.
  - 8) When the OUT OF SERVICE switch is actuated, the elevator shall return to the lowest landing before shutting off.
- 2. Elevator fire detection sensor: Provide space and mounting holes for smoke and fire detection sensors to be furnished and installed as required by building, electrical, elevator and local codes. Install wiring from the sensor location in the car to interface terminal cabinet in the machine room, for connection from the sensors to the smoke and fire detection system. Coordinate with installers to allow installation of sensors and operational checkout of the system.
- 3. Passenger - Kiosk communications (VIOP) system:
  - a. Communications signal button in elevator car momentary contact to illuminate back-lighted signal button in car and latch on a continuous audible signal and illuminated indicator in the kiosk.
  - b. Communications buttons at landings, momentary contact, to illuminate back lighted signal button at the landing and latch on a continuous audible signal and illuminated indicator in the kiosk.

- c. Push button in kiosk to activate intercom system and reset indicator lamps and audible alarm.
- d. Each passenger operated device shall have identification markings as specified for car operating devices.
- e. The voice communication intercom system shall function as a master remote network. The master station shall be located in the kiosk annunciator panel and shall include a speaker-microphone, audio amplifier, on-off indicator lamp, audible signal device control and push button lamp for the operations. A remote station shall include a speaker-microphone and a communications signal button shall light the signal button and cause a continuous audible signal at the master station and light indicator lamp corresponding to the calling remote station. Communications between master and remote station shall be established upon the actuation of the master station push-button control corresponding to the calling remote station with the master station push to talk control determining the direction of transmission.
- f. If successive calls are received from other remote stations while communication is in progress with one remote station, the audible signal shall sound the indicator lamps corresponding to the calling remote stations shall light and both shall remain on the indicate waiting calls.
- g. Means shall be provided to clear the indicating lamps independently. Communication initiated from the master station shall be established upon actuation of the push button control corresponding to the called remote station, with the master station push-to-talk control determining the direction of transmission.
- h. The audio amplifier at the master station shall be all solid state in construction and shall control incoming and outgoing volumes for all of the remote stations. The volume levels shall be preset during installation and shall be adjustable to provide a maximum of five watts rms at the speaker-microphones.
- i. The power supply shall supply all ac and dc voltages necessary for all circuitry associated with the voice communications intercom system, and shall operate from the 120-volt ac, 60 Hertz emergency power supply located in the elevator machine room.
- j. The audio amplifier and the speaker-microphones shall have a frequency response of plus or minus three Db from 300 Hertz to 5,000 Hertz. Power consumption shall be 5 watts maximum in standby and 50 watts maximum under load.
- k. The Contractor shall be responsible for shielding, grounding and other measures necessary to protect the voice communications intercom system from interference from other electrical systems.
- l. Speaker grilles shall have a minimum of 35 percent open area over the entire surface of the speaker cone.

- m. Switches and relays used with this system shall have an operating life exceeding 5,000,000 cycles. Documentation shall be provided by the Contractor to the Engineer, for his approval, to substantiate this life cycle level.
- n. The system shall perform adequately, as approved by the Engineer, with both the remote and the master station test personnel speaking from three feet away from the speaker-microphones.
- o. Communication in the car shall also rollover to a 24-hour manned site (Rail Operations Control Center) in the event that the kiosk does not respond to the call.
- p. Each passenger-operated device shall be identified in accordance with ADA/ADAAG requirements.
  - 1) ADA requirement for providing emergency two-way communications between an elevator and a point outside the hoist way (the Kiosk).
  - 2) Device mounting heights shall comply with:
    - a) ADAAG requirements.
    - b) ASME A17.1-2007. The highest operable part of the two-way communication system shall be a maximum of 48 inches from the floor.
  - 3) A Braille Instruction Plate shall be permanently affixed on each remote intercom unit.
    - a) ADA Standards: Raised symbol and lettering (Signage) located adjacent to the device.

**2.05 EMERGENCY POWER OPERATION**

- A. Provide control equipment and interlocks sufficient to operate at least one elevator for group of three at a time in the event of failure of normal building power supply.
- B. Provide for sequential operation to return elevators to the main entrance floor. Upon transfer to generator power source as evidenced by signal generated by contact closure at elevator automatic transfer switch, start one elevator at a time and return that elevator to the main floor and park with the door open before starting next elevator.
- C. Provide selector switch for automatic and manual selection of the elevator that is to operate on generator power source. Locate selector switch adjacent to elevator door key or as directed by the Engineer.
- D. When normal building power is restored, as evidenced by signal generated by contact closure at elevator automatic transfer switch, return elevators to normal operation without disruption to normal operating circuits or electrical systems.
- E. The key lock shall be ChicagoLock 7500.
- F. The minimum requirements of the Code shall be met.

**PART 3 – EXECUTION**

**3.01 EXAMINATION**

- A. Prior to beginning installation of elevator equipment, examine the following and verify that no irregularities exist that would affect quality or execution of work as specified.
  - 1. Hoistway size and plumbness.
  - 2. Sill pockets.
  - 3. Anchor brackets
  - 4. Sill supports.
  - 5. Spreader/Divided beams.
  - 6. Machine beams and any other supplied by others.
  - 7. Pit Depth
  - 8. Overhead clearance
- B. Do not proceed with installation until previous work conforms to project requirements.

**3.02 INSTALLATION**

- A. Coordinate work in this section with all trades to ensure that the installation of the elevators is not in conflict with the work performed of other trades.
- B. Make necessary wiring connections.
- C. Paint metal surfaces in accordance with Section 09\_91\_99.
- D. Install elevator equipment, materials and accessories in accordance with the OEM's installation procedures and approved Shop Drawings to make elevator fully operational.
- E. Erect guides plumb and securely fasten to building structure.
- F. Provide protective coverings for finished surfaces.
- G. Upon completion, touch up and restore/ replace damaged or defaced factory finished surfaces. Touch up any marred finishes and replace as directed by the Authority.
- H. Remove protective coverings and clean exposed surfaces after completion.

**3.03 FIELD TESTING:**

- A. Operating Adjustments and tests: At all times, until issued final acceptance by ELES representative, adjust equipment to operate satisfactorily, conduct performance tests and make necessary readjustments.
  - 1. Provide test instruments, materials, other necessary facilities, and all labor required for acceptance tests specified.
  - 2. All faults recorded during performance period will be turned over to the

Authority for review. The review period should be not less than 20 working days. A fault such as, but not limited to:

- a. Door lock or car gate switch malfunction.
  - b. Emergency stop switches and safety circuit malfunction.
  - c. Door protection timer.
  - d. Motor overload circuits
  - e. Stuck button protection features.
  - f. Low oil and oil pressure devices.
  - g. Test emergency telephone in car
- B. Any deficiencies found during the performance period will be repaired by the contractor at no charge to the Authority.  
The warranty shall include materials and labor necessary to correct defects.
- C. Defects shall include, but not be limited to, noisy, rough, or substandard operation; loose, damaged, missing parts and fluid leaks.
- D. Arrange for tests and inspection by jurisdictional authorities to obtain certificate of acceptance.
- E. Coordinate with the Engineer to have the Authority personnel witness acceptance tests.
- F. When the elevator work included in this Contract is fully completed, demonstrate to the satisfaction of ELES representative that the proper operation of every part of the equipment complies with Contract requirements including compliance with all applicable requirements of ANSI/ASME A17.1. The inspection procedure outlined in ANSI/ASME A17.2 will form a part of the final inspection.
- G. Shop test of elevator motor and certified test sheets will be required. The heating, insulation and resistance of the motors will also be determined under actual conditions after installation.

**3.04 ACCEPTANCE TESTS:**

Notification Requirements: Notify the Project Manager and the Engineer a minimum of five (5) working days prior to each scheduled test.

- A. Furnish all test instruments and materials, required at the time of final inspection, to determine compliance of the work with Contract requirements. Materials and instruments furnished shall include standard 50-pound test weights, megohmmeter, alternating current voltmeter and ammeter, centigrade calibrated thermometers, spirit level, and stop watch. At the time of final inspection, tests shall include the following:
- 1. After installation, each elevator shall be tested without load by the Contractor. The elevator shall be subjected to a test for a period of eight—hours continuous run. During the test run, the car shall be stopped at top and bottom levels, in both directions of travel with a standing period of 10 seconds at each landing.

2. Full-load run test: The elevator shall be subjected to a test for a period of one-hour continuous run, with full specified rated load in the car. During the test run, the car shall be stopped at top and bottom levels in both direction of travel with a standing period of 10 seconds at each landing.
3. Car Leveling Test: Determine accuracy of floor landing tests both before and after full load run tests. Minimum of 1/4 inch leveling must be maintained. Test accuracy of landing at all floors with full load and no load in car, in both directions of travel.
4. Speed test: The actual speed of the elevator car shall be determined in both directions of travel, with full specified rated load and with no load in the elevator car. Speed tests shall be made before and after the full load run test. Speed shall be determined with a Tachometer. Car speed when ascending shall be not more than 10 percent above not more than 10 percent below the specified car speed.
5. Temperature rise test: The temperature rise of the drive unit motor shall be determined during the full load test run. Temperatures shall be measured by the use of thermometers inserted into the windings and shielded by cotton waste. Under these conditions, the temperature rise of the motor shall not exceed NEMA specified temperature rise. Test shall be started only when all parts of equipment are within 5<sup>0</sup> C of the ambient temperature at the time of starting test.
6. Insulation resistance test:
  - a. The complete wiring system of elevator shall be free from short circuits and accidental grounds. The insulation resistance of the system shall be more than one megohm when tested by using a 500-volt megohmmeter.
  - b. The elevator structure, equipment, and raceway shall be tested for continuity to ground.

### 3.05 ELEVATOR PROTECTION:

1. The finished elevator installations shall be completely barricaded and enclosed to preclude their use without permission of the Contractor until Final Acceptance and release by the Contractor for general use. The enclosure shall be fabricated to allow easy access for maintenance, testing and adjustment.
2. The Contractor shall be responsible for the security of the contents of each machine room. The Contractor shall control access to that room, and ensure that it shall remain secure at all times until the completion of the Contractor's interim maintenance obligation.
3. Protection: During installation and until all elevator systems are fully operational and accepted by WMATA, make all necessary provisions to protect all elevator components from damage, deterioration, and adverse environmental conditions. Do not use or allow the use of the elevator for construction purposes such as hauling materials or worker transport during construction.
4. Security Of Machine Rooms: The Contractor shall be responsible for the security of the contents of each machine room. The Contractor shall control access to that room and ensure it shall remain locked and secure at all times.
5. Field Painting: Metal parts visible to the public shall be field painted.

**3.06 WARRANTY**

Warranty: Two-year warranty of construction shall start at Final Contract completion.

- A. The OEM shall warrant in writing that all equipment manufactured and installed under this specification, for a period of twenty four (24) months from the date of Final Acceptance by the Authority, be free of defects in design, materials, and workmanship, under normal use and service. Defective work shall be repaired or replaced at no additional cost to the Owner.
- B. The warranty shall include materials and labor necessary to correct defects.
- C. The warranty does not begin until all of the following requirements have been met.
  - 1) The Operations and Maintenance Manuals are accepted by WMATA.
  - 2) The required training has been completed to the satisfaction of WMATA.
  - 3) All field tests have been successfully completed.
  - 4) The acceptance testing has been successfully completed.
  - 5) The elevators are in service for passenger/public use.
  - 6) The State and local jurisdictions have inspected the elevators and issued the respective certificates of Operation.
  - 7) All spare parts have been delivered and received by WMATA.
  - 8) Any discrepancy identified by the ELES representative shall be repaired or replaced by the Contractor at no additional cost to the Authority.

**3.07 MAINTENANCE:**

3. Maintenance Service

The Contractor shall perform full maintenance service for a period of two years on each elevator in accordance with the manufacturer's maintenance manual and WMATA ELES maintenance program prior to WMATA providing permanent maintenance. The period of maintenance shall begin after test(s) and Provisional Acceptance of each elevator and shall extend to the scheduled date of Final Acceptance for all units in the same facility plus a period of two years. In no case shall the interval between inspections and testing be greater than one month. The maintenance service during the warranty period shall be provided by fully trained elevator mechanics. The maintenance tasks shall include, but not be limited to, the following:

- a. Inspection of completed installation and periodic testing to maintain the elevators in completely operable condition.
- b. Contractor shall provide support for periodic, accident and incident, PM compliance inspections.

- c. Lubrication of parts, and the protection of the equipment.
- d. Replacement of defective parts at no additional cost to the Authority.
- e. Annual clean down of the elevator and hoistway enclosure is required. Make necessary arrangements with Authority in order to minimize any inconvenience.
- f. Contractors performing maintenance are responsible for all service, repair work and emergency call. The contractors shall provide unlimited service during regular time and twenty-four (24) hour (including Holidays) emergency call back service at no additional cost.
  - A. Provide twenty (24) hour (including Holidays) emergency service during the maintenance period consisting of a prompt response (within 1 hour) to emergency request by telephone or otherwise from Authority or designated representative if an elevator is inoperable or in case of injury, entrapment, or potential injury to persons.
  - B. Unlimited service callbacks are included with a required response time of one (1) hour (including Holidays).
- g. Periodic maintenance (based on WMATA schedule) shall be performed off peak hours to minimize service interruption as long as the other elevator serving the same platform is operational.
- h. Reporting: Detailed monthly records of tasks performed including names of individuals performing the tasks, date and time performed, and other pertinent data. In addition, the reports are to be provided in an electronic format acceptable to WMATA's needs.
- i. Contractor performed maintenance shall follow the WMATA Office of Elevator and Escalator Operations procedures, schedules and check charts.

Within three (3) months prior to the termination of this contract, the Authority or his designated representative(s) shall make a thorough maintenance inspection of all equipment covered under this contract. The contractor shall provide personnel to remove, test, and operate equipment as necessary. All deficiencies found as a result of this inspection shall be corrected by the Contractor as required in this agreement with no additional cost to the Authority.

**3.08 REMOTE MONITORING SPECIFICATIONS:**

- A. Allen Bradley DF1 or industry standard Modbus protocol shall be provided to transmit data from the Elevator/Escalator controller to the Authority's AEMS RTU computer control and data system. The Design-Builder shall provide a controller data interface to a DH-485 network located in the Elevator /Escalator machine room. The DH-485 controller interface shall be programmable for data rates up to 115Kbps. The interface shall allow other nodes such as other Elevator or Escalators to be readily incorporated into the DH-485 network. The controller data interface shall include one Allen Bradley SLC PLC per station to function as a data concentrator to consolidate data from all the controllers in the station. The software for the data concentrator shall be as specified by the Authority. The data concentrator shall receive controller data over the DH-485 data network and provide formatted data to the AEMS RTU through a RS 232 link. This data transmission may be accomplished by a separate PLC controller integrated into the control system.
- B. The Elevator /Escalator control system shall automatically initiate the transmittal of data when data is requested by the Authority's AEMS system and continue until all data is received by the AEMS RTU in the station AC switchboard room. The Authority will perform final integration of the data in the AEMS system.
- C. The Contractor shall also provide the required hardware to download data from any fault finding annunciator panel to a supplied laptop PC being utilized at the Elevator/Escalator location. The provided software shall permit the downloading and storage of data on the supplied laptop PC from multiple fault finding annunciator panels.
- D. The Contractor shall install an Allen Bradley network interface module, (model 1761-NET-AIC, or approved alternative) beside the PLC in the controller and provide 24 VDC power to the module. The Allen Bradley PLC will be used for remote monitoring capabilities into WMATA established engineering monitoring network.
- a) The Contractor shall provide all wiring and programming of the PLC to communicate with station data concentrators on the DH-485 network. Coordinate work with WMATA ELES Engineering.
  - b) The Contractor shall pull all remote monitoring cables to the interface in the elevator controller from the remote monitoring network going back to WMATA's Automated Energy Management System (AEMS) remote terminal unit (RTU).
  - c) Provide Ethernet communication between the elevator machine room and WMATA's communication room. The communication port shall be located less than 6' from the controller and shall have minimum of two ports for data communication.
- E. Terms and Definitions
- 1. Boolean - A single bit data type.
  - 2. DF1 - A Rockwell Automation Company proprietary communications protocol.
  - 3. DH485 - An industrial communications network used by Allen Bradley programmable controllers.

4. Integer - A data type 16 bit signed (range -32768 to 32767).
5. PLC - Programmable Logic Controller.
6. QEI - QEI Inc. Springfield NJ
7. RTU - Remote Terminal Unit

F. Elevator Remote Monitoring Data Specification

1. Overview

The design of the WMATA escalator & elevator monitoring system shall include a data concentrator PLC to gather data from the elevator control PLC's over an Allen Bradley DH 485 network. The QEI RTU shall read data from the WMATA data concentrator PLC via an RS 232 serial connection to a 1746-BAST module using Allen Bradley DF1 protocol. See figure 1.1 for reference. This specification defines data to be presented by the WMATA data concentrator PLC to the QEI RTU. The WMATA data concentrator PLC station shall poll the escalator & elevator controller(s) periodically for data and format the data into blocks within the WMATA data concentrator. An Ethernet TCP/IP connection is available at the Data concentrator PLC. The data concentrator PLC has been designed to collect data from up to (10) escalators and/or elevators. The data concentrator PLC is to be mounted into the existing QEI RTU enclosures and powered by a 120 VAC source from within the RTU. For Metro stations where more than (10) escalators and elevators are present additional data concentrator PLC's will be required.

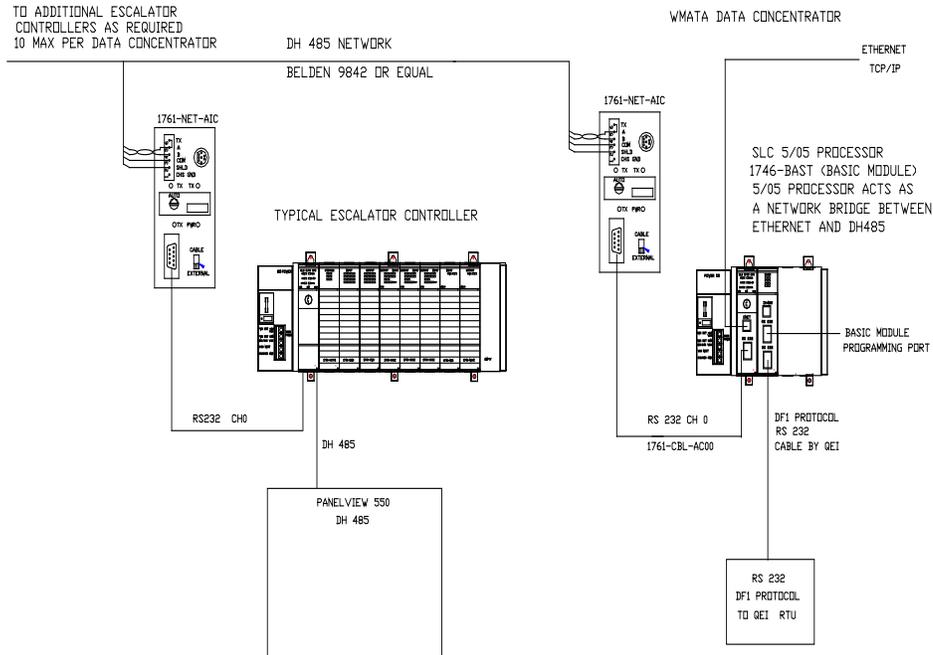


Figure 1.1

## 2. Data Concentrator PLC Data File Assignments.

The WMATA data concentrator PLC shall store data for up to (10) escalators and/or elevators in any combination as defined in table 2.1.

**Table 1**

Escalator DH485 node #	Elevator H485 node #	Status bits File	Analog Data File	DC PLC MSG file#	DC PLC MSG buffer file#
1		N20	N21	N81	N101
2		N22	N23	N82	N102
3		N24	N25	N83	N103
4		N26	N27	N84	N104
5		N28	N29	N85	N105
6		N30	N31	N86	N106
7		N32	N33	N87	N107
8		N34	N35	N88	N108
9		N36	N37	N89	N109
10		N38	N39	N90	N110
	11	N40	N41	N121	N141
	12	N42	N43	N122	N142
	13	N44	N45	N123	N143
	14	N46	N47	N124	N144
	15	N48	N49	N125	N145
	16	N50	N51	N126	N146
17		N52	N53	N127	N147
18		N54	N55	N128	N148
19		N56	N57	N129	N149

20		N58	N59	N130	N150
Concentrator PLC (DC)	25	N80	N79		

Each data file shall begin with word 1 (example: escalator #1 status bits begin with N20:1 and end at N20:20)

The data concentrator PLC communication ports shall be configured as follows.

**Channel 1**

Driver: Ethernet  
 IP Address: TBD  
 Subnet Mask: TBD  
 Gateway Address: TBD

**Channel 2**

Driver: DH485  
 Baud Rate: 19.2K  
 Node Address: 25

1756-BAST basic module communication ports shall be configured as follows.

**Port 1:** Programming port

Settings -- 19,200 Baud, No parity, 8 bits, 1 stop bit, No handshaking

**Port 2:** DF1 port

Settings -- 19,200 Baud, No parity, 8 bits, 1 stop bit, No handshaking

DF1 – Op Code 19 (Full Duplex, NHS, ER, Enable DPD, CRC error checking,

Timeout = 50

Retries = 3

RTS on delay = 20 msec

RTS off delay = 20 msec

Module address = 10

DH485 Port – Not Available

**3. Data Format**

Data Concentrator status in File N80 per table 3.0

**Table 3.0 Data Concentrator Status Bits**

WORD	BIT	DATA TYPE	DESCRIPTION	"0" STATE	"1" STATE
1	0	BOOLEAN	Spare		
	1	BOOLEAN	Data Concentrator PLC Battery Status	FAULT	NORMAL
	2	BOOLEAN	Data Concentrator Basic Module Battery Status	FAULT	NORMAL
	3	BOOLEAN			
	4	BOOLEAN			
	5	BOOLEAN			
	6	BOOLEAN			
	7	BOOLEAN			
	8	BOOLEAN			
	9	BOOLEAN			
	10	BOOLEAN			
	11	BOOLEAN			
	12	BOOLEAN			
	13	BOOLEAN			
	14	BOOLEAN			
	15	BOOLEAN			

WORD	BIT	DATA TYPE	DESCRIPTION	"0" STATE	"1" STATE
2		BYTE	Data Concentrator checksum byte1		
3		BYTE	Data Concentrator checksum byte2		

Words 4 through 20 of the Data Concentrator status file (N80) are unused.

The Data Concentrator Analog data file (N79) is unused.

#### Elevator data:

Two 20 word (40 BYTE) blocks of data shall be developed for each elevator one block for status bits and one block for analog data. Table 3.3 defines the format of data for status bits. Table 3.4 defines the format for analog data.

**Table 3.3 Elevator Status Bits**

WORD	BIT	FAULT TYPE	DESCRIPTION	"0" STATE	"1" STATE
1	0	FAULT	24 VDC POWER SUPPLY	FAULT	NORMAL
	1	FAULT	SAFETY CIRCUIT GOOD	FAULT	NORMAL
	2	FAULT	TOP FINAL LIMIT TRIPPED	FAULT	NORMAL
	3	FAULT	BOTTOM FINAL LIMIT TRIPPED	FAULT	NORMAL
	4	FAULT	DRIVE FAULTED	FAULT	NORMAL
	5	FAULT	OVERLOAD TRIPPED	FAULT	NORMAL
	6	FAULT	STOP BUTTON ACTIVATED	FAULT	NORMAL
	7	STATUS	IN-CAR ALARM BUTTON PRESSED	ALARM	NORMAL
	8	FAULT	OUT OF SERVICE BY DELAY	FAULT	NORMAL
	9	FAULT	MOTOR LIMIT TIMER TRIPPED	FAULT	NORMAL
	10	FAULT	VALVE LIMIT TIMER TRIPPED	FAULT	NORMAL

	11	STATUS	INSPECTION OPERATION ON	ON	OFF
	12	STATUS	INDEEDANT SERVICE ON	ON	OFF
	13	STATUS	VISCOSITY CONTROL ON	ON	OFF
	14	STATUS	CONTROLLER TEST SWITCH ON	ON	OFF
	15	STATUS	FIRE SERVICE PHASE 1 ON	ON	OFF

WORD	BIT	FAULT TYPE	DESCRIPTION	"0" STATE	"1" STATE
2	0	STATUS	FIRE SERVICE PHASE 2 ON	ON	OFF
	1	FAULT	SMOKE SENSOR @ MAIN ON	ON	OFF
	2	FAULT	SMOKE SENSOR @ OTHERS ON	ON	OFF
	3	STATUS	EMERGENCY POWER OPERATION	ON	OFF
	4	STATUS	OVERRIDE ON	ON	OFF
	5	STATUS	CAR IS RUNNING UP	NOT-RUN	RUNNING
	6	STATUS	CAR IS RUNNING DOWN	NOT-RUN	RUNNING
	7	STATUS	BRAKE LIFTED	LIFTED	NORMAL
	8	STATUS	CAR IS IN DOOR ZONE	NOT IN ZONE	IN ZONE
	9	STATUS	INTERLOCKS ARE MADE	OPEN	NORMAL
	10	STATUS	FRONT DOOR GATE SWITCH MADE	OPEN	NORMAL
	11	STATUS	FRONT DOOR FULLY CLOSED	OPEN	CLOSED
	12	STATUS	FRONT DOOR FULLY OPEN	CLOSED	OPEN
	13	STATUS	FRONT DOOR REVERSAL ACTIVATED	OFF	ACTIVE
	14	STATUS	FRONT DOOR PROTECTION ACTIVATED	OFF	ACTIVE
	15	STATUS	REAR DOOR GATE SWITCH MADE	OPEN	NORMAL

WORD	BIT	FAULT TYPE	DESCRIPTION	"0" STATE	"1"STATE
3	0	STATUS	REAR DOOR FULLY CLOSED	OPEN	CLOSED
	1	STATUS	REAR DOOR FULLY OPEN	CLOSED	OPEN
	2	STATUS	REAR DOOR REVERSAL ACTIVATED	OFF	ACTIVE
	3	STATUS	REAR DOOR PROTECTION ACTIVATED	OFF	ACTIVE
	4	FAULT	DOOR REVERSAL DEVICE FAILURE	FAULT	NORMAL
	5	FAULT	ROPE BRAKE SET	FAULT	NORMAL
	6	FAULT	LEVELING SYSTEM FAILURE	FAULT	NORMAL
	7	FAULT	WATER INTRUSION ALARM ACTIVE	FAULT	NORMAL
	8	STATUS	ELEVATOR SLC 5/03 LOW BATTERY	FAULT	NORMAL
	9	STATUS	ELEVATOR SLC 5/03 COMM. ACTIVE	FAULT	NORMAL
	10	STATUS	ELEVATOR SLC 5/03 LOCAL/REMOTE	REMOTE	LOCAL
	11	STATUS	ELEVATOR SLC 5/03 RUN/PROG	PROG	RUN
	12	FAULT	FAULTED	FAULT	NORMAL
	13	STATUS	Out of Service	FAULT	NORMAL
	14		SPARE		
	15		SPARE		

WORD	BIT	FAULT TYPE	DESCRIPTION	"0" STATE	"1"STATE
4	0	STATUS	CAR POSITION 1	NOT AT POSITION	AT POSITION
	1	STATUS	CAR POSITION 2	NOT AT POSITION	AT POSITION
	2	STATUS	CAR POSITION 3	NOT AT POSITION	AT POSITION
	3	STATUS	CAR POSITION 4	NOT AT POSITION	AT POSITION
	4	STATUS	CAR POSITION 5	NOT AT POSITION	AT POSITION

	5	STATUS	CAR POSITION 6	NOT AT POSITION	AT POSITION
	6	STATUS	CAR POSITION 7	NOT AT POSITION	AT POSITION
	7	STATUS	CAR POSITION 8	NOT AT POSITION	AT POSITION
	8				
	9				
	10				
	11				
	12				
	13				
	14				
	15				

Words 5 through 20 are unused.

**Table 3.4 Elevator Analog Data**

WORD	DATA TYPE	MIN VALUE	MAX VALUE	UNITS	SCALE FACTOR	DESCRIPTION
1	INTEGER			AMPS	X10	DRIVE MOTOR AMPS
2	INTEGER			KWH	X1	PRE DAY KWH
3	INTEGER				X1	PRE DAY UP COUNT
4	INTEGER				X1	PRE DAY DOWN COUNT
5	INTEGER				X1	PRE DAY FRONT DOOR CYCLES
6	INTEGER				X1	FAULT CODE
7	INTEGER				X1	PRE DAY REAR DOOR CYCLES
8	INTEGER					
9	INTEGER					
10	INTEGER					

11	INTEGER					
12	INTEGER					
13	INTEGER					
14	INTEGER					
15	INTEGER					
16	INTEGER					
17	INTEGER					
18	INTEGER					
19	INTEGER					
20	INTEGER					

Note: All analog values are multiplied by 16 in the data concentrator to bit shift left 4 bits to align with QEI's 12 bit analog data types.

A note on communication loss

A 60 second watchdog timer is coded into each escalator file. If communications are lost between the data concentrator and the escalator controller for more than 60 seconds the watchdog timer will timeout. When the timer has timed out the communications loss bit will be reset (0) to indicate the communications loss condition.

**3. Time and date sync**

The QEI RTU shall provide clock synchronization to the WMATA data concentrator PLC every 5 minutes. Table 4.1 defines the address and data format of the clock registers in the WMATA data concentrator PLC. The data concentrator PLC shall set the escalator controller date and time every day at 3 AM.

**Table 4.1**

FUNCTION	ADDRESS	FORMAT
YEAR	N13:10	4 DIGITS

MONTH	N13:11	2 DIGITS
DAY	N13:12	2 DIGITS
HOUR	N13:13	2 DIGITS 24 HOUR
MINUTE	N13:14	2 DIGITS
SECOND	N13:15	2 DIGITS

#### 4. Data Concentrator PLC Program

The data concentrator PLC includes code to monitor up to 10 escalators and 5 elevators. Each escalator and elevator has an independent code file and a configuration bit. If an elevator is to be monitored the configuration bit must be set corresponding to the DH485 station address of the elevator controller. If the configuration bit is reset (0), the status and analog data table values for the elevator or escalator will be set to 0.

The configuration bits are as follows.

Escalator Configuration Bit	DH485 Address of Escalator Controller	Elevator Configuration Bit	DH485 Address of Elevator Controller
B9:0/1	1	B9:1/1	11
B9:0/2	2	B9:1/2	12
B9:0/3	3	B9:1/3	13
B9:0/4	4	B9:1/4	14
B9:0/5	5	B9:1/5	15

B9:0/6	6	B9:1/6	16
B9:0/7	7	B9:1/7	17
B9:0/8	8	B9:1/8	18
B9:0/9	9	B9:1/9	19
B9:0/10	10	B9:1/10	20

**3. Data Concentrator Gateway IP addresses.**

The Data concentrator PLC acts as a gateway between the Ethernet and DH485 networks. The PLC contains a list of IP addresses, known as the routing table which will be allowed access to the DH485 network. The routing table will contain 20 addresses.

Station	IP Address
1	TBD
2	
3	
4	
5	
6	
7	

8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

END OF SECTION

**SECTION 14245  
GEARED TRACTION PASSENGER ELEVATORS**

**PART 1 - GENERAL**

**1.01 DESCRIPTION**

- A. This provides guidelines for the fabrication, installation and testing of the heavy-duty Traction Passenger Elevators, Signs and Kiosk information system.
- B. The following sections include related requirements and are performed by other trades:
  - 1. Specifications Section 02000 – Site Construction
  - 2. Specifications Section 05000 – Metal Fabrication
  - 3. Specifications Section 08800 – Glass and Glazing
  - 4. Specifications Section 09920 – Painting
  - 5. Division 7 Section “Waterproofing” for water proofing of elevator pit
  - 6. Division 15 Sections for heating, ventilating and/or air conditioning of elevator machine room.
  - 7. Division 16 Sections for electrical service to elevator equipment, fire alarm systems and communications systems.
- C. Definitions:
  - 1. Heavy duty elevator: An elevator designed specifically for the harsh environment and duty load cycles common to transportation system usage.
  - 2. Elevator - a hoisting and lowering mechanism, equipped with a car or platform, which moves in guide rails or racks and serves two or more landings
  - 3. Elevator, passenger - an elevator used primarily to carry persons other than the operator and persons necessary for loading and unloading.
  - 4. Elevator, Geared: A traction machine-type elevator in which the energy from the motor is transmitted to the drive sheave through worm gearing. The motion of the car is obtained through friction between the suspension ropes and a traction sheave.
  - 5. Contractor: The General Contractor.
  - 6. Installer: The responsible party who installs the elevator.

7. OEM: Original Equipment Manufacturer.
8. Dwell time: The period of time the elevator is at a landing while the doors open, passengers transfer and doors close.
9. Substantial completion: The point at which the elevator is ready for use, whether the site is finished or not. This is where the jurisdictional inspection usually takes place.
10. Final Acceptance: The point at which the owner accepts the elevator project as being complete including all submittal requirements. This may be a different point in time than substantial completion.
11. Interim Maintenance: Maintenance from the point of substantial completion, but prior to Revenue Service.
12. Beneficial Use: When the elevator is placed into service, may be prior to the site being ready for public use.
13. Revenue Service: The station or facility opening date.
14. Notice to Proceed (NTP): within this document shall mean the date which the elevator installer is notified to proceed with the project.
15. Override Switch – A switch located in a kiosk panel, which disables the Hall Call Buttons.
16. MSDS - Material Safety Data Sheet.
17. BOM - Bill of Material
18. SMNT - Systems Maintenance (WMATA)
19. WMATA: Washington Metropolitan Area Transit Authority.

## **1.02 REFERENCES AND QUALITY ASSURANCE**

### **A. Codes, Regulations, Reference Standards and Specifications:**

1. Codes and regulations. of the jurisdictional authorities.
2. ANSI/ME: A17.1, A17.1a, A17.1b, A117.1.
3. ASTM: A123, A153, A525, A568, C1048.
4. Uniform Federal Accessibility Standard,
5. Americans with Disabilities Act.
6. FS: RR-W-410.
7. American Institute of Steel Construction (AISC).
8. American Iron and Steel Institute (AISI).

9. American National Standards Institute (ANSI): C80.1
  10. American Welding Society (AWS): D1.1.
  11. Environmental Protection Agency (EPA).
  12. Federal Transit Administration (FTA).
  13. Institute of Electrical and Electronic Engineers (IEEE): 1202.
  14. International Code Council (ICC) – International Building Code (IBC).
  15. National Association of Architectural Metal Manufacturers. (NAAMM): C54, C55.
  16. National Institute of Standards and Technology (NIST).
  17. National Electrical Code (NEC).
  18. National Electrical Manufacturers' Association (NEMA): WC 70, KS 1, AB 1, 250, PB 1, MG 1.
  19. National Electrical Safety Code (NESC)
  20. National Elevator Industry, Inc. (NEII)
  21. National Fire Protection Association (NFPA): NFPA-130-2003.
  22. Occupational Safety and Health Act (OSHA).
  23. Society of the Plastics Industry (SPI).
  24. Underwriters' Laboratories, Inc. (UL), UL-94HB, 6, 50, 62, 98, 360, 486, 489, 514, 1591.
  25. United States Department of Transportation (DOT).
  31. Any additional requirements imposed by local agencies and/or codes having jurisdiction shall be incorporated into elevator installation.
  32. In the event of a conflict between codes, regulations or standards, the most stringent requirement as determined by the Contractor and approved by the Authority shall take precedence unless specifically addressed herein.
- B. Elevator Manufacturer and/or Installer's Qualification:
1. Manufacturer Qualification: : Shall provide documents stating that their firm has successfully produced elevators for transit system applications for a minimum of ten (10) years and regularly engaged for the past five (5) years in the manufacture of major components for traction passenger elevators. As a standard of quality the elevator equipment design and installation shall comply with the Code.
  2. Installer's Qualifications: Shall be the original manufacturer of elevator equipment or manufacturer's authorized agent who is trained and approved for installation of units required for this Project.
  3. The Contractor shall obtain and pay for all permits and licenses and perform all required inspections.

C. Quality Assurance:

1. The elevator contractor shall guarantee the materials and workmanship of the apparatus furnished under these specifications and will make good any defects not due to ordinary wear and tear or improper use or carelessness, which may develop within two (2) years from date of completion of each elevator, inclusive of labor and traveling expenses. Defective work shall be repaired or replaced at no additional cost to the Authority.
2. Welding: Welding shall be performed in accordance with the requirements of AWS or CWB Welders shall produce evidence of current certification by AWS or CWB.
3. Labeling Requirements: Every elevator shall be clearly marked with rated load and speed, manufacture serial number and the designated Authority identification.
  - a. All elevators shall be permanently numbered with number designations corresponding to the indications on the kiosk annunciator panel. A station sketch showing the elevator numbers shall be submitted for WMATA ELES Engineering. The elevators shall be numbered in sequence, starting at the north entrance left to right facing to the elevator at each station and proceeding clockwise around the station. The numbering shall proceed into the station toward the end of the platform. Corresponding numerical identification shall be affixed to the equipment in the machine rooms. The elevator numbering shall be approved by the ELES Engineer.

**1.03 SUBMITTALS**

Submit the following for approval in accordance with the General Requirements and the additional requirements as specified for each to WMATA/ELES.

A. Shop Drawings:

The contractor to provide detailed drawings that shows the dimensions, tolerance and specification that may include the material specification, hardness or electrical rating for each component that is being used. In regards to assemblies, they must provide a top level drawing with BOM and quantities with detailed material specifications and drawings with dimensional tolerances. The contractor also to provide as-built CAD models of all elevator components.

The name of the manufacturer and type or style designation shall be listed on the equipment shop drawings. Drawings submitted shall include, but not be limited to, the following. Submit three sets include the following:

1. Fully dimensioned layout in plan and elevation, showing the arrangement of equipment and all pertinent details of each specified elevator unit, including as appropriate:
  - a. All equipment located in machine rooms.
  - b. Location of circuit breaker, switchboard panel, disconnect switches, light switch, and feeder extension points in machine rooms,

- c. Location in hoistway of outlets for connection of traveling cables for car light, fire detectors, communication, and control systems.
  - d. Car, drive and motors, safeties governors, supporting beams, guide rails, buffers, and other components located in the hoistways for each elevator.
  - e. Maximum Rail bracket spacing and maximum horizontal forces on guide rails in accordance with Part 2.23 of the ANSI/ASME Code.
  - f. Reactions at points of supports.
  - g. Weight of principal parts.
  - h. Loads on hoist beams.
  - i. Loads imposed on racks requiring transfer to building structure.
  - j. Top and bottom clearance and travel of car and counterweight runby.
  - k. Refuge space on top of car and pit.
  - l. Cab design, dimensions and layout.
  - m. Color/material schedule and selection chart for cab and entrance features.
2. Complete wiring diagram of the elevator system and subsystems. Complete data regarding electrical characteristics and connection requirements.
  3. Drawings of the hoistway entrances and doors showing their method of operation, details of construction, and fastenings to the structural members of the station structure.
  4. Drawings of the car for each design specified, showing details of construction, and fastenings to platform car floor covering, car-lighting, ventilation, communication, provision for closed circuit television monitor, and location of equipment.
  5. Cuts or drawings showing details of all signal and operating devices, identifying graphics and kiosk interface where applicable.
  6. Electrical characteristics and connection requirements.
  7. Complete assembly detail of machine, machine mounting, machine beam assembly, dead end hitch and beam assemblies.
  8. Machine performance data sheets.
  9. Elevator controller, including manufacturer's technical data and catalog cuts, and interface hardware and software requirements.
  10. Power door operator.

11. Door interlocks and electrical contacts including test reports showing that hoistway door interlocks, car door contacts, and car top emergency contacts meet the requirements of the ANSI/ASME Code and certification by the NBS or other approved laboratory.
12. Car ventilation.
13. Car lighting.
14. Cabling.
15. Hall and car fixtures at each landing including the car operating panel (COP).
16. Buffer, including stroke and certified maximum striking speed for car.
17. Mechanical, electrical, and architectural design details of communication systems and intrusion systems for both elevator and kiosk systems. Provide diagram and schematic of kiosk annunciator panel.
18. Design and architectural details of electrical protective device for car doors.
19. Where use of adjoining dissimilar metals is required, descriptions of protective measures to be employed to avoid corrosive damage.
20. Certification from independent testing laboratory that glazing gaskets meet the specified requirements.
21. Conduit and wireway cladding configuration from the point of origin to the final destination.
22. Interface wiring diagrams with other systems showing terminal board location and identification.
23. Expected heat dissipation of elevator equipment in machine room and control areas (i.e. BTU's/hr.) based on 240 round cycles per hour.

**B. Samples:**

Three of each of the following samples shall be submitted for approval.

1. Stainless Steel: One of stainless steel sheet of thickness and finish specified, 6 inches square.
2. Glass: One, 12 inches square.
3. Floor covering: One, 12 inches square in the color and finish to be supplied.
4. Neoprene gasket: One of each type.
5. Landing selector button mounted in cover plate with identity

marking along side button.

6. Ceiling material.
7. Signs: One of each type.

C. Certification:

1. Certificates of inspection and acceptance issued by jurisdictional authority.
2. The Acceptance Inspection (Specifications and Code) by the Elevator and Escalator (ELES) Department shall take place prior to the Final Acceptance Inspection by the Jurisdictional Authority, and the elevators and associated equipment shall be free of defective material, imperfect work and faulty operation.

All defective work identified by ELES representatives shall be repaired or replaced at no additional cost to the Authority prior to the Final Acceptance Inspection by the Jurisdictional Authority.

D. Operation and Maintenance Manuals:

Six sets of the approved manuals, elevator installation, operation instructions, troubleshooting techniques and related equipment drawings and software (all publication must be in English) – two copies of which to be delivered to the WMATA/ELES Engineer representing of the Authority prior to installation. Each binder shall have the Binder Cover and Spine Insert which contain the Station Name and Unit ID.

Submit an additional electronic copy on Flash Drive(s)/CD(s). The Information shall be saved/presented as follows:

- a. Graphic images in “.dwg” AutoCad and “.pdf” formats. All revisions shall be made by using computer software. Hand written changes are not acceptable.
- b. Text in Microsoft Word .doc, “.pdf” or approved equal format.

The manuals shall include the following:

1. Complete operation and maintenance Instructions of the elevator equipment included complete illustrated, exploded views of all assemblies and a complete illustrated, exploded view for identification all system parts.
2. Complete nomenclature of replaceable parts, part numbers, current cost, and warehouse location. If product source is another vendor, Contractor shall include name and address of other vendor.
3. Furnish a summation, in tabular form, of all parts incorporated in the elevators supplied under the Contract. Include but not be limited to the following:

- a. Nomenclature of part.
  - b. Contractor's part number.
  - c. Nomenclature of next higher assembly in which used.
  - d. Manufacturer and part number.
  - e. Model number of elevator on which used.
  - f. Total quantity.
  - g. Current unit price to the Authority.
  - h. Serial numbers of all serialized assemblies, subassemblies, motors, and other major components supplied and installed.
4. Control and schematic electrical wiring diagrams of controller including wiring of safety devices.
- a. Wiring Diagrams shall be full size (11x17), ladder type, complete "as-built" wiring and single line diagrams showing the electrical connections, functions and sequence of operation of apparatus connected with each elevator, using standard symbols or proprietary symbols defined on the diagram, both in the machine room and in the hoistway, shall be furnished in duplicate for each elevator.
  - b. Wiring diagrams shall incorporate the wiring identification labeling to identify the controller and field wiring used for each circuit. Wiring diagrams shall have sheets numbered with an indication of the total number of sheets in the diagram set. Each page should include unit number where the diagram belongs to.
  - c. After approval, a copy of each print (11x17) shall be laminated and mounted with non-metallic holder in each elevator machine room. A reproducible .003 mil Mylar set of wiring diagrams for each elevator shall be delivered to ELES Engineering Office.
  - d. Coded diagrams are not acceptable.
5. Complete detailed drawings and wiring diagram of elevator system.
6. Lubricants, sealers, paints and any other potentially hazardous substances are subject to review and approval by the Authority.
- a. Provide MSDS for all the lubricants/chemicals.
  - b. Provide manufacturer part number.
  - c. Provide name of the manufacturer.
7. Detailed lubrication and cleaning schedule.
8. Procedures for adjusting all elevator components.

9. Complete set of contract software including operating control software.
10. Detailed, record and as-built layout drawings.
11. The entire manual, all software upgrades and service tools for elevators shall be provided in an electronic format on Flash Drive/CD-ROM that is acceptable to the WMATA Engineering and Maintenance Department.
12. All hard copy publications shall be in loose-leaf form, on 30-pound paper and with punch holes reinforced with plastic, cloth or metallic material.
  - a. The O&M manual shall only contain information related to equipment installed under this contract. Generic information that does not pertain to the equipment installed shall not be included. Scanned documents are not allowed. The fonts should be standard format.
  - b. All covers shall be resistant to oil, moisture, and wear commensurate with their intended use. Diagrams and illustrations shall not be loose or in pockets. All printed material shall be capable of being reproduced on dry copying machines.
13. Each elevator shall be treated as a whole and not as a grouping of disassociated parts. The material in the Wiring Diagram Manual shall be organized and indexed by the elevator classifications included in this Specification. All manual sections shall be sub-divided, to the extent required by the subject matter, and shall include, but not necessarily limited to the following topics:
  - a. General system or sub-system description and operation.
  - b. Sequence of operation.
  - c. Replacement and step by step adjustment procedure for all components and systems.
  - d. Block diagrams.
  - e. Functional schematics.
  - f. Functional as-built wiring diagram.
  - g. Lubrication and cleaning, including frequency, methods, and trade identifications of recommended materials.
  - h. Component location and description.
  - i. Inspection and maintenance standards including wear limits, settings, and tolerances.
  - j. Installation and removal sequence.
  - k. Test and evaluation procedures.
  - l. Spare parts lists and special tools.

14. The contractor shall provide all information: manuals, drawings, design changes, modifications, techniques, procedures and any other documents related to maintenance, safety, operations which relate to any part, component, system, subsystem or material and applicable to the elevator equipment. All operating, programming, control software and licensing keys (if applicable) to the PLC control system for the installation.
15. All of the above referenced shall be provided as it pertains to the original installation and for a period of ten (10) years after final acceptance of the elevator. During a ten (10) years period, In case of any items are obsolete or no longer available from the manufacturer the Elevator Contractor shall provide the alternative products.

**1.04 PRODUCT DELIVERY, STORAGE AND HANDLING**

- A. Ship equipment and accessories securely packaged and labeled for safe handling and to prevent damage.
- B. Protect equipment exposed finishes during transportation storage and erection against damage and stains.
- C. Deliver components with factory-installed wooden skids and lifting lugs; pack components in factory-fabricated protective containers.
- D. Store in in clean, dry and secure areas and protect them from weather and damage.

**1.05 WORK BY OTHER TRADES**

The following will be provided in accordance with other sections of the Contract Specifications or by separate contracts; coordination is the Contractor's responsibility:

- A. Hoistway conforming to code and specified requirements, plumb to within ¼ inch, including machine beams, pit, and pit ladders.
- B. Intermediate rail bracket supports.
- C. Grouting around hoistway entrances and sills.
- D. Temporary and Permanent Electrical Power Services:  
Contractor shall provide and coordinate the following:
  1. For the elevator drive systems: 480 (460) volts, 3 phase, 3 wire, 60 Hertz terminating in a disconnect switch within sight of the controller. The disconnect shall be free on any obstruction for a total of 36" from any part of the disconnect.
  2. For lighting and GFCI receptacles: 120 volts, 1 phase, 3 wire, 60 Hertz terminating at the elevator controller location.

- 3. Separate disconnect for cab lighting and wiring to cab. This disconnect shall be located close to the mainline disconnect.
- 4. Separate service for sill heaters where required.
- E. Cutouts in hoistway walls for fixtures.
- F. Smoke and/or heat sensors in machine room, in car and above each hoistway entrance.
- G. Closed circuit television camera (CCTV) in elevator car.
- H. Intrusion detectors on machine room doors.
- I. Space in kiosk for elevator annunciator panels.
- J. All embedded electrical conduit between elevator hoistway, machine room and kiosk.
- K. Pit Drainage means to prevent water from accumulating in the pit for outdoor and indoor elevators. If pumps are used, they shall have a backup power source.
- L. Lock and Key Requirements: Contractor shall coordinate with WMATA. The keys for all elevators except of Code requirements shall be keyed the same. Each station shall have a key and a master key shall be furnished which will operate all elevator locks in the Metro System, including previously installed elevators.
- M. Contractor shall coordinate any alterations required to accommodate elevators with the Authority.
- N. Contractor shall attend appropriate safety training programs provided by WMATA at no extra cost.
- O. As-Built Drawings: Contractor is responsible to provide revised Contract Drawings to reflect the actual as built condition including all structural, architectural, electrical, mechanical and plumbing connections to the elevators.

**1.06 COORDINATION WITH OTHERS**

The elevator installer shall install all elevator wiring in the embedded conduit provided by other trades including that to the kiosk. Other trades will bring wiring for their services to either the elevator machine room or the elevator pit, terminated on a terminal block. The elevator installer shall extend wires from the terminal blocks to the appropriate location or device within the elevator enclosure or hoistway. Some of these circuits shall require shielded wires or separate isolated circuits.

**1.07 OPERATION AND MAINTENANCE TRAINING**

- A. Training: The Contractor shall develop and provide operation, troubleshooting and maintenance training in accordance with the General Requirements and as follows:
1. Three days of classroom plus two days hands on training on the field shall be provided for 10 students per class. Six training session for a total of 60 students is required.
  2. Time and place of training will be determined by the Authority, but must be completed no later than 30 days prior to the Final Completion.
  3. Training shall be organized to make optimum use of the required maintenance and operation manuals including training for replacement of all parts contained in the Parts Inventory list.
  4. At the completion of the first training session, a narrated and properly edited training video shall be submitted for the authority on DVD or flash drive. The video shall be taken by the professional camera operator with quality image and sound track and will be used for the future trainings. The video shall cover operation of the elevator, function of the devices, maintenance, adjustment procedures and troubleshooting. The following items shall be included as minimum requirements:
    - 1) Step by step adjustment procedure on the followings:
      - 1.1 Door operators, DCL, DOL, full door opening, and so on...
      - 1.2 Car Leveling and adjustment of leveling sensors and vans
      - 1.3 Door: door interlock, proper pressure, restrictors ...
    - 2) General overview of major items:
      - 2.1 Controller:
      - 2.2 Controller display:
      - 2.3 Door sills
      - 2.4 Guide rails
    - 3) Daily operation and sequence of operation
    - 4) Replacement and Installation of components:
      - 4.1 door photo eye
      - 4.2 Door clutch
      - 4.3 Door pickup rollers
    - 5) Proper guide roller adjustment
    - 6) Verification of safety circuit
    - 7) Maintenance procedure and Frequency of maintenance
    - 8) Proper access of pit and top of car for inspection
    - 9) Proper test of fire service operation
    - 10) Proper lubrication of components

- 11) Troubleshooting techniques
  - 12) How to use proper communication device, machine room, car top, and kiosk
  - 13) Proper adjustment of shaft and drive encoders
  - 14) Proper run learn adjustment
  - 15) Operation of Governor and adjustment procedure
  - 16) How to perform governor tripping test
  - 17) Function of Rope gripper
  - 18) Lubricate rope and check for wear
  - 19) Maintenance and inspection of buffer
  - 20) Test and inspection of safety plunk
  - 21) Overview of car and counterweight run-by
  - 22) Operation of brake and proper adjustment procedure.
  - 23) Check Gear box for wear and oil check
  - 24) Inspect Sheave for wear and bearings lubrication
5. Provide one additional copy of all required submittals to the ELES Engineer for Authority use.
  6. Provide two copies in DVD format of training materials along with visuals and handouts to the Engineer for the Authority use.
    - a. Video shall be narrative.
    - b. Video shall be separated by major components Sections
    - c. Equipment Identification shall be as a part of the section title.
  7. Separate training manual shall be submitted for approval prior the scheduling of the training. The O&M manual shall not be used as a training manual.

**B. Scope of Work**

1. All training, as described below, shall take place prior to Final Acceptance of equipment or materials by the Authority. The contractor shall video tape all training sessions and provide WMATA/ELES with edited copy of the recording.
2. The Training shall be tailored specifically to the furnished and installed equipment, and designed to teach the day-to-day operation of all equipment. The training shall be sufficient to bring personnel to a level of operating proficiency such that routine vendor support is not needed.
3. The Training shall be tailored specifically to the furnished and installed equipment, and designed to develop the knowledge and skills required to maintain all item(s) delivered.
4. The training shall be subdivided into two major levels as follows:

- a. System Level Maintenance Training, covering:
  - i. Theory of operation of the system and its major components.
  - ii. System configuration.
  - iii. Preventative maintenance, consisting of written procedures and schedules for the periodic maintenance of all equipment.
  - iv. Written and validated inspection procedures and a system-level trouble-shooting guide (to the lowest field-replaceable unit).
- b. Shop Level Maintenance Training, covering
  - i. Detailed theory of operation to module, board, and/or device level.
  - ii. Component level troubleshooting and component replacement.
  - iii. Testing and alignment procedures of repaired units.

**C. Deliverables**

1. The following course materials shall be delivered by the Contractor, according to the following specifications:
  - a. An Instructor's Guide containing all the information and direction necessary for the instructor to make an effective presentation. It shall include adequate guidelines to conduct a comprehensive training program. Individual lessons within the course shall be organized as separable blocks (or modules) which may be taught as a unit. The Instructor's Guide shall contain, as a minimum:
    1. Discussion of student prerequisites (if any).
    2. Program overview.
    3. A statement of overall program goals.
    4. Lesson plans (a session-by-session outline containing the following):
      - a. Student learning objectives, stated in measurable term
      - b. Overview of each lesson.
  - b. A Student Manual including all materials for the student to interact in the learning situation. It shall contain, as a minimum:
    1. Program overview and introduction.

2. Statement of overall program goals.
  3. Learning objectives, stated in measurable terms that specifically describe desired behaviors or knowledge to be gained.
  4. A fully developed prose treatment (not outline format) of content presentation, developed in the same modular format as the Instructor's Guide.
  5. Illustrations, charts, photos or other graphics of actual system components as needed to enhance content presentation.
  6. The training manuals shall be prepared and submitted for approval to WMATA/ELES prior to training. The training manuals shall include procedures for adjustment and replacement of all electrical and mechanical components, and a troubleshooting guide.
- c. Audio-visual Aids consisting of a narrated video of not less than 90 minutes duration to include, but not limited to, the following:
1. General overview of major features.
  2. Daily operations.
  3. Maintenance procedures (lubrication, adjustments, critical measurements, etc.).
  4. Frequency of maintenance procedures.
  5. Parts replacement safety devices, lighting, etc.
  6. Verification of safety circuits, methods of accessing and preserving computerized functional data if required.
  7. Step by step adjustment procedures and installation of components.
  8. Handouts, transparencies and/or slides as necessary to ensure clear and comprehensive presentations.
  9. The training video shall be taken from actual equipment installed under this contract.
- D. Supplemental Materials consisting of a functional mock-up or a functional representation is required of any equipment that requires theoretical discussion. This may be in the form of an animated schematic, a model of the equipment, an actual device, an interactive video training device, or an approved substitute. All mock-ups shall become the property of the Authority for eventual turn over to WMATA/ELES.
- E. The final copies shall be delivered to the Authority as follows:

1. One complete set of training materials that is completely camera-ready. Camera-ready copy is defined as typewritten or typeset originals or high-quality copies such that further copies can be made from them with no noticeable decrease in copy quality.
  2. Five copies of all student and instructor materials, to be used for archival purposes, in the WMATA ELES Technical Library.
  3. A set of complete student materials including training manuals for each participant enrolled in training classes. The O&M manual, training manuals and special tools shall be approved by WMATA prior to the training.
  4. The contractor shall video record all training sessions and provide WMATA/ELES with edited DVD copy of the recording to be used as training guide for other WMATA ELES employees.
- F. The following specifications shall be meet in instructional delivery:
1. Instructor Qualifications. A description of instructor qualifications, a resume, curriculum vitae, or other description of instruction qualifications must be submitted at least 60 days prior to the presentation of training. The description shall document a thorough knowledge of the equipment being taught, an understanding of the adult learning process, and demonstrated experience in vocational instructional. The ELES Engineering Office will review and approve the Instructor candidacy.
  2. Course length. The length of the course shall be 5 working days with 3 days in the classroom and 2 days hands-on training.
  3. Student qualifications. For the purposes of course development and presentation, vendors shall assume all students are high school graduates (or equivalent), and that maintenance personnel will possess the ability to use basic hand tools and electronic test equipment.
  4. Testing. Instructors must give written and/or practical tests as a measuring device to determine knowledge transference. Tests shall use a multiple-choice or short answer format, and have been validated in a pilot course or by some other means agreed to by the Authority and Contractor. Whenever possible, a practical hands-on test shall be developed to demonstrate the transference of operational/mechanical skills.

**1.08 SPARE PARTS AND SERVICE FACILITY**

- A. At the expiration of the warranty requirements of the General Provisions, the Contractor is responsible to provide a source for spare parts and service facility in the United States which can be obtained for an additional five years. If product source is another vendor, Contractor shall include name and address of other vendor.
- B. The Contractor shall propose and provide a spare parts inventory to be approved by the Engineer and provided to the Authority not less than 90 days prior to scheduled completion, equal in value to seven percent of the cost of each elevator.
- C. This provision requires the furnishing of a Recommended Spare Parts and Special Tools List based on manufacturer's recommendations, defines criteria to be used by the Contractor in developing spare parts recommendations; defines the manner of identifying spare parts on the list and the labeling and identification of spare parts upon delivery; and the timing of delivery of spare parts.

Elevator parts list, grouped by system and subsystem for stocking identification and the list shall contain the following information for each item listed:

- a. Component name and Part number(s)
  - b. Manufacturer's name
  - c. Model number(s)
  - d. A blank column for WMATA's part number
  - e. Manufacturer's recommended quantity
  - f. Anticipated annual usage
  - g. Unit price
  - h. Special storage and handling requirements
- D. The manufacturer's recommended quantities shall be based upon the following reliability, usage and lead time considerations:
    - a. Wear: Components which may be expected to require replacement under normal maintenance schedule and operations, such as mechanical parts subject to continuous operation within projected mean time between failure levels.
    - b. Consumables or Expendables: Components which are consumed, used up, destroyed, or upon failure, are otherwise made usable for their intended purpose and are economically unrecoverable except for inherent scrap value.
    - c. Recoverable or Repairable: Components which, upon failure, are capable of being repaired or remanufactured to a serviceable, operational condition and maintained available for use within their initial intended purpose.

- d. Long Lead: Components that are not available from commercial distributors or within 48 hours from the manufacturers such as specifically made or selected components.
- E. Cross referencing: Where replacement components are common to more than one system or subsystem, include a cross reference and indexing system in the replacement components list:
- F. Non-Unique parts: In all components lists, items that are not unique to the system and have been manufactured by others shall be identified by the manufacturer's name and part number.
- G. WMATA will provide the Elevator Contractor with shipping instructions, with WMATA part numbers for each item the Elevator Contractor is required to furnish.
- H. The parts shall be shipped to the locations as directed by the Authority. Shipping documents shall identify the Contract number, manufacturer's part number, quantity, unit price and WMATA part number.
- I. Spare parts shall be properly packaged or crated so as to prevent damage during shipment and long-term storage. An individual packing slip shall be included inside the package or crate.
- J. Spare parts shall be the same in all respects as their counterparts furnished as a part of the assembled equipment to be delivered.
- K. Parts furnished in accordance with this provision are WMATA spares, separate and distinct from any Contractor obligation to replace parts, components or assemblies under any warranty provision.
- L. Parts lists contained in Operations and Maintenance Manuals provided under the Contract shall include assigned WMATA part numbers.
- M. A Manufacturer's Recommended Spare Parts List shall be provided. Parts to be provided shall be based on the criteria described herein and require the Authority approval and shall be provided prior to Final Acceptance.
- N. Any Special Tool(s) used including, but not limited to, troubleshooting, maintaining the elevator, software and/or hardware shall be provided as part of the spare parts to ELES Engineering Office. Any tools provided shall be the same as those issued to the Adjuster and equivalent members of the subcontractor's staff.

**1.09 STORAGE CABINET**

The contractor shall install a lockable metal cabinet of suitable size with a key specifies by the WMATA Engineering and Maintenance Dept. in each elevator machine room for the storage of special tools and necessary spare parts, The cabinet shall be mounted on legs or a pedestal, a minimum of 4 inches off the floor. A Mobile Tool Storage Cabinet with wheels is not allowed.

**1.10 SPECIAL TOOLS**

- A. A complete set of special tools and instruments necessary for troubleshooting, inspection, maintenance, repair and making all adjustments on every part of the elevator installation, including software and hardware shall be furnished for each elevator machine room and delivered to the Engineer as part of the spare parts inventory. Tools that are designed specifically for tasks associated with elevator inspection, maintenance and repair or that are required for these tasks, and are not readily available through normal purchasing channels are defined as special tools.
- B. Any "Special Tool/ equipment" that is required to troubleshoot, maintain, adjust, and test the system; the tool/equipment shall remain operational for the life of the equipment.
  - a. Provide all special tools and equipment necessary for making all system adjustments to the signal and speed controller and door equipment. A programming unit, approved by the Original Equipment Manufacturer (OEM) such as a laptop with 4GB memory, 15-inch display and DVD drive, with all software packages required to setup and program all equipment in the elevator system shall be provided, one per station or location. Software shall be provided for the display unit, DeviceNet, hoist motor drive, if applicable, and any other programmable devices, as well as for the controller PLC. Any hardware or software required for configuring, programming and or communicating to controller or any parts of the elevator shall be submitted to ELES engineering. Using the provided laptop, the contractor shall demonstrate loading, downloading (programming) any and all software that is required for the elevator for all operating needs. This includes display, PLC and any I/O controls. No special tools with decaying circuits or clocks are permitted.
- C. Keys: Provide ten (10) sets of keys to operate all keyed switches and locks prior to completion of the first unit.

**1.11 AUTHORITY COORDINATION:**

The elevators shall not be in service for passenger/public use until all of the following requirements have been met.

- 1. The Operations and Maintenance Manuals have been approved and received by WMATA.
- 2. The Training and Student Manuals as well as a complete training video have been approved and received by WMATA
- 3. The required training has been completed in accordance with this specification.

4. All field tests have been successfully completed.
5. The acceptance testing has been successfully completed.
6. All spare parts have been delivered and received by WMATA.
7. All Special Tools/Equipment and Software have been delivered and received by WMATA.
8. All discrepancies identified by the WMATA's CEI (Certified Elevator Inspector) representative shall be completed.

**PART 2 - PRODUCTS**

**2.01 DESIGN REQUIREMENTS**

A. General:

1. Elevators furnished under the Contract shall be Passenger Traction elevators type. All parts shall be built to standard dimensions, tolerances, and clearances so that similar machines and devices supplied under contract are completely interchangeable. The mechanical fastening used throughout the equipment on parts subject to wear and requiring replacement shall be key and seat, nut, screw, or other removable and replaceable type not requiring physical deformation or field positioning. The use of rivets or similar devices will not be acceptable as mechanical fastenings for such parts.
2. Hours of Operation: Elevator shall be designed for continuous operation seven days per week, 24 hours per day.
3. Elevators shall be designed, installed, and tested to operate with full-specified performance while exposed to the climatic and environmental conditions specified. In addition, during installation and until the beginning of scheduled maintenance service, the elevators will be subject to more extreme environmental conditions. The Contractor shall furnish protection necessary to prevent damage to or deterioration of the elevators during this period.
  - a. Elevators shall be designed to operate in dry bulb temperature range of -10<sup>0</sup>F to 140<sup>0</sup>F and operate while exposed to the natural elements of weather, including sunlight, rain, snow, slush, salt; all condition of relative humidity, de-icing chemicals, debris, airborne dust, and corrosive elements.
  - b. The elevators shall have a special winter operation. The elevators shall be designed to operate in the event the outside temperature falls below a pre-established minimum value. The elevator contractor shall furnish and install the necessary timers and thermostat to accommodate the desired function

4. Make provision for and provide a closed circuit television camera (CCTV), in the elevator car(s) with the ability to monitor the CCTV from the Kiosk annunciator panel. Submit drawings for approval before fabrication.
  - a. Provide electrical connections, through shielded traveling cables, between camera and the communications terminal block in machine room or pit.
5. Painting: The pit, pit walls and machine room floor shall be painted. All machine room equipment shall be given two coats of approved machinery paint. All new iron work shall be given one coat of rust- inhibiting paint.

**B. Fasteners**

1. Fasteners shall be compatible with materials being fastened.
2. Fasteners shall be furnished with self-locking nuts or retaining rings (spring washers, toothed disks).
3. Fasteners shall be equal to or of greater corrosion resistance than the most corrosion resistant metals being fastened.
4. Fasteners securing removable sheet metal materials shall be operable with the aid of simple tools and concealed wherever possible. When the framework to which the metal is fastened is less than ¼ inch thick, steel backup plates ¼ inch thick shall be added with tapped holes and clearance holes where necessary.

**C. Capacity, Speed, Travel, Platform Size**

1. All parts of the elevator equipment shall be of such design, size, and material as to satisfactorily function under all conditions of loading and operation within its rated load and speed, all with a proper factor of safety, maximum mechanical and electrical efficiency, and minimum wear on parts. Traction elevators shall have sufficient capacity to lift the rated load at 300 feet per minute, minimum and 400 feet per minute, maximum.
2. Elevator shall be of size, arrangement, capacity and shall comply with design criteria and as shown on the Contract Drawings, and in accordance with the requirements of the ANSI/ASME A17.1
3. The top enclosure shall be reinforced to support two men and be capable of sustaining, without damage or permanent deformation, a load of three hundred pounds on any area two feet square and 100 pounds applied at any point. An emergency exit shall be installed in the car top in conformance with the Code.
4. Travel, location terminal floors, number of stops and openings, and overall car platform size shall be as shown on the Contract Drawings.

**D. General Environmental Operation Conditions:**

- a. Operation Under Fire or Other Emergency Conditions: Elevator shall be equipped to function in accordance with the requirements of ANSI/ASME A 17.1 and applicable local codes.
  - b. Sound Level: No elevator car or elevator power unit shall generate noise in excess of NC45 sound level. Measurement of noise shall be made at a point 36 inches from the hoistway, machine room entrances, and ventilation openings.
- E. Hoistway Movement:
- 1. Elevators shall be designed to sustain the load and operate with the following lateral movements of the hoistway structures:
    - a. In any individual glazed area. ¼ inch.
    - b. In total height of hoistway structure for aerial and surface structures: 5/8 inch.
- F. Reliability:
- 1. Each elevator shall be capable of operating at full load under any of the normal modes of operation at a level of availability of not less than 98 percent over a period of 365 days.
  - 2. Availability (A) is defined as the percent of normal operational time during which the equipment is available for use. Or

$$A = \frac{MTBF}{MTBF + MTTR}$$

Where:

- MTBF* = Mean time between failure in days
- = Operating time, *t* (in days) /Number of failures in time *t*
- MTTR* = The average time in days required to restore an elevator to operation after a report of a failure.

- G. Workmanship:
- 1. Joints shall be welded their full length and dressed smooth and flush on exposed surfaces. Spot welding shall be used where practicable in preference to screw or rivet fasteners.

2. Sheet metal materials shall be accurately rolled and leveled, and have smooth finish and uniform color. Joints shall be formed to a tight fit, with abutting edges flush, and shall be securely welded or riveted together in such a manner as to give strength equivalent to the solid sheet. Riveted construction shall have heavy reinforcement on the back, and no rivets shall show on exposed surfaces, Welds shall be solid and dressed flush, and holes for screws or bolts shall be drilled and countersunk.
  3. Wrought work shall have joints milled to a tight even fit and, where possible, shall be made without screws. Square turns and comers shall be sharp, Curves and loops shall be true and without visible joints. Abutting members shall be welded, riveted or both. Similar bars shall be halved at intersections and wide bars shall be punched for the small bars to pass through.
  4. The finished work shall be strong, rigid and neat in appearance. Plane surfaces shall be smooth and free from warp or buckle. Molded members shall be clean cut, straight, and true. Miters shall be well formed and in true alignment. Fastenings shall be concealed from face side of the material.
- H. Corrosion Protection: The contractor shall design the elevator assembly in such a manner to avoid corrosion and galvanic action due to physical contact between dissimilar metals or due to other causes.

**2.02 MANUFACTURERS**

- A. The major elevator components shall be the products of one of the three manufacturers of established reputation, except they may be the products, either wholly or in part, of another manufacturer of established reputation provided such items are capably engineered and produced under coordinated specifications to ensure a high grade, safe reliable, and smooth operating system.
- B. Major components to be furnished for this project shall be of a make or makes that have performed satisfactorily together for transit system applications for not less than five years and at least ten other elevator installations of equal or greater capacity and speed.

**2.03 PRODUCTS AND MATERIALS**

- A. Elevator Car Characteristics:
  1. Rated load. Minimum rated load for the car will be as determined by the inside net platform area per ANSI/ASME A17.1.
  2. Rated speed: as per Contract Drawings
  3. Inside dimensions: As shown.
  4. Landings served: As shown.

5. Number of openings: As shown.
  6. Travel: As shown.
  7. Operation: Selective/Collective. Drive Type: AC – VVVF
  8. Car and landing operating buttons: Illuminated type, vandal resistant, in accordance with ADA requirements.
  9. Car door and hoistway entrances: High-Speed, Heavy-Duty Master Door Operator GAL – MOVFR. Door Type: per Contract Drawings. Door Size: per Contract Drawings
- B. Operation:
1. Operation shall be automatic. Automatic operation by means of car and landing buttons. Stops registered by momentary actuation of car buttons to be made irrespective of number of buttons actuated or of sequence in which buttons are actuated.
  2. Operating station in car containing bank of buttons numbered to correspond to landing served position indicators. EMERGENCY CALL button, keyed EMERGENCY STOP button, DOOR OPEN/DOOR CLOSE buttons, independent maintenance key switch, and key-operated light and fan switches, with legends as specified. Identification as specified for emergency telephone. Emergency call button connected to bell that serves as emergency signal. Panel finish: Stainless Steel.
  3. Landing: Single push-button fixture at each terminal landing. Button fixture having push buttons with UP and DOWN legends at intermediate landing. Button identification as specified for Person with disabilities per latest ADA regulation (ADA rule 4.10.3).
  4. Momentary pressure on car button or landing button illuminates that button, which remains illuminated until call is answered. Illuminated buttons serve as visual indication that call has been registered and that car will stop at that landing. The Push Buttons shall be flush, round, have a Metalized Halo and center jewel. The metalized halo shall be from different color and approved by ELES Engineer.
  5. Stops, registered by momentary actuation of landing buttons. All stops subject to respective car or landing button being actuated sufficiently in advance of arrival of car at that landing to enable stop to be made. Direction of travel for idle car established by first car or landing button actuated.
  6. UP landing calls answered while car is traveling in up direction and DOWN landing calls answered while car is traveling down, car reversing after uppermost or lowermost car or landing call has been answered and proceed to answer car calls and landing calls registered in opposite direction of travel.

7. Elevators to park at the secure landing level selected by the Engineer.
8. Push-button units to be Dupar US85 or approved equal with button identification as specified by latest ADA regulation.
9. Emergency-stop button shall be key operated rather than push-pull arrangement with key removal only in off position.
10. All elevator car control panel operating devices shall be designated by Braille and by raised standard alphabet characters for letters, Arabic characters for numerals, and standard symbols as required by the Code and ADAAG.
11. Lettering shall have a highly visible coloring, such as white, that is permanently affixed.
12. Independent Service: Provide a key switch in the car operating panel which, when actuated, shall cancel previously registered car calls, disconnect the elevator from the hall buttons and allow operation from the car buttons only. Car door shall remain open unless closed fully by the door close button.
13. Two-Stop Collective Simplex Automatic Operation:  
The two-stop collective simplex automatic operation shall be used and checked for the following:
  - a. System shall be designed so that when the car is standing at either terminal landing, pressure on car button for the other terminal shall automatically dispatch car to that landing. Pressure of landing button at either terminal landing shall call car automatically to that landing. If a landing call is registered while the car is making its trip, that call shall remain registered until the car responds to that call. If no car calls are registered car shall start automatically and respond to hall calls. Provide time limit relay arranged to hold car at landing at which it has stopped for predetermined time after car stops. After all car landing calls have been answered, car shall remain parked at landing where last used with car and hoistway doors closed until another call is registered. Pressing the landing button at floor at which car is parked shall automatically open car and hoistway doors. In all normal operations, the starting of the car shall be contingent upon establishment of hoistway door interlock and car door circuits.
  - b. Automatic dispatching operation: all two stop elevators shall include "Step-in-and-Go" feature. Calls for the opposite landing will be automatically set when the elevator opens its doors for a hall call. This feature shall be provided for all elevators that have public access for two stops (i.e., any elevators with key operated service landings

will be included).

**C Position Indicators:**

1. Car indicator: In accordance with ADA requirements. Mounted in vertical row in car-operating panel to show position of car in hoistway by illumination of indicators corresponding to landing at which the car is stopped or passing. Finish for exposed-to-view metal components: Stainless Steel.
2. Landing indicator: In accordance with ADA requirements. Two-element direction-of-travel indicator mounted above call station or hoistway entrance as shown, including one red and one white indicator. Direction of car's operation shown by illumination of red indicator for DOWN and white indicator for UP.
3. In-car signals: Audible signal indicating car's direction of travel, signal sounding once for UP direction and twice for DOWN direction.
4. Landing signals: Audible signal at each hoistway entrance indicating car's direction of travel, signal sounding once for UP direction and twice for DOWN direction.

**D. Lighting:**

1. Machine Room Emergency Lighting: Emergency lighting shall be provided in each elevator machine room.
  - a) There shall be a minimum of one lighting fixture.
2. Car interior: LED fixture, 120-volt operation, with clear prismatic glass diffuser, flush mounted in ceiling, cool white bulbs. Illumination level shall be 15-foot candles minimum at car operating panel.
3. Car top and underside of car floor: Medium-base porcelain lamp receptacles, with wire lamp guards.
4. Car Emergency Lighting:
  - a. Fixture: Recess mounted, with stainless steel frame, location as shown.
  - b. Diffuser: Prismatic polycarbonate plastic.
  - c. Lamps: Two, size 16-51
  - d. Remote power supply:
    - 1) Power pack: Sealed gel cell battery with integral regulating charger and an alarm bell.

- 2) Capable of operating bell for one-hour minimum and light at car-operating panel at 0.2 low candles minimum for four hours minimum.
- 3) Location: in top of car or COP with easy access provided.
- E. Inspection Operation: Key switch in car to nullify car and landing buttons permitting operation of elevator from top of car for inspection purposes:
  - 1. Top of Car Inspection Station: The Inspection Station contains continuous pressure UP and DOWN buttons, emergency stop button and toggle switch to activate inspection devices. The device shall also have an 110v ac outlet for extension cord and provided with a light and guard.
- F. Leveling: Automatic leveling device to stop car within 1/8 inch of landing level regardless of load or direction of travel. Landing level maintained within leveling zone irrespective of hoistway doors being open or closed.
- G. Emergency Service:
  - 1. Controls to return elevator to designated floor by means of key-operated switch outside street or ground floor hoistway entrance in compliance with ANSI/ASME A17.1.
  - 2. In-car control during emergency operation by means of key switch in compliance with ANSI/ASME A17.1.
  - 3. Terminals on elevators controllers for connection of circuit from heat and smoke sensing devices, with wiring from sensing devices to elevator controller.
- H. Telephone Facilities:
  - 1. Provide all audio/visual communication, signaling, and monitoring in accordance with ADA and ANSI. "Hands-free" phone integral with control panel, mounted in accordance with ADA requirements; having inscription EMERGENCY TELEPHONE as specified for Person with disabilities; finish exposed-to-view components to match stainless steel control panel; color of letters to contrast with panel.
    - a. Provide emergency communicators in accordance with ADA requirements to include auxiliary push button to summon help and visual feedback indicating that the call has been responded to.
  - 2. Provide wiring and jacks for a portable self-contained battery-powered maintenance telephone system. Jacks shall be located on car top, inside car, and in machine room. Furnish three telephone instruments for use of maintenance personnel.
- I. Elevator Components:

Provide and install, Passenger Traction elevators with machine unit, roping, governors, safeties, rope gripper, counterweight, and related equipment. Provide for locating and installing the machine units and associated control equipment in the controller rooms. Provide and install any and all necessary auxiliary beams, structural members or other such devices needed to assure proper and safe operation of all elevator equipment. Vibration isolating machine foundation shall be of approved type which shall effectively prevent transmission of machine vibration to the building structure.

1. Guide Rails:
  - a. Guides shall be steel T-section rails. Rail surfaces shall be machined smooth to insure proper operation of guides. Rail ends shall be accurately machined with tongue and matching groove centrally located on web. Non wearing rail surfaces are to be painted at the completion of the elevator in color selected by the Engineer.
  - b. Guides shall be joined and installed in accordance with Section 2.23 of the Code.
  - c. Rail bracket spacing and maximum horizontal forces and guide rails in accordance with ASME A17.1.
2. Roller Guides: Roller guides shall be mounted on top and bottom of the car and counterweight frames to engage the guide rails and provide a smooth ride.
3. Machine: Provide AC geared machine. The hoisting motor shall drive a grooved sheave through a worm and gear. The hoisting machine shall be of the worm-gear traction-type with induction motor, brake, worm gearing, and sheave mounted on a common bedplate. Induction motor is specified under Electrical Work Machine.
  - a. The motors shall be of the alternating current reversible asynchronous or synchronous type of a design adapted to the severe requirements of elevator service. Motor shall be capable of developing the torque required to meet or exceed an acceleration rate of 2 ft/sec<sup>2</sup> for the elevator car.
  - b. A means to protect the windings and bearings from airborne dust shall be provided.
  - c. Insulation of all windings shall be impregnated and baked to prevent absorption of moisture and oil. The insulation resistance between motor frame and windings shall not be less than one megohm. The motor windings shall stand a dielectric test of twice the normal voltage plus 1000 RMS volts of 60 Hertz, alternating current for one minute.
  - d. Motor leads in the conduit box shall have the same insulation class as the windings. Motor lead wire shall be rated 125 C and shall be sized

- for 105 C at the motor nameplate amperes at 1.0 Power Factor per Electrical Apparatus Service Association (EASA) recommendations. Leads are to be numbered for clockwise rotation when facing opposite the shaft end.
- e. The motor shall be designed to stand the severe loads encountered in elevator service and the windings shall have a minimum insulation temperature rating two ratings higher than the actual temperature rise of the motor, with a minimum rating of NEMA class F.
  - f. The motor shall be designed to the ASME A17.1 rated load requirements.
4. Brake: Disc type brake shall be securely mounted to the shaft and shall run concentric to the shaft. Disc shall be machined to obtain a smooth and accurate face. The brake shall be spring actuated, direct current, electrically released, heavy construction with proper braking area for the load and speed specified. The brake shall be provided with sufficient power to stop and hold the car with 25% overload. Disc brakes shall be of caliper or multiple disc design. Provide operation to prevent the elevator from striking the hoistway overhead or unintended car movement per the requirements of code.
  5. Gear Housing: The gear housing shall be divided horizontally at the centerline of the shaft to provide access to the worm gear. Suitable drain plugs and overflow pipes shall be provided.
  6. Bed plate shall be of structural steel, either separate or integral with the machine frame. Bed plate shall be heavily ribbed or reinforced to provide the rigidity required to maintain accurate alignment of parts. Accurately machined surfaces shall be provided to seat all parts secured to the bed plate or machine frame. Use of brackets or other extensions bolted to the bed plate as supports for principal parts will not be permitted. All parts shall be bolted in place with finished bolts or cap screws. All protruding edges of machine beams shall be rounded off to a 1/2" radius.
  7. Bearings: Bearing shall be rigidly fastened to, or be integral with the main structure of bed plate or machine frame. Bearing mounting and method of machining and assembly must be such as to insure accurate bearing alignment. Bearings shall be of the anti-friction ball or roller bearing type. Bearings and lubricant reservoirs shall be virtually dust-tight, and shall incorporate effective lubricant seals or other means to prevent lubricant leakage. Outer ends of bearings shall be closed with a removable oil-tight plate or cap. Roller and ball bearings shall be either immersed in oil, or subject to oil flood lubrication, or shall be arranged for grease lubrication and be fitted with grease gun connection and drain plugs. Machine shall have highest grade, double-acting thrust bearing of the ball or roller type. Bearing shall have two sets of balls or rollers arranged to eliminate backlash. Thrust bearing shall be removable without dismantling machine.

8. Worm: Worm shall be accurately cut from a solid steel forging or heat treated steel bar stock integral with worm shaft. Worm gear shall have an accurately machined bronze rim of such composition that the gear will not show appreciable wear after five years' service. Worm gear shall be of such diameter relative to that of sheave so that the maximum pressure between worm gear and worm will not exceed a safe value. Worm gear shall operate without appreciable noise, and shall cause no appreciable vibration in the car. Worm gear rim shall be shrunk or pressed on a cast iron or cast steel center or spider, and shall be bolted thereto by means of tightly fitted turn bolts in reamed holes, with bolt nuts positively secured in an approved manner. Boltholes through outer peripheral joints of center and the rim will not be permitted. Worm gear center may either be integral with the traction sheave center, or may be pressed on and keyed to sheave shaft. Integral traction sheave and worm gear centers shall either be pressed on the sheave shaft, or be fitted to bearings on sheave shaft. Use of worm gear and shave centers on the sheave shafts will not be permitted.
9. Dynamic Balance: The worm and its shaft, and the sheave, gear and gear spider shall be dynamically balanced as required to eliminate any source of noise or harshness.
10. Elevator Drive System: Variable Voltage Variable Frequency (VVVF) Drive: The drive shall be microprocessor and IGBT based using vector control algorithms. The algorithms shall incorporate a motor model to determine the electromagnetic state of the motor. The motor model shall also encompass a temperature compensation algorithm which is essential for speed accuracy.
  - a. Velocity shall be controlled by a feedback loop to within +/- 2% of contract speed and speed shall be independently supervised.
  - b. Position of floors in the building shall be learned during a slow speed setup run. Once learned, floor locations shall be stored in non-volatile memory. Power loss shall not require the floors to be re-learned. Stopping accuracy shall be +/- 5 mm or less. Re-leveling shall be automatic.
  - c. Resistors shall be provided to absorb the power regenerated by the motor. They shall dissipate power only when the motor is regenerating. Control shall be by IGBT.
  - d. Maximum total harmonic distortion shall not exceed IEEE Std. 519 to be measured at the elevator disconnect.
  - e. For hoist motors 50Hp and above, the drive shall be regenerative feeding the three-phase power supply of the controller.

11. Hoistway Operating Devices: Normal terminal stopping devices. Emergency terminal stopping device as required, controller switches and circuitry arranged in accordance with ANSI/ASME requirements. All switches to be compatible with control system.
12. Stop Switch: Emergency stop switch mounted in the pit of each elevator in accordance with Section 2.2.6 of the Code, shall prevent operation of elevator when switch is activated.
13. Car Safety. The car safety shall be Type B. as specified in the ANSI/ASME Code, mounted under the car platform and securely bolted to the car sling. It shall be sized for the capacity and speed noted on the Contract Drawings. The car safety shall be actuated by the speed governor upon a predetermined overspeed downward. When tripped, the safety mechanism shall engage the rails with sufficient force to stop a fully loaded car with an average rate of retardation within the limits given by the ASME A17.1 Code for the capacity. The safety shall stop the elevator whenever excessive descending speed is experienced and means shall be provided to cut off power from the motor and apply brake prior to application of the safety. The safety shall be modified and adjusted as necessary so that its operation complies with Code requirements and requirement of all authorities having jurisdiction.
14. Governor: Friction type over-speed governor rated for the duty of the elevator specified and to operate the car safety. The governors shall be located where the car or the counterweight cannot strike it in case of over travel, and where there is adequate space for full movement of governor parts and driven by a governor rope suitably connected to the governor rope-releasing carrier.
  - a. An electrical governor over speed protective switch that, when operated, shall remove power from the driving machine motor and brake before or at the time of application of the safety.
  - b. The governor shall be sealed and tagged with the running speed, tripping speed, and date last tested as required by Code.
15. Rope Gripper: Rope Gripper shall stop the elevator in the event of a mechanical or electrical failure and during overspeed in the up direction or if the elevator leaves the floor with the doors opened. The rope gripper shall be provided with grip pad made of soft and metal particles to provide powerful grip but gentle on the rope. The action of the Rope Gripper shall not cause any undue wear of the hoist ropes. The moving jaw plate of the rope gripper shall spring loaded. The hydraulic piston shall hold the Rope Gripper in unclamped position during normal operation.
16. Terminal Limits: The limit switches shall slowdown and stop the car at the terminals if the primary automatic stopping system fails.
17. Tension Sheave: A tension sheave shall be provided in accordance with governor and car safety loading requirements.

18. Life Safety Provisions: Provide Life safety hooks and/or other life safety devices for fall protection in accordance with OSHA standards/guidelines. Life safety hooks and/or other life safety devices locations to be coordinated and installed by the Installer.
19. Counterweight: A counterweight shall be provided for the elevator equal to the weight of the complete car and 40 percent of the rated car. Tie rods shall pass through holes in each subweight and through holes in frame members above and below subweights in such a manner as to securely hold subweights in place. The bottom of the counterweight shall have a buffer striking plate and means to attach knock-off blocks during rope stretch. Roller guides shall be mounted on top and bottom of the counterweight frames to engage the guide rails. Each counterweight shall be painted. Submit paint finish of counterweights for approval.
  - a. Idler Sheave: To be located directly above the counterweight frame and integral with counterweight frame. The sheave material shall be accurately machined as per manufacturers requirements.
  - b. Counterweight guides shall be of the roller type; each guide shall consist of a set of at least three (3) large diameter polyurethane rollers equipped with sealed preloaded ball bearings. Each roller shall automatically adjust itself to guide rail misalignment and prevent excessive lateral car movement.
20. Compensation for the weight of hoisting ropes and unbalanced portion of traveling cables shall be provided where required to produce proper operation of elevator for car travel of 50 to 100 feet. All elevators requiring compensation shall have rope compensation.
  - a. Rope compensation shall consist of an appropriate number and size of iron steel wire ropes attached to the underside of car frame and counterweight frame and passing under a weighted idler sheave in pit. A metal data tag giving the number, diameter, type, month and year installed, and names of manufacturer and installer of compensating ropes shall be securely attached to one of the compensating rope fastenings.
  - b. The weighted idler shall be provided to equalize tension in the compensating rope. The idler sheave shall be provided with bearing of anti-friction bearing metal, ball or roller-type similar to those specified for hoisting machine. Suitable metal guards shall be provided for, or be incorporated in, the design of the equipment, to prevent rope jumping off sheave.

21. Buffers: Provide and install car and counterweight buffers of the oil type as indicated by Code with blocking and support, mounted on the supporting channel or block on the pit floor. Buffers shall comply with all applicable codes. Buffer anchorage at pit floor to be designed and installed without damage to pit floor.
  22. Car Frame: A suitable car frame shall be provided with adequate bracing to support the platform and car enclosure. Provide welded or bolted or type 316 stainless steel channel uprights affixed to crosshead and plank channels with welded or bolted bracing members and gusset plates which will remove strain from car enclosure.
  23. Platform: Havy Loading Type. The car platform shall be designed to accommodate one-piece loads weighing up to 25% of the APTA rated load, such as wheeled food carts, hand trucks, etc. The platform shall be type 316 stainless steel.
  24. Provide and install all necessary accessory beams, auxiliary beams or other devices needed for safe and normal operation and installation of all elevator equipment and devices. It is the elevators installer's responsibility to ensure provided elevator equipment will function as designed in the available space and with the steel beams, steel members or other such equipment in the machine rooms and hoistways in place at the time of installation.
- J. Controller-System:
1. An Allen Bradley PLC-based controller shall be provided, governing starting and stopping as well as preventing damage to the motor from overload or excessive current. It shall automatically cut off the motor current and bring the car to rest in the event any of the safety devices are activated.
    - a. System shall coordinate the functioning of elevator drive unit relative to actual location and status of elevator. It shall interface with door control and all required safety circuits, switches and devices. The controller shall be mounted in a NEMA 4X stainless steel air-conditioned cabinet within the controller room.
    - b. The diagnostic system shall be an integral part of the controller and provide user-friendly interaction between the service person and the controller system.
    - c. The supervisory logic shall be performed by a main controller or coordinated between the elevator controllers which will interface directly into the Allen Bradley DH485 protocol Remote Monitoring network, transmitting data from the elevator controller through a data concentrator to the Authority's AEMS RTU computer control and data system. The supervisory logic will coordinate dispatching assignments, interfacing operational demand data

- accumulated from car and corridor operating fixtures, selector and door control functions.
- d. Controller shall be capable of operating with an operating temperature range of 320F to 140F with non-drip environment and no more than 90 percent relative humidity. However the air conditioner on controller cabinet shall maintain the operating temperature in range of 50<sup>0</sup> F to 90<sup>0</sup> F.
2. An Allen Bradley CompactLogix 1769-L32E (or ELES Engineering approved equal) based PLC control system shall be provided.
- 1) The exclusive Allen Bradley DH485 protocol data port will transmit data from the elevator controller to the station or facility data concentrator. The contractor shall provide a controller data interface to a DH 485 network. Contractor shall provide Data cables to connect from the PLC controller to data concentrator in the station and available for connection to the controller DH485 interface. The contractor shall pull Belden 9842, or ELES Engineering approved equal, cables to connect the controller into the monitoring DH485 network. The DH 485 controller interface shall be programmable for data rates up to 115 Kbps. The interface shall allow other nodes such as other elevators and escalators to be readily incorporated into the DH 485 network.
  - 2) A data concentrator PLC shall be installed using an Allen Bradley MicroLogix 1400 or SLC5/05 PLC per station to function as data concentrated or to consolidate data from all controllers in the station. The software for the data concentrator shall receive controller data over the local monitoring DH 485 network and provide formatted data to the AEMS RTU through an RS232 link. The data concentrator shall provide an Ethernet port for interfacing with the WMATA wide area network. A data concentrator connection to the WMATA wide area network shall be provided.
4. The PLC shall accommodate the following Signal List, as Applicable, and provide data to the data concentrator as specified in specification.

5. The PLC CPU module shall store the last 99 faults, accessible via laptop connection, controller fault/status display and remote communications. The contractor shall provide WMATA with a programming and monitoring unit, such as a laptop computer with the newest version of Allen Bradley RS-Logix and any other software required to setup and program all electronic items in the control system, for each elevator that this system is installed, for the purpose of troubleshooting and remote monitoring modifications. The laptop should allow uploading, editing, and downloading any software that is being used on this elevator for any operation.
6. An Allen Bradley PanelView Plus 6, EZAutomation or ELES Engineering approved equal, fault/status display/interface shall be provided in the controller cabinet. Control system timers and other setup criteria shall be programmable through this unit. All fault, status and setup data shall be stored in the controller CPU module.
7. In cases where the programming is done by the supplier, the supplier shall provide a copy of all working programs, including labels for all inputs and outputs, data tables and internal logic points, on Flash Drives/CD-R disks as well as a printed program listing. The programs and setup data shall require a password for access and modification. The password shall be provided to ELES Engineering as part of the Submittal.
8. The main control of an elevator shall contain at least the following devices or electronic sensing: phase failure line voltage monitor, motor current and ground fault monitor.
9. The controller cabinet shall contain a permanently mounted fault indicator panel with LED indicator lights. Tripped safety devices, door position, door reversal, car running status, and control system status shall be indicated.
10. All terminals shall have identification markings and all wires, including field wires, shall be provided with permanent heat shrink sleeve cable markers. These wiring identifications shall be provided in the wiring diagram at each end of the circuit connections.
11. The controller shall be equipped with the AC vector drive installed in-line before the hoist motor contactor and the hoist motor.
12. The AC vector drive shall be capable of accelerating and decelerating the hoist motor smoothly and gradually.
13. Adjustable settings for acceleration and deceleration ramps shall be provided.
14. The controller shall have, at least, one dedicated serial port for interface to the DH485 monitoring network and programming access without disconnecting any other ports.
15. The Programmable Controller shall have, at least, one dedicated port to support the controller fault/status display.

16. The controller PLC shall provide the following Remote Monitoring and diagnostic network support:
- a) All applicable faults, statuses and data listed in Table 1 shall be provided
  - b) Fault indications shall remain until reset in the controller.
  - c) Status and analog data shall be provided for the duration of the condition.
  - d) Software in the controller PLC shall format monitoring data responses to data concentrator polling as specified in the specification.
  - e) The monitoring data port in the controller shall be setup for DH485 protocol with the port network identification number programmed for the particular elevator identification. For instance, identification number 11 applies to elevator 1, 12 to elevator 2, etc.
  - f) All faults, statuses and data shall be held by the controller CPU and sent from the CPU when polled by the data concentrator.
17. Provide sufficient non-volatile CPU memory, for non-volatile retention of program memory, system status and operating parameters.
18. Diagnostics
- a) The processor shall have built-in diagnostics and self-test, such that each time power is cycled, the processor does a complete CPU and RAM memory test. Additionally the power-up test will momentarily light up all diagnostic LED's to be sure they are working. A power up test will not reset fire-service status signals if the internal flag (bit) for Fireman's Service Phase I is latched. The processor shall be capable of reporting major and minor fault codes and processor status information back to the data concentrator provided the fault is not a catastrophic hardware failure where the processor is unable to power up.
  - b) The processor shall have a built-in watchdog timer to ensure that all processor program scans occur within the time limit set by the watchdog timer.
  - c) The processor shall have individual LED indicators that are clearly visible and labeled for easy identification. At a minimum the following indicators must be provided:
    - (1) CPU is in RUN mode
    - (2) CPU is FAULTED
    - (3) CPU battery is LOW
    - (4) I/O points are FORCED and are not under program control  
COMMUNICATION channels are active.
19. Input/Output Modules
- a. The Input/Output Modules shall be compatible with the PLC processor I/O structure. Each module shall be provided with a detachable terminal strip to connect wiring to the module. Each wire on the terminals shall be identified by the module terminal.

- b. Discrete Input Modules: Suitable for the input voltage and compatible with the Allen Bradley system.
  - c. Discrete Output Modules: Suitable for the voltage and load and compatible with the Allen Bradley system.
  - d. Analog Input Modules: Converts analog signals to optional twelve-bit binary values. The module shall accept 4 to 20 mA signals. Provide modules compatible with the Allen-Bradley system.
20. I/O Mounting and Power Supply
- a) The controller chassis shall have an additional three spare modules.
  - b) Power supplies shall provide power to the PLC processors, I/O and other function modules. The power supply shall be suitable for operation of 120 VAC, single phase power. Power supply capacity shall be a minimum of 150% of the connected load
21. Air Conditioning:
- Provide an independent air conditioning unit for each controller to maintain specified recommended operating temperatures. Condensate from the air conditioning unit must be piped to a suitable drain.
22. Selective Collective Operating: As defined by ASME A17.1 and shall be the pressure upon one or more car buttons to correspond to landings in the order in which the landings are reached by the car, irrespective of the sequence in which the buttons are pressed, provided the hoistway door interlock and car door switch circuits are completed. During this operation, the car shall also answer calls from the landings, which are in the prevailing direction of travel. Each landing call shall be canceled when answered
- a. Momentary pressure on car button or landing button illuminates that button, which remains illuminated until call is answered. Illuminated buttons serve as visual indication that call has been registered and that car will stop at that landing.
  - b. Operation shall be automatic by means of the car and landing buttons. Stops registered by the momentary actuation of the car or landing buttons shall be made in the order in which the landings are reached in each direction of travel after the buttons have been actuated.
  - c. UP landing calls answered while car is traveling in up direction and DOWN landing calls answered while car is traveling down, car reversing after uppermost or lowermost car or landing call has been answered and proceed to answer car calls and landing calls registered in opposite direction of travel.
  - d. Should both an up and a down call be registered at an intermediate landing, only the call responding to the direction in which the car is traveling shall be canceled upon the stopping of the car at the landing.

23. Supervisory Control: A processor based system to coordinate dispatching assignments, interfacing operational demand data accumulated from car and corridor operating fixtures and other special feature commands issuing from computer processing, selector and door control functions. Incorporate in the system specific operational features as herein described.
- a. Allocate service to demand, make decisions to prevent crowding, save energy, and provide efficient coverage throughout the building. Respond in real time to prevailing traffic conditions as well as historical traffic patterns.
  - b. Constantly compare passenger demand, car load, anticipated demand, car motion status, machine status and other prevailing conditions and evaluate this information in the context of the following dispatching approaches:
    - 1) Give priority to contiguous calls, assigning calls on adjacent floor to the same car if other criteria is satisfied.
    - 2) Give priority to coincident calls, having the same car let a riding passenger off and a waiting passenger on at the same floor.
    - 3) Anticipate demand based on hall calls and car calls already registered and floors with a high possibility of demand.
    - 4) Evaluate relative system response time for each car in the group, weighing all of the above factors.
    - 5) Allocate calls and position cars to minimize waiting time, response time and travel time. The other elevator shall respond for hall calls without any delay after the first elevator left the door zone.
    - 6) When there is a hall call registered and an elevator left the landing, the other elevator shall run toward opposite landing.
  - c. Provide the capability to make both car to call or call to car assignments.
  - d. During light traffic conditions, assign cars without demand to specific parking areas until requested for a hall call. Continuously evaluate dispatching assignment and immediately release a car from its assigned area to meet heavy demand elsewhere in the building.
  - e. In determining relative system response time for a car to answer a hall call, factor in round-trip calculations for each car as well as other system parameters before deciding which car shall respond to a hall call.

24. Other Features:
- a. Independent Operation: Provide TWO-position keyed switch (ChicagoLock 7500) marked Independent Service, OFF and ON in the lower portion of the car operating panel of all cars. The switch shall be spring loaded type. When placed in ON position, car will be removed from the automatic operating system and will not respond to demands registered at the hall push buttons. It will respond only to floor with doors open until another demand is registered in the car. Demands registered at the landing will remain registered until answered by another elevator. The car only responds to car calls and that the doors remain open after a stop until closed by continuous pressure on the door close button.
  - b. The controller shall be designed to operate automatically on standby power.
25. Controller Room Two Way Communication Device: Provide within each controller/machine room a two way communication device that will interface with any type of ADA compliant telephone. The device shall be mounted directly on or within hands distance proximity to the elevator controller.
26. Any junction boxes installed in the machine room or hoistway shall be accessible for Maintenance.
- a. Drilling or opening top end of enclosure is not acceptable
  - b. Wire nuts or splicing without terminal strips is prohibited.
  - c. All openings shall be properly sized for the conduits.
- K. Door Operator Equipment:
1. Provide a water resistant heavy-duty GAL MOVFR or ELES Engineering approved equal door operator with encoderless VVVF drive. Closed loop door operator designed to operate car and hoistway doors simultaneously at the speed specified. Door shall open automatically when car stops at landing to discharge passengers or to answer valid calls and close automatically after predetermined time interval has elapsed. The doors shall be capable of smooth and quiet operation without slam or shock. Door operator to have the following features:
    - a) ½ hp motor and heavy duty sprocket, chain, belt, and sheaves.
    - b) Closed loop regulated speed performance.
    - c) Hand-held keypad programming.
    - d) Adjustments can be stored in the keypad and downloaded to another operator.
    - e) Adjustable door obstruction reversal.
    - f) Optical cams with LED indicators.
    - g) Test switches for open, close, nudging and speed zone set up.
    - h) Universal inputs for open, close, and nudging.

- i) Reversing switch to back up the door reversal device.
  - j) Designed for interior and exterior applications.
2. Provide a non-contact door reversal device with light immunity: The Door Reopening Device shall cause both the car and hoistway doors to reverse, should they detect an obstruction in the elevator entrance. The device electrical wiring shall be supplied with quick disconnects terminals to facilitate replacement. The infrared curtain detector shall include the following:
- a. A protective infrared detector field extending from 1 1/2" above the car sill to a height of 68".
  - b. A fail-safe control system to prevent the doors from closing in case of power loss to the detector.
  - c. A one-piece full door height protective lens cover designed to be completely waterproof and to withstand impact, abrasion and vandalism.
- L. Hoistway Entrances:
- 1. Doors of elevators shall be of the horizontal sliding type, single-speed, center-opening. All elevator door openings shall be a minimum of 42-inches wide per the Americans with Disabilities Act.
  - 2. Entrance frames shall be of welded or bolted construction for complete one-piece unit assembly. All frames shall be securely fastened to fixing angles mounted in the hoistway and shall be type 316 stainless steel. Provide an additional type 316 stainless steel sill angle support. The landing sills shall be extruded stainless steel with a mill finish.
  - 3. All materials and finished surfaces exposed to public view shall be stainless steel with embossed finish and/or glass panels as indicated on Contract drawings. Glass panels (if provided) to be completely flush with door assembly. In a glass hoistway the struts or any brackets should not be visible to public.
  - 4. Fascia and Dust Cover in the hoistway shall be galvanized or type 316 stainless steel and extend at least the full width of door opening on each side. Toe guard shall be fastened to the sill at the lowest landing.
  - 5. Hoistway doors are to be stainless steel and provided with keyways as required for operating mechanisms and door hangers. Provide glass panels that are completely flush with door, as indicated in A17.1. Each door panel shall have stainless steel bottom guides that run in landing sill slots. Guides shall be replaceable without removing door panels. All doors shall have fixed fire gibs.
  - 6. Interlocks and Contacts:

- a. The doors at each hoistway entrance shall be equipped with approved hoistway door interlocks of the hoistway unit system type tested as required by the Code. Interlock shall prevent operation of the car away from a landing until doors are locked in the closed position. Interlock shall prevent doors from opening at any landing from the corridor side unless car is at rest at that landing, or is in the leveling zone and stopping at that landing.
  - b. Provide key-operated hoistway door unlocking devices. A device shall conform to the requirements of the Code and shall permit authorized persons to open the hoistway doors from the landing when car is away from landing. The key for emergency use shall be mounted in a receptacle with a breakable transparent cover clearly marked in letter at least 1/8 inch high ELEVATOR DOOR KEY FOR FIRE DEPARTMENT AND EMERGENCY USE ONLY. The location of the receptacle shall be as directed by the Engineer.
7. Provide raised floor/level designations in characters and Braille on each jamb at 60 inches from floor to centerline. Characters shall be two inches high and in accordance with ADA requirements.
- M. Wiring and Cable: Division 16, except elevator traveling cable.
- 1. Elevator Traveling Cable.
    - a. NEC Type ETT, size and number of conductors to suit service, 16AWG minimum, each conductor with different numbered insulation.
    - b. Cable exceeding 100 feet in length to have steel supporting fillers, cable 100 feet or less with steel or nonmetallic fillers.
    - c. Conductors for electrical, signal, control telephone and sensing devices.
    - d. Ten feet of additional telephone, communications and sensing-device conductors in elevator machine room for connection to future interface panel by others.
    - e. Each traveling cable shall have a minimum of 10 percent spare conductors, but not less than 6 spare conductors in each traveling cable.
    - f. A separate coax cable or a shielded twisted pair should be added to accommodate the security video cameras inside the elevator.
    - g. Provide separate traveling cables for car lighting and fan control circuits and 14 AWG minimum size for elevator lighting circuit.
    - h. All insulated wiring, control wiring and wiring in traveling cables shall be tag coded at their terminals in the motor/controller room, and hoistway junction box, elevator cab junction box, and push-button stations within the cab, and shall agree with the approved wiring diagrams.

- i. Cables shall be free from any possible contact with hoistway structure, car or other equipment. Furnish and install shields or pads to protect the cables.

**N. Conduit Raceways and Boxes: Division 16.**

- 1. Rigid conduit and fittings shall be UL-Listed rigid galvanized steel conforming to the requirements of UL 6 and ANSII C80.1. Minimum diameter shall be 3/4 inch for power circuits, one inch for fire and intrusion circuits, and 3/4 inch for audio and control circuits. Liquid-tight flexible conduit shall conform to the requirements of UL 360 and consist of a flexible galvanized steel core containing a copper bonding conductor spiral-wound between convolutions and a neoprene or outer jacket overall. Fittings for liquid-tight flexible conduit shall be watertight and shall conform to the requirements of UL 514.
  - a. All conduit terminating in steel cabinets, junction boxes, wireways, switch boxes, outlet boxes and similar locations shall have approved insulation bushings. If the bushings are constructed completely of insulation material, a steel locknut shall be installed under the bushing. At ends of conduits not terminating in steel cabinets or boxes, the conductors shall be protected by terminal fittings having an insulated opening for the conductors.
  - b. The Contractor shall furnish all materials and completely wire all parts of the electrical equipment of the elevators including electrical devices on hatch doors.
- 2. Auxiliary gutters, wireways, and raceways shall be constructed of galvanized sheet steel conforming to the requirement of the NEC and shall be UL listed. Raceway, conduit and wireways within the hoistway exposed to public view shall be concealed within steel cladding.
- 3. Electrical boxes:
  - a. Outlet, junction and pull boxes shall be galvanized sheet steel or galvanized malleable iron, cast iron or ductile iron conforming to the requirement of UL 50, UL 514, and NEC 370-C. Pull boxes shall have screw cover with a liquid-tight gasket.
  - b. Junction boxes on car top, bottom and hoistway connecting the traveling cable shall contain approved terminal blocks for connection of traveling cable conductors. Terminal blocks shall have indelible identification numbers for each terminal connection.
  - c. All wire connection terminal blocks shall have the same identification number as labeled on the associated electrical wiring. All electrical wires shall use a labeling tube and heat shrink and match the terminal numbers.
  - d. During field installation of junction boxes or control boxes, the contractor/subcontractor shall not drill or cut into the top sides of the box for wiring.

- e. All boxes in machine room or pit shall be mounted on strut channels in order to prevent future corrosion and water damage. The strut channels shall be mounted to the wall and a minimum of 18 inches above the floor.
  - f. All solid state and electrical components located on top of the car enclosure or in the hoistway shall be installed within NEMA 4X enclosures.
4. Disconnect Switches for Car Lights and Mainline Power
- a. Disconnect switches shall be the following: UL 98, NEMA KS 1, heavy-duty, quick-make/quick-break switching mechanism with operating handle external to enclosure, with positions labeled ON and OFF, defeatable interlock to prevent opening of enclosure door when switch is ON. Enclosures shall be NEMA 250 Type 4x. Label disconnect switches in accordance with the NEC.
  - b. Mainline power disconnect switch shall be located in close proximity to the machine room entrance and shall be easily identifiable from other disconnect.
- O. Metal Work:
- 1. Steel sheet and steel fabrications:
    - a. Stainless steel sheet for cladding shall be minimum 16-gauge, best grade cold-rolled furniture steel. Stainless steel sheet for top enclosure shall be minimum 12-gauge. Stainless steel sheet for hoistway door frame shall be minimum 12-gauge.
    - b. Steel sheet for corrugated floor decking shall be minimum 10-gauge.
    - c. Steel shed for subfloor shall be minimum 3/8-inch thick.
    - d. Stainless steel for screws, bolts and nuts shall be AISI Alloy 303.
    - e. Galvanized steel material shall comply with ASTM A123, ASTM A153, ASTM A525 (G90 coating) and ASTM A568, as applicable. Steel sheet and steel fabrications, except stainless and lubricated machinery parts, which are not shown or specified to have other applied finishes, shall be galvanized.
  - 2. Steel Finishes:

Provide protection for all metal parts, fittings, and accessories by painting or galvanizing, except for stainless steel or anodized aluminum.

    - a. Where visible to the public, cladding and related steel surfaces shall be 316 stainless steel satin finish.
    - b. Paint finish, where shown, shall be aliphatic polyester polyurethane as follows:
      - 1) Primer shall be high-build epoxy-polyamide type, Tnemec Series 66-1211 or equal.

- 2) Finish coat shall be aliphatic polyester polyurethane, Tnemec 71 Endura-shield or equal.
- 3) Total dry film thickness shall be not less than six mils.

**P. Cab Enclosure:**

1. The elevator car and car components shall conform to the requirements of the Code, and shall operate without squeaks or metallic sounds.
2. Entire car assembly, including car frame and platform, shall be free from warps, buckles, and squeaks and rattles. Joints shall be lightproof.
3. Handrails: Handrails shall be ½ inch by 6 inch stainless steel #4 satin finished tube suitably mounted.
4. Car threshold: Car threshold shall be stainless steel with non-slip surface.
5. Toe guard aprons:
  - a. The toe guard aprons (cladding) at entrance side of elevator car shall be not less than 16 USSG sheet steel, galvanized and shall extend at least three inches beyond entrance jambs at each side. Toe guard shall have a straight vertical face, extending below the level of finished car floor, of not less than the depth of leveling zone plus three inches. The bottom of guard shall extend 3 inches below vertical face and be beveled at a 15-degree angle from the vertical. The toe guard shall be secured to car platform construction and be reinforced and braced to withstand a constant force of 150 pounds on its face without permanent deformation or deflection exceeding ¼ inch.
  - b. On glass elevators, the toe guard shall extend full width of cab.
6. Suspended Ceiling:
  - b. The suspended ceiling shall be faced and edged with solid stainless steel panels, 0.075-inch thick with a fully adhered ¾-inch thick core of noncombustible, sound-absorbent material and backed with galvanized sheet steel. ASTM A653M, G90 coating or better.
  - c. Mounting brackets and any necessary holes for the CCTV camera shall be provided on the top of the ceiling. The CCTV 360 degree camera shall be provided that will cover the entire car area. Coordinate bracket configuration and location with the CCTV subcontractor.
  - d. Mounting brackets and any necessary holes for the smoke and fire detection sensors shall be provided on the top of the ceiling, as further specified. Coordinate bracket configuration and location with the fire and intrusion system subcontractor
7. Laminated tempered safety glass:

- a. Glass shall be laminated. Heat-strengthened, safety glass conforming to requirements of ASTM C 1048 and ANSI Standard Z97.1 and shall consist of two pieces of ¼ inch thick glass and a 0.060 inch thick polyvinyl butyryl interlayer, laminated together.
  - b. Color: Tint by Globe-Amerada Co., used as a standard of quality, or comparable and approved equal.
  - c. Weatherproof tape for field installation of final edge seating shall be compatible with the interlayer.
8. Dry pressure glazing materials:
- a. The setting blocks, edge blocks, and face gaskets shall be ozone resistant, virgin neoprene.
  - b. Setting blocks for installation at each quarter point of the sill shall be 90 durometer, shore A hardness approximately full channel width, 4 inches long, and high enough to afford correct cover and provide 3/8 inch edge clearance for the glass.
  - c. Edge blocks, for vertical insulation at the bottom of each joint channel, shall be 50 durometer, shore A hardness approximately full channel width, three inches long, and provide 3/8 inch edge clearance for the glass.
  - d. Face gaskets shall be continuous, 50 durometer hardness, and provide 3/16 inch face clearance both inside and outside.
9. Sub floor material to be nominal ¼” stainless steel to prevent water infiltration between finished floor, cab and platform base.
- Floor covering: Poured Acrylic Epoxy, polymer system or approved equal, color selection and samples to be submitted to the Authority for approval by the Engineer, with slip-resistant surface, ¼ inch thickness, covering elevator car floor area. Flooring shall be non-shrinking, manufactured of prime quality compound, free of calendaring and curing defects, resistant to grease, oil, chemicals, aging, and ozone. Flooring shall be poured incorporating a full membrane system for the entire cab floor width and depth.
10. Emergency exit: Car shall have a top emergency exit conforming to requirements of the ANSI/ASME Code, the applicable jurisdictional requirements. The door shall open toward the top of elevator and shall have a latching mechanism to keep it in place.
11. Ventilation: A 350 cfm exhaust fan for continuous car ventilation shall be provided. Connect continuous ventilation fan to emergency power system. The exhaust fan shall be controlled from the car operating panel with Chicago Lock 7500. Provide sixty (60) minute backup battery power for fan.
12. Lighting fixtures and plug receptacles:

- a. Car lighting shall provide a minimum of 15-foot candles measured at any point on the cab floor and shall of the LED type. Car lighting shall be provided with emergency battery backup upon failure or interruption of normal car lighting. Emergency lighting unit shall provide required lighting for a minimum of four (4) hours. Battery charger shall be capable of restoring battery to full charge within sixteen (16) hours after resumption of normal power.
  - b. Exterior car lighting shall be as specified. On glass-enclosed elevators they shall be concealed under access panels flush with cab top or bottom surfaces, respectively. A duplex plug receptacle shall be provided in the pit and on top and bottom of each car. The lighting fixtures and receptacles on exterior of car shall be controlled by a switch adjacent to each fixture.
  - c. Provide 115 volt ac plug receptacle (GFCI) within 12 inches of CCTV camera location. Coordinate the installation of CCTV equipment within the design of the elevator cab as the elevator contractor is responsible for the installation of the camera and wiring to the control room.
13. Car Doors and Door Equipment:
- a. Car doors and door frames shall be suitably reinforced and provided with a laminated stainless steel #4 finish on cab side and baked enamel finish on hoistway side. Doors shall protect the full width and height of car entrance opening when in the fully closed position. Car door frame shall be integral with front wall of cab.
  - b. Hanger cover plate sections above the door opening shall be removable from the hoistway. Doors shall be guided at the bottom by composition gibs engaging threshold grooves with minimum clearance.
  - c. Car/Hoistway Door Operator: Car and hoistway doors at each landing shall be opened and closed quietly and smoothly by a direct current electric operator.
  - d. Door operation automatic at each landing with door opening being initiated as car arrives at landing and closing taking place after expiration of specified time interval, with electric contact to prevent starting elevator away from landing unless car door is in its fully closed position.
    - a. Time door closing to start 5 seconds minimum from notification that car is answering landing call.
    - b. Time doors to remain open five seconds minimum.
    - c. Time shall be adjustable to 20 seconds.
    - d. The interval of time that the doors remain open at intermediate landings shall be less for a stop made in response to a landing call. Door open time at a dispatching terminal shall be longer than the time for a stop in response to an intermediate landing call.

- e. All door timers shall be adjustable from the controller display panel.
- 14. Capacity plate: The car capacity plate shall be of plain stainless steel and contain the data required by the ANSI/ASME Code but shall not bear the name of the elevator manufacturer.
- 15. Signal Devices and Fixtures:
  - 1) Car Operating Station:
    - a. Provide one (1) main station in the front and one (1) auxiliary station. The COP shall be a vertical type.
    - b. General: Provide signal fixtures and control devices for each elevator. Buttons and signals shall be tamper resistant of the illuminated type that light-up when activated and remain lit until call or other function has been fulfilled. All signal fixture and control device faceplates shall be of Type 316L, nominal 0.135 inch thick stainless steel with No. 4 finish, unless otherwise shown on the Contract Drawings.
    - c. Car operating stations shall contain Braille plates adjacent to each call button. Contractor to coordinate proper landing call outs based on maximum characters as indicated on Contract drawings. Buttons for DOOR-OPEN, DOOR-CLOSE, ALARM, EMERGENCY PHONE call functions are to be supplied. Buttons are to be vandal resistant and of the positive stop type.
    - d. Station shall have a locked service cabinet for keyed switches of the car light; exhaust fan, independent operation, GFI duplex outlet as indicated on the Contract drawings.
    - e. Provide Emergency Communication: "Hands-free" ADA compliant telephone/intercom.
  - 2) Hall Station: Riser of hall stations of the push-button, call acknowledging, stainless steel, tamper resistant type shall be mounted at all elevator landings. Highest landing shall have a single DOWN button. Lowest landing shall have a single UP button. Incorporate ADA compliant telephone with each hall station. Braille Indicator Plate shall be provided. Faceplate finish shall be Type 316L stainless steel #4 finish. The Hall Station shall be flush to the surface and shall not be projected out.
  - 3) Hall Lanterns:
    - a. Tamper resistant hall lanterns shall be equipped with illuminated (LED type) UP and DOWN signal arrows, but provide single arrow where only one direction is possible. Provided units projecting from faceplate for ease of angular viewing. Match materials, finishes and mounting method with hall stations.
    - b. In conjunction with each hall lantern, provide an adjustable electronic chime signal to indicate that a car is arriving in

response to a hall call and to indicate direction of car travel. Signal shall sound one for up direction of travel and twice for down direction.

- 4) Bell Alarm System: Bell alarm system for each elevator shall be properly located within building and audible outside hoistway when activated by the EMERGENCY ALARM call button on each car control building/station. When emergency stop switch is activated inside fire service box, the bell alarm system should not be activated.
- 5) Firefighters' Service System: Firefighters' service system shall be provided in compliance with code requirements.

**R. Machine Room Equipment:**

Machine room for the single elevator shall be 224 sq.ft minimum.

1. Machine Room Emergency Lighting: Emergency lighting shall be provided in each elevator machine room.
  - a. There shall be a minimum of one lighting fixture.
2. Clearance around equipment in each machine room shall comply with provisions of all applicable codes. Clear distance for the maintenance purposes shall be at least 18". In no case shall this clearance supersede minimum Code requirements.
3. Equipment in the elevator machine room and hoistway sheaves area shall be so arranged that replaceable items can be removed for repair or replacement either by overhead hoist and dolly, or other conventional means, without dismantling or removing other equipment components in the same machine room. The overhead hoist and dollies shall be part of the construction.
4. Machine rooms must be air conditioned and heated to maintain an ambient temperature of 50F to 90 degrees F and a relative humidity between 35% to 50%. The Air Conditioner shall be Split System. The heating system for the machine room is also a built in system. A forced removal should be done by moving the air from the room to the outside of the building to another part of the building to keep an air exchange through the equipment room. Intake and exhaust vent should not be located close to each other.
5. Any component attached to the controller shall have a minimum clearance of 18 inches from the side(s) of the component requiring access for maintenance and free air circulation.
6. Provide Mats of insulating rubber or other suitable floor insulation in the front of the Controllers.
  - a. The Resistance range shall be  $1 \times 10^4 < 1 \times 10^6$  and shall meet ANSI/ESD requirements.
  - b. The rubber mat shall be the width of the controller plus 12".
  - c. The length of rubber mat shall be a minimum of 24".
  - d. The rubber mat shall be a ¼" thickness and beveled at

each end.

**2.04 KIOSK SURVEILLANCE CONTROL AND COMMUNICATION:**

A. Surveillance Camera Provisions (Surface Elevators). All requirements for CCTV shall comply with the WMATA SMNT Department.

1. Space provisions and mounting holes shall be provided for closed-circuit television (CCTV) cameras to be furnished and install by CCTV subcontractor.

a. The Contractor shall coordinate with the CCTV subcontractor and install wiring from the CCTV location within the elevator cab to an interface terminal and video transmitter located on the elevator car. Final equipment selection has not been performed and is subject to change. Coordinate model, configuration, and location with the CCTV subcontractor.

1) Power will be required by the video transmitter and CCTV camera and shall be provided.

2) Equipment: Fiber Optic Video Transmitters (Elevator Cameras)

b. The Contractor shall work with the CCTV subcontractor to install CCTV subcontractor-provided fiber-optic cable and transmitter to a terminal location specified by the CCTV subcontractor. The Contractor shall tag the cables appropriately, indicating that they are for future use by others.

B. Supply the following status indication, control, and communication functions for each elevator car and landing at an annunciator panel in the kiosk: indication, control, and communication functions in each elevator and landing; and all interconnecting wiring required to provide a complete and operable system. Systems to be provided and installed include the following:

1. Kiosk annunciator panel: Panel shall be a single panel approximately 7-½ by 19 inches. Coordinate design to ensure that the panel is compatible with the mounting provisions, previous designs, and human factors. The panels shall contain:

a. Indicators:

1) Visual display of elevator car status, to include landing stopped at or being approached and direction of travel:

a) Designate elevator by functional name, e.g., Garage 1.

b) For garage elevators designate landing by garage floor level.

2) Out of service because of malfunction.

3) In-Car stop switch is actuated.

- 4) Continuous audible alarm activated when emergency alarm switch in car is initiated.
- 5) Indicator lamps shall be LEDs, with life expectancy of 50,000 average rated hours.
- b. Controls:
  - 1) Out of service.
  - 2) Override control.
  - 3) Door open.
  - 4) Landing selection.
  - 5) Push button switches shall have limited over-travel to prevent damage due to abuse and shall be equipped with lift-up covers to avoid inadvertent operation, have mechanical and electrical life of 25,000 cycles, with integral or isolated illumination circuit and be normally open with momentary action or alternate action circuitry.
  - 6) When the override control switch is OFF, the kiosk controls shall function in parallel with the car and landing controls, i.e., the selective/collective control system shall respond to a kiosk-initiated landing selection with the normal priority afforded the remaining system landing selection and call buttons.
  - 7) When the override control switch is ON, the following actions shall take place:
    - a) If the car is stationary at a landing, it shall remain at the landing and the doors, if open, shall close and remain closed.
    - b) If the car is in motion, it shall stop at the first landing reached and the doors shall remain closed.
    - c) The elevator control system shall then respond only to the kiosk controls and car station.
    - d) The car shall park at the designate landing.
  - 8) When the OUT OF SERVICE switch is actuated, the elevator shall return to the lowest landing before shutting off.
2. Elevator fire detection sensor: Provide space and mounting holes for smoke and fire detection sensors to be furnished and installed as required by building, electrical, elevator and local codes. Install wiring from the sensor location in the car to interface terminal cabinet in the machine room, for connection from the sensors to the smoke and fire detection system. Coordinate with installers to allow installation of sensors and operational checkout of the system.

3. Passenger - Kiosk communications (VIOP) system:
  - a. Communications signal button in elevator car momentary contact to illuminate back-lighted signal button in car and latch on a continuous audible signal and illuminated indicator in the kiosk.
  - b. Communications buttons at landings, momentary contact, to illuminate back lighted signal button at the landing and latch on a continuous audible signal and illuminated indicator in the kiosk.
  - c. Push button in kiosk to activate intercom system and reset indicator lamps and audible alarm.
  - d. Each passenger operated device shall have identification markings as specified for car operating devices.
  - e. The voice communication intercom system shall function as a master remote network. The master station shall be located in the kiosk annunciator panel and shall include a speaker-microphone, audio amplifier, on-off indicator lamp, audible signal device control and push button lamp for the operations. A remote station shall include a speaker-microphone and a communications signal button shall light the signal button and cause a continuous audible signal at the master station and light indicator lamp corresponding to the calling remote station. Communications between master and remote station shall be established upon the actuation of the master station push-button control corresponding to the calling remote station with the master station push to talk control determining the direction of transmission.
  - f. If successive calls are received from other remote stations while communication is in progress with one remote station, the audible signal shall sound the indicator lamps corresponding to the calling remote stations shall light and both shall remain on the indicate waiting calls.
  - g. Means shall be provided to clear the indicating lamps independently. Communication initiated from the master station shall be established upon actuation of the push button control corresponding to the called remote station, with the master station push-to-talk control determining the direction of transmission.
  - h. The audio amplifier at the master station shall be all solid state in construction and shall control incoming and outgoing volumes for all of the remote stations. The volume levels shall be preset during installation and shall be adjustable to provide a maximum of five watts rms at the speaker-microphones.
  - i. The power supply shall supply all ac and dc voltages necessary for all circuitry associated with the voice communications intercom system, and shall operate from the 120-volt ac, 60 Hertz emergency power supply located in the elevator machine room.

- j. The audio amplifier and the speaker-microphones shall have a frequency response of plus or minus three Db from 300 Hertz to 5,000 Hertz. Power consumption shall be 5 watts maximum in standby and 50 watts maximum under load.
- k. The Contractor shall be responsible for shielding, grounding and other measures necessary to protect the voice communications intercom system from interference from other electrical systems.
- l. Speaker grilles shall have a minimum of 35 percent open area over the entire surface of the speaker cone.
- m. Switches and relays used with this system shall have an operating life exceeding 5,000,000 cycles. Documentation shall be provided by the Contractor to the Engineer, for his approval, to substantiate this life cycle level.
- n. The system shall perform adequately, as approved by the Engineer, with both the remote and the master station test personnel speaking from three feet away from the speaker-microphones.
- o. Communication in the car shall also rollover to a 24-hour manned site (Rail Operations Control Center) in the event that the kiosk does not respond to the call.
- p. Each passenger-operated device shall be identified in accordance with ADA/ADAAG requirements.
  - 1) ADA requirement for providing emergency two-way communications between an elevator and a point outside the hoist way (the Kiosk).
  - 2) Device mounting heights shall comply with:
    - a) ADAAG requirements.
    - b) ASME A17.1-2007. The highest operable part of the two-way communication system shall be a maximum of 48 inches from the floor.
  - 3) A Braille Instruction Plate shall be permanently affixed on each remote intercom unit.
    - a) ADA Standards: Raised symbol and lettering (Signage) located adjacent to the device.

**2.05 EMERGENCY POWER OPERATION**

- A. Provide control equipment and interlocks sufficient to operate at least one elevator for group of three at a time in the event of failure of normal building power supply.

- B. Provide for sequential operation to return elevators to the main entrance floor. Upon transfer to generator power source as evidenced by signal generated by contact closure at elevator automatic transfer switch, start one elevator at a time and return that elevator to the main floor and park with the door open before starting next elevator.
- C. Provide selector switch for automatic and manual selection of the elevator that is to operate on generator power source. Locate selector switch adjacent to elevator door key or as directed by the Engineer.
- D. When normal building power is restored, as evidenced by signal generated by contact closure at elevator automatic transfer switch, return elevators to normal operation without disruption to normal operating circuits or electrical systems.
- E. The key lock shall be ChicagoLock 7500.
- F. The minimum requirements of the Code shall be met.

**PART 3 – EXECUTION****3.01 EXAMINATION**

- A. Prior to beginning installation of elevator equipment, examine the following and verify that no irregularities exist that would affect quality or execution of work as specified. Notify the Authority if there is any non-conformances.
  - 1. Hoistway size and plumbness.
  - 2. Sill pockets.
  - 3. Anchor brackets
  - 4. Sill supports.
  - 5. Spreader/Divided beams.
  - 6. Machine beams and any other supplied by others.
  - 7. Pit Depth
  - 8. Overhead clearance
- B. Do not proceed with installation until previous work conforms to project requirements.

**3.02 INSTALLATION**

- A. Coordinate work in this section with all trades to ensure that the installation of the elevators is not in conflict with the work performed of other trades.
- B. Make necessary wiring connections.
- C. Paint metal surfaces in accordance with Section 09\_91\_99.
- D. Install elevator equipment, materials and accessories in accordance with the OEM's installation procedures and approved Shop Drawings to make elevator fully operational.
- E. Erect guides plumb and securely fasten to building structure.
- F. Provide protective coverings for finished surfaces.

- G. Upon completion, touch up and restore/ replace damaged or defaced factory finished surfaces. Touch up any marred finishes and replace as directed by the Authority.
- H. Remove protective coverings and clean exposed surfaces after completion.

**3.03 FIELD TESTING:**

- A. Operating Adjustments and tests: At all times, until issued final acceptance by ELES representative, adjust equipment to operate satisfactorily, conduct performance tests and make necessary readjustments.
  - 1. Provide test instruments, materials, other necessary facilities, and all labor required for acceptance tests specified.
  - 2. All faults recorded during performance period will be turned over to the Authority for review. The review period should be not less than 20 working days. A fault such as, but not limited to:
    - a. Door lock or car gate switch malfunction.
    - b. Emergency stop switches and safety circuit malfunction.
    - c. Door protection timer.
    - d. Motor overload circuits
    - e. Stuck button protection features.
    - f. Low oil and oil pressure devices.
    - g. Test emergency telephone in car
- B. Any deficiencies found during the performance period will be repaired by the contractor at no charge to the Authority.  
The warranty shall include materials and labor necessary to correct defects.
- C. Defects shall include, but not be limited to, noisy, rough, or substandard operation; loose, damaged, missing parts and fluid leaks.
- D. Arrange for tests and inspection by jurisdictional authorities to obtain certificate of acceptance.
- E. Coordinate with ELES Engineer to have the Authority personnel witness acceptance tests.
- F. When the elevator work included in this Contract is fully completed, demonstrate to the satisfaction of ELES representative that the proper operation of every part of the equipment complies with Contract requirements including compliance with all applicable requirements of ANSI/ASME A17.1. The inspection procedure outlined in ANSI/ASME A17.2 will form a part of the final inspection.
- G. Shop test of elevator motor and certified test sheets will be required. The heating, insulation and resistance of the motors will also be determined under actual conditions after installation.

**3.04 ACCEPTANCE TESTS:**

Notification Requirements: Notify the Project Manager and ELES Engineer a minimum of five (5) working days prior to each scheduled test.

- A. Furnish all test instruments and materials, required at the time of final inspection, to determine compliance of the work with Contract requirements. Materials and instruments furnished shall include standard 50-pound test weights, megohmmeter, alternating current voltmeter and ammeter, centigrade calibrated thermometers, spirit level, and stop watch. At the time of final inspection, tests shall include the following:
1. After installation, each elevator shall be tested without load by the Contractor. The elevator shall be subjected to a test for a period of eight—hours continuous run. During the test run, the car shall be stopped at top and bottom levels, in both directions of travel with a standing period of 10 seconds at each landing.
  2. Full-load run test: The elevator shall be subjected to a test for a period of one-hour continuous run, with full specified rated load in the car. During the test run, the car shall be stopped at top and bottom levels in both direction of travel with a standing period of 10 seconds at each landing.
  3. Car Leveling Test: Determine accuracy of floor landing tests both before and after full load run tests. Minimum of 1/4 inch leveling must be maintained. Test accuracy of landing at all floors with full load and no load in car, in both directions of travel.
  4. Speed test: The actual speed of the elevator car shall be determined in both directions of travel, with full specified rated load and with no load in the elevator car. Speed tests shall be made before and after the full load run test. Speed shall be determined with a Tachometer. Car speed when ascending shall be not more than 10 percent above not more than 10 percent below the specified car speed.
  5. Temperature rise test: The temperature rise of the drive unit motor shall be determined during the full load test run. Temperatures shall be measured by the use of thermometers inserted into the windings and shielded by cotton waste. Under these conditions, the temperature rise of the motor shall not exceed NEMA specified temperature rise. Test shall be started only when all parts of equipment are within 5<sup>0</sup> C of the ambient temperature at the time of starting test.
  6. Insulation resistance test:
    - a. The complete wiring system of elevator shall be free from short circuits and accidental grounds. The insulation resistance of the system shall be more than one megohm when tested by using a 500-volt megohmmeter.
    - b. The elevator structure, equipment, and raceway shall be tested for continuity to ground.

**3.05 ELEVATOR PROTECTION:**

1. The finished elevator installations shall be completely barricaded and enclosed to preclude their use without permission of the Contractor until Final Acceptance and release by the Contractor for general use. The enclosure shall be fabricated to allow easy access for maintenance, testing and adjustment.

2. The Contractor shall be responsible for the security of the contents of each machine room. The Contractor shall control access to that room, and ensure that it shall remain secure at all times until the completion of the Contractor's interim maintenance obligation.
3. Protection: During installation and until all elevator systems are fully operational and accepted by WMATA, make all necessary provisions to protect all elevator components from damage, deterioration, and adverse environmental conditions. Do not use or allow the use of the elevator for construction purposes such as hauling materials or worker transport during construction.
4. Security Of Machine Rooms: The Contractor shall be responsible for the security of the contents of each machine room. The Contractor shall control access to that room and ensure it shall remain locked and secure at all times.
5. Field Painting: Metal parts visible to the public shall be field painted.

**3.06 WARRANTY**

Warranty: Two-year warranty of construction shall start at Final Contract completion.

- A. The OEM shall warrant in writing that all equipment manufactured and installed under this specification, for a period of twenty four (24) months from the date of Final Acceptance by the Authority, be free of defects in design, materials, and workmanship, under normal use and service. Defective work shall be repaired or replaced at no additional cost to the Owner.
- B. The warranty shall include materials and labor necessary to correct defects.
- C. The warranty does not begin until all of the following requirements have been met.
  - 1) The Operations and Maintenance Manuals are accepted by WMATA.
  - 2) The required training has been completed to the satisfaction of WMATA.
  - 3) All field tests have been successfully completed.
  - 4) The acceptance testing has been successfully completed.
  - 5) The elevators are in service for passenger/public use.
  - 6) The State and local jurisdictions have inspected the elevators and issued the respective certificates of Operation.
  - 7) All spare parts have been delivered and received by WMATA.
  - 8) Any discrepancy identified by the ELES representative shall be repaired or replaced by the Contractor at no additional cost to the Authority.

**3.07 MAINTENANCE:**

- a. Maintenance Service

The Contractor shall perform full maintenance service for a period of two years on each elevator in accordance with the manufacturer's maintenance manual and WMATA ELES maintenance program prior to WMATA providing permanent maintenance. The period of maintenance shall begin after test(s) and Provisional Acceptance of each elevator and shall extend to the scheduled date of Final Acceptance for all units in the same facility plus a period of two years. In no case shall the interval between inspections and testing be greater than one month. The maintenance service during the warranty period shall be provided by fully trained elevator mechanics. The maintenance tasks shall include, but not be limited to, the following:

- a. Inspection of completed installation and periodic testing to maintain the elevators in completely operable condition.
- b. Contractor shall provide support for periodic, accident and incident, PM compliance inspections.
- c. Lubrication of parts, and the protection of the equipment.
- d. Replacement of defective parts at no additional cost to the Authority.
- e. Annual clean down of the elevator and hoistway enclosure is required. Make necessary arrangements with Authority in order to minimize any inconvenience.
- f. Contractors performing maintenance are responsible for all service, repair work and emergency call. The contractors shall provide unlimited service during regular time and twenty-four (24) hour (including Holidays) emergency call back service at no additional cost.
  - 1) Provide twenty (24) hour (including Holidays) emergency service during the maintenance period consisting of a prompt response (within 1 hour) to emergency request by telephone or otherwise from Authority or designated representative if an elevator is inoperable or in case of injury, entrapment, or potential injury to persons.
  - 2) Unlimited service callbacks are included with a required response time of one (1) hour (including Holidays).
- g. Periodic maintenance (based on WMATA schedule) shall be performed off peak hours to minimize service interruption as long as the other elevator serving the same platform is operational.
- h. Reporting: Detailed monthly records of tasks performed including names of individuals performing the tasks, date and time performed, and other pertinent data. In addition, the reports are to be provided in an electronic format acceptable to WMATA's needs.
- i. Contractor performed maintenance shall follow the WMATA Office of Elevator and Escalator Operations procedures, schedules and check charts.

Within three (3) months prior to the termination of this contract, the Authority or his designated representative(s) shall make a thorough

maintenance inspection of all equipment covered under this contract. The contractor shall provide personnel to remove, test, and operate equipment as necessary. All deficiencies found as a result of this inspection shall be corrected by the Contractor as required in this agreement with no additional cost to the Authority.

### 3.08 REMOTE MONITORING SPECIFICATIONS:

- A. Allen Bradley DF1 or industry standard Modbus protocol shall be provided to transmit data from the Elevator/Escalator controller to the Authority's AEMS RTU computer control and data system. The Design-Builder shall provide a controller data interface to a DH-485 network located in the Elevator /Escalator machine room. The DH-485 controller interface shall be programmable for data rates up to 115Kbps. The interface shall allow other nodes such as other Elevator or Escalators to be readily incorporated into the DH-485 network. The controller data interface shall include one Allen Bradley SLC PLC per station to function as a data concentrator to consolidate data from all the controllers in the station. The software for the data concentrator shall be as specified by the Authority. The data concentrator shall receive controller data over the DH-485 data network and provide formatted data to the AEMS RTU through a RS 232 link. This data transmission may be accomplished by a separate PLC controller integrated into the control system.
- B. The Elevator /Escalator control system shall automatically initiate the transmittal of data when data is requested by the Authority's AEMS system and continue until all data is received by the AEMS RTU in the station AC switchboard room. The Authority will perform final integration of the data in the AEMS system.
- C. The Contractor shall also provide the required hardware to download data from any fault finding annunciator panel to a supplied laptop PC being utilized at the Elevator/Escalator location. The provided software shall permit the downloading and storage of data on the supplied laptop PC from multiple fault finding annunciator panels.
- D. The Contractor shall install an Allen Bradley network interface module, (model 1761-NET-AIC, or approved alternative) beside the PLC in the controller and provide 24 VDC power to the module. The Allen Bradley PLC will be used for remote monitoring capabilities into WMATA established engineering monitoring network.
  - a) The Contractor shall provide all wiring and programming of the PLC to communicate with station data concentrators on the DH-485 network. Coordinate work with WMATA ELES Engineering.
  - b) The Contractor shall pull all remote monitoring cables to the interface in the elevator controller from the remote monitoring network going back to WMATA's Automated Energy Management System (AEMS) remote terminal unit (RTU).
  - c) Provide Ethernet communication between the elevator machine room and WMATA's communication room. The communication port shall be located less than 6' from the controller and shall have minimum of two ports for data communication.
- E. Terms and Definitions

1. Boolean - A single bit data type.
2. DF1 - A Rockwell Automation Company proprietary communications protocol.
3. DH485 - An industrial communications network used by Allen Bradley programmable controllers.
4. Integer - A data type 16 bit signed (range -32768 to 32767).
5. PLC - Programmable Logic Controller.
6. QEI - QEI Inc. Springfield NJ
7. RTU - Remote Terminal Unit

#### F. Elevator Remote Monitoring Data Specification

##### 1. Overview

The design of the WMATA escalator & elevator monitoring system shall include a data concentrator PLC to gather data from the elevator control PLC's over an Allen Bradley DH 485 network. The QEI RTU shall read data from the WMATA data concentrator PLC via an RS 232 serial connection to a 1746-BAST module using Allen Bradley DF1 protocol. See figure 1.1 for reference. This specification defines data to be presented by the WMATA data concentrator PLC to the QEI RTU. The WMATA data concentrator PLC station shall poll the escalator & elevator controller(s) periodically for data and format the data into blocks within the WMATA data concentrator. An Ethernet TCP/IP connection is available at the Data concentrator PLC. The data concentrator PLC has been designed to collect data from up to (10) escalators and/or elevators. The data concentrator PLC is to be mounted into the existing QEI RTU enclosures and powered by a 120 VAC source from within the RTU. For Metro stations where more than (10) escalators and elevators are present additional data concentrator PLC's will be required.

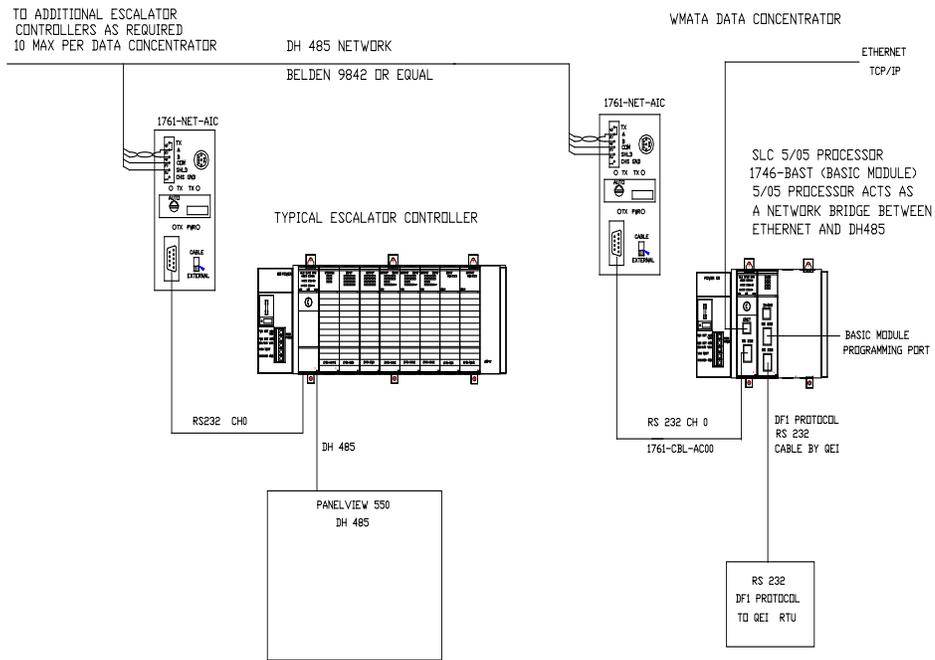


Figure 1.1

2. Data Concentrator PLC Data File Assignments.

The WMATA data concentrator PLC shall store data for up to (10) escalators and/or elevators in any combination as defined in table 2.1.

Table 1

Escalator DH485 node #	Elevator H485 node #	Status bits File	Analog Data File	DC PLC MSG file#	DC PLC MSG buffer file#
1		N20	N21	N81	N101
2		N22	N23	N82	N102
3		N24	N25	N83	N103

4		N26	N27	N84	N104
5		N28	N29	N85	N105
6		N30	N31	N86	N106
7		N32	N33	N87	N107
8		N34	N35	N88	N108
9		N36	N37	N89	N109
10		N38	N39	N90	N110
	11	N40	N41	N121	N141
	12	N42	N43	N122	N142
	13	N44	N45	N123	N143
	14	N46	N47	N124	N144
	15	N48	N49	N125	N145
	16	N50	N51	N126	N146
17		N52	N53	N127	N147
18		N54	N55	N128	N148
19		N56	N57	N129	N149
20		N58	N59	N130	N150
Concentrator PLC (DC)	25	N80	N79		

Each data file shall begin with word 1 (example: escalator #1 status bits begin with N20:1 and end at N20:20)

The data concentrator PLC communication ports shall be configured as follows.

**Channel 1**

Driver: Ethernet

IP Address: TBD

Subnet Mask: TBD  
Gateway Address: TBD

**Channel 2**

Driver: DH485  
Baud Rate: 19.2K  
Node Address: 25

1756-BAST basic module communication ports shall be configured as follows.

**Port 1:** Programming port

Settings -- 19,200 Baud, No parity, 8 bits, 1 stop bit, No handshaking

**Port 2:** DF1 port

Settings -- 19,200 Baud, No parity, 8 bits, 1 stop bit, No handshaking

DF1 – Op Code 19 (Full Duplex, NHS, ER, Enable DPD, CRC error checking,

Timeout = 50

Retries = 3

RTS on delay = 20 msec

RTS off delay = 20 msec

Module address = 10

**DH485 Port** – Not Available

**3. Data Format**

Data Concentrator status in File N80 per table 3.0

**Table 3.0 Data Concentrator Status Bits**

WORD	BIT	DATA TYPE	DESCRIPTION	"0" STATE	"1" STATE
------	-----	-----------	-------------	-----------	-----------

1	0	BOOLEAN	Spare		
	1	BOOLEAN	Data Concentrator PLC Battery Status	FAULT	NORMAL
	2	BOOLEAN	Data Concentrator Basic Module Battery Status	FAULT	NORMAL
	3	BOOLEAN			
	4	BOOLEAN			
	5	BOOLEAN			
	6	BOOLEAN			
	7	BOOLEAN			
	8	BOOLEAN			
	9	BOOLEAN			
	10	BOOLEAN			
	11	BOOLEAN			
	12	BOOLEAN			
	13	BOOLEAN			
	14	BOOLEAN			
	15	BOOLEAN			

WORD	BIT	DATA TYPE	DESCRIPTION	"0" STATE	"1" STATE
2		BYTE	Data Concentrator checksum byte1		
3		BYTE	Data Concentrator checksum byte2		

Words 4 through 20 of the Data Concentrator status file (N80) are unused.

The Data Concentrator Analog data file (N79) is unused.

**Elevator data:**

Two 20 word (40 BYTE) blocks of data shall be developed for each elevator one block for status bits and one block for analog data. Table 3.3 defines the format of data for status bits. Table 3.4 defines the format for analog data.

**Table 3.3 Elevator Status Bits**

WORD	BIT	FAULT TYPE	DESCRIPTION	"0" STATE	"1" STATE
1	0	FAULT	24 VDC POWER SUPPLY	FAULT	NORMAL
	1	FAULT	SAFETY CIRCUIT GOOD	FAULT	NORMAL
	2	FAULT	TOP FINAL LIMIT TRIPPED	FAULT	NORMAL
	3	FAULT	BOTTOM FINAL LIMIT TRIPPED	FAULT	NORMAL
	4	FAULT	DRIVE FAULTED	FAULT	NORMAL
	5	FAULT	OVERLOAD TRIPPED	FAULT	NORMAL
	6	FAULT	STOP BUTTON ACTIVATED	FAULT	NORMAL
	7	STATUS	IN-CAR ALARM BUTTON PRESSED	ALARM	NORMAL
	8	FAULT	OUT OF SERVICE BY DELAY	FAULT	NORMAL
	9	FAULT	MOTOR LIMIT TIMER TRIPPED	FAULT	NORMAL
	10	FAULT	VALVE LIMIT TIMER TRIPPED	FAULT	NORMAL
	11	STATUS	INSPECTION OPERATION ON	ON	OFF
	12	STATUS	INDEEDENDANT SERVICE ON	ON	OFF
	13	STATUS	VISCOSITY CONTROL ON	ON	OFF
	14	STATUS	CONTROLLER TEST SWITCH ON	ON	OFF
	15	STATUS	FIRE SERVICE PHASE 1 ON	ON	OFF

WORD	BIT	FAULT TYPE	DESCRIPTION	"0" STATE	"1" STATE
2	0	STATUS	FIRE SERVICE PHASE 2 ON	ON	OFF

	1	FAULT	SMOKE SENSOR @ MAIN ON	ON	OFF
	2	FAULT	SMOKE SENSOR @ OTHERS ON	ON	OFF
	3	STATUS	EMERGENCY POWER OPERATION	ON	OFF
	4	STATUS	OVERRIDE ON	ON	OFF
	5	STATUS	CAR IS RUNNING UP	NOT-RUN	RUNNING
	6	STATUS	CAR IS RUNNING DOWN	NOT-RUN	RUNNING
	7	STATUS	BRAKE LIFTED	LIFTED	NORMAL
	8	STATUS	CAR IS IN DOOR ZONE	NOT IN ZONE	IN ZONE
	9	STATUS	INTERLOCKS ARE MADE	OPEN	NORMAL
	10	STATUS	FRONT DOOR GATE SWITCH MADE	OPEN	NORMAL
	11	STATUS	FRONT DOOR FULLY CLOSED	OPEN	CLOSED
	12	STATUS	FRONT DOOR FULLY OPEN	CLOSED	OPEN
	13	STATUS	FRONT DOOR REVERSAL ACTIVATED	OFF	ACTIVE
	14	STATUS	FRONT DOOR PROTECTION ACTIVATED	OFF	ACTIVE
	15	STATUS	REAR DOOR GATE SWITCH MADE	OPEN	NORMAL

WORD	BIT	FAULT TYPE	DESCRIPTION	"0" STATE	"1"STATE
3	0	STATUS	REAR DOOR FULLY CLOSED	OPEN	CLOSED
	1	STATUS	REAR DOOR FULLY OPEN	CLOSED	OPEN
	2	STATUS	REAR DOOR REVERSAL ACTIVATED	OFF	ACTIVE
	3	STATUS	REAR DOOR PROTECTION ACTIVATED	OFF	ACTIVE
	4	FAULT	DOOR REVERSAL DEVICE FAILURE	FAULT	NORMAL
	5	FAULT	ROPE BRAKE SET	FAULT	NORMAL
	6	FAULT	LEVELING SYSTEM FAILURE	FAULT	NORMAL

	7	FAULT	WATER INTRUSION ALARM ACTIVE	FAULT	NORMAL
	8	STATUS	ELEVATOR SLC 5/03 LOW BATTERY	FAULT	NORMAL
	9	STATUS	ELEVATOR SLC 5/03 COMM. ACTIVE	FAULT	NORMAL
	10	STATUS	ELEVATOR SLC 5/03 LOCAL/REMOTE	REMOTE	LOCAL
	11	STATUS	ELEVATOR SLC 5/03 RUN/PROG	PROG	RUN
	12	FAULT	FAULTED	FAULT	NORMAL
	13	STATUS	Out of Service	FAULT	NORMAL
	14		SPARE		
	15		SPARE		

WORD	BIT	FAULT TYPE	DESCRIPTION	"0" STATE	"1"STATE
4	0	STATUS	CAR POSITION 1	NOT AT POSITION	AT POSITION
	1	STATUS	CAR POSITION 2	NOT AT POSITION	AT POSITION
	2	STATUS	CAR POSITION 3	NOT AT POSITION	AT POSITION
	3	STATUS	CAR POSITION 4	NOT AT POSITION	AT POSITION
	4	STATUS	CAR POSITION 5	NOT AT POSITION	AT POSITION
	5	STATUS	CAR POSITION 6	NOT AT POSITION	AT POSITION
	6	STATUS	CAR POSITION 7	NOT AT POSITION	AT POSITION
	7	STATUS	CAR POSITION 8	NOT AT POSITION	AT POSITION
	8				
	9				
	10				
	11				
	12				

	13				
	14				
	15				

Words 5 through 20 are unused.

**Table 3.4 Elevator Analog Data**

WORD	DATA TYPE	MIN VALUE	MAX VALUE	UNITS	SCALE FACTOR	DESCRIPTION
1	INTEGER			AMPS	X10	DRIVE MOTOR AMPS
2	INTEGER			KWH	X1	PRE DAY KWH
3	INTEGER				X1	PRE DAY UP COUNT
4	INTEGER				X1	PRE DAY DOWN COUNT
5	INTEGER				X1	PRE DAY FRONT DOOR CYCLES
6	INTEGER				X1	FAULT CODE
7	INTEGER				X1	PRE DAY REAR DOOR CYCLES
8	INTEGER					
9	INTEGER					
10	INTEGER					
11	INTEGER					
12	INTEGER					
13	INTEGER					
14	INTEGER					
15	INTEGER					
16	INTEGER					
17	INTEGER					
18	INTEGER					

19	INTEGER					
20	INTEGER					

Note: All analog values are multiplied by 16 in the data concentrator to bit shift left 4 bits to align with QEI's 12 bit analog data types.

A note on communication loss

A 60 second watchdog timer is coded into each escalator file. If communications are lost between the data concentrator and the escalator controller for more than 60 seconds the watchdog timer will timeout. When the timer has timed out the communications loss bit will be reset (0) to indicate the communications loss condition.

**3. Time and date sync**

The QEI RTU shall provide clock synchronization to the WMATA data concentrator PLC every 5 minutes. Table 4.1 defines the address and data format of the clock registers in the WMATA data concentrator PLC. The data concentrator PLC shall set the escalator controller date and time every day at 3 AM.

**Table 4.1**

FUNCTION	ADDRESS	FORMAT
YEAR	N13:10	4 DIGITS
MONTH	N13:11	2 DIGITS
DAY	N13:12	2 DIGITS
HOUR	N13:13	2 DIGITS 24 HOUR
MINUTE	N13:14	2 DIGITS
SECOND	N13:15	2 DIGITS

#### 4. Data Concentrator PLC Program

The data concentrator PLC includes code to monitor up to 10 escalators and 5 elevators. Each escalators and elevators has an independent code file and a configuration bit. If an elevator is to be monitored the configuration bit must be set corresponding to the DH485 station address of the elevator controller. If the configuration bit is reset (0), the status and analog data table values for the elevator or escalator will be set to 0.

The configuration bits are as follows.

Escalator Configuration Bit	DH485 Address of Escalator Controller	Elevator Configuration Bit	DH485 Address of Elevator Controller
B9:0/1	1	B9:1/1	11
B9:0/2	2	B9:1/2	12
B9:0/3	3	B9:1/3	13
B9:0/4	4	B9:1/4	14
B9:0/5	5	B9:1/5	15
B9:0/6	6	B9:1/6	16
B9:0/7	7	B9:1/7	17
B9:0/8	8	B9:1/8	18
B9:0/9	9	B9:1/9	19
B9:0/10	10	B9:1/10	20

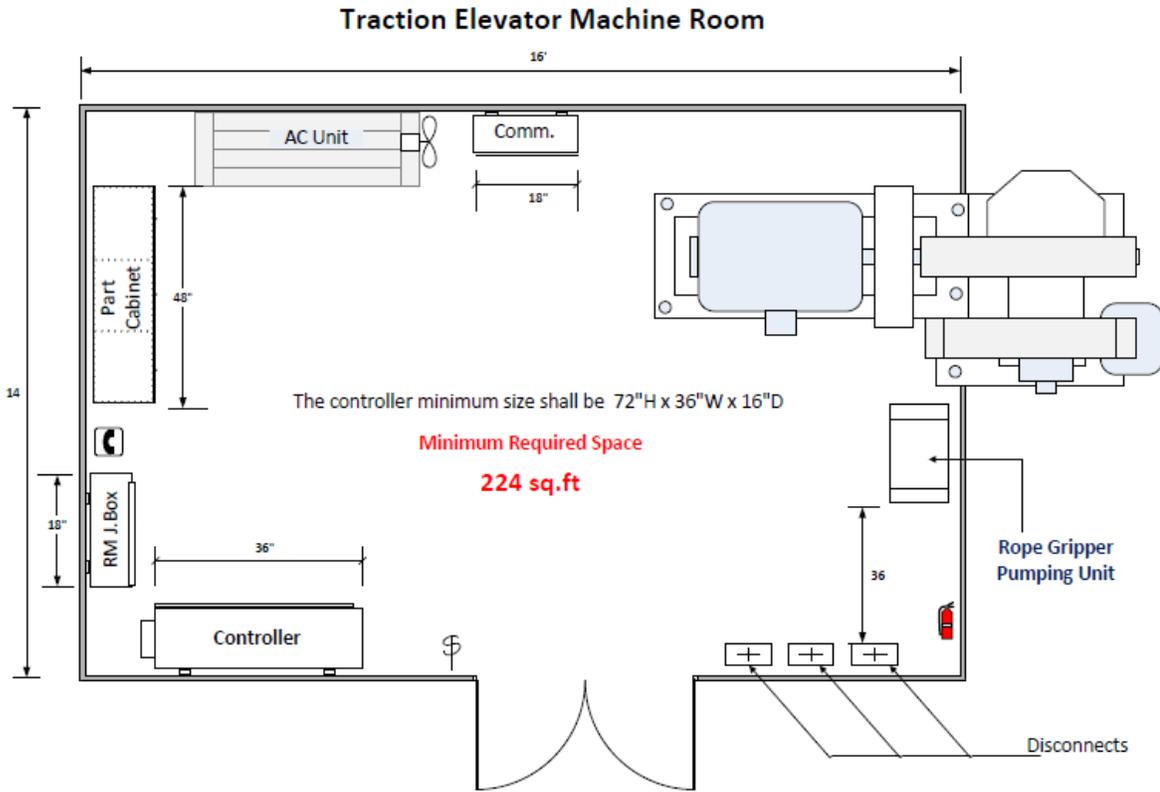
**3. Data Concentrator Gateway IP addresses.**

The Data concentrator PLC acts as a gateway between the Ethernet and DH485 networks. The PLC contains a list of IP addresses, known as the routing table which will be allowed access to the DH485 network. The routing table will contain 20 addresses.

Station	IP Address
1	TBD
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	

13	
14	
15	
16	
17	
18	
19	
20	

3.09 EXHIBIT 1. Traction (Basement or Side) Elevator Machine Room



END OF SECTION

**SECTION 14300  
HEAVY-DUTY ESCALATORS**

**PART 1 – GENERAL**

**1.01 DESCRIPTION**

- A. This section specifies work pertaining to the design, fabrication, and installation of heavy-duty escalators, designed specifically for heavy rail transit system use.
  
- B. The following sections include related requirements and are performed by other trades:
  - 1. Specifications Section 02000 – Site Construction
  - 2. Specifications Section 05000 – Metal Fabrication
  - 3. Specifications Section 08800 – Glass and Glazing
  - 4. Specifications Section 09920 – Painting
  - 5. Division 7 Section “Waterproofing” for water proofing of escalator pit
  - 1. Division 15 Sections for heating, ventilating and/or air conditioning of escalator controller room.
  - 2. Division 16 Sections for electrical service to escalator equipment, fire alarm systems and communications systems.
  
- C. Definitions
  - 1. The WMATA escalators included in this Specification are classified as "Class A" or "Class B" which corresponds to the designations applied to the wellway structures. These are WMATA classifications, chosen for convenience to define machine installations having similar operating characteristics and ranges of vertical rise. The various classes and designation number of escalators are shown on the drawings.
    - a. Class A escalators shall have a vertical rise up to 24 feet nominal, three flat steps at the upper and lower landings, and rated speed of 90 to 100 feet per minute.  
A1: Not exceeding 20 ft. vertical rise  
A2: Over 20 to 24 feet vertical rise
    - b. Class B escalators shall have a vertical rise above 24 feet through 30 feet, and shall have four flat steps and a rated speed of 90 feet per minute.  
B1: Over 24 to 30 feet vertical rise

B2: Over 30 to 40 feet vertical rise

B3 escalators shall have a vertical rise above 40 feet through 60 feet, and shall have four flat steps and a rated speed of 90 feet per minute.

2. Heavy-Duty Escalators are defined as escalators designed specifically for heavily traveled, heavy rail transit system usage according to the structural and operational parameters defined herein and substantially more robust and superior to commercial units in the design of truss, machine, steps, step chain, and step chain tensioning device. Minimum design life shall be 30 years based on maximum loading conditions of (320 pounds per exposed step) for 75% of the operational hours.
3. The Working Point is the point of intersection of the step nosing line and the horizontal projection of the top of the landing plates. The landing plates shall be horizontal and shall be at the same elevation as the finish floor at the point of intersection with face of the truss bearing plate. This should not be confused with a working point internal to the escalator that is used by escalator installers to align the components, which is different from the previous building reference point.
4. Flat steps: The number of flat steps specified shall be measured from the point where the comb teeth join the comb plate in a horizontal direction to the first exposure of the riser of an adjacent step at the upper and lower landings.
5. Step width: The horizontal distance between skirt panels.
6. Escalator support: These are the upper, lower, and intermediate supports needed to support the total loads of the escalator.
7. Noncombustible materials are those materials that meet the requirements of the National Fire Protection Association (NFPA), Fire Protection Handbook, and for applicable plastics, Underwriters Laboratories (UL)-94HB.
8. Final Acceptance: The point at which the owner accepts the escalator project as being complete including all submittal requirements. This may be a different point in time than substantial completion.
9. Interim Maintenance: Maintenance from the point of substantial completion, but prior to Revenue Service.

10. Beneficial Use: When the escalator is placed into service, may be prior to the site being ready for public use.
11. Revenue Service: The station or facility opening date.
12. Notice to Proceed (NTP): within this document shall mean the date which the escalator installer is notified to proceed with the project.
13. MSDS - Material Safety Data Sheet.
14. BOM - Bill of Material
15. SMNT - Systems Maintenance (WMATA)
16. WMATA: Washington Metropolitan Area Transit Authority.

## **1.02 QUALITY ASSURANCE**

- A. Codes, Regulations, Reference Standards and Specifications.
  1. Comply with codes and regulations of the Authority Having Jurisdiction. The American Public Transportation Association (APTA): Heavy Duty Transportation System Escalator Design Guidelines.
  2. American Society of Mechanical Engineers (ASME) A17.1 Safety Code for Elevators & Escalators and A17.2 Guide for Inspection of Elevators, Escalators and Moving Walks.
  3. WMATA Design Criteria requirements indicated in Section VI-Mechanical.
  4. American Institute of Steel Construction (AISC).
  5. American Iron and Steel Institute (AISI).
  6. American National Standards Institute (ANSI): C80.1
  7. American Society for Testing and Materials (ASTM): A36, A123, A167, A240, A276, A312, A325, A385, A490, A500, A501, A525, A653, B3, B8, B108, B221, D471, D635, D1056, D2628, E84, E136.
  8. American Wire Gauge (AWG).
  9. Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG).
  10. American Welding Society (AWS): D1.1.
  11. Environmental Protection Agency (EPA).
  12. Federal Transit Administration (FTA)

13. International Code Council (ICC) – International Building Code (IBC).
14. Institute of Electrical and Electronic Engineers (IEEE): 1202.
15. National Association of Architectural Metal Manufacturers (NAAMM): C54, C55.
16. National Institute of Standards and Technology (NIST).
17. National Electrical Code (NEC).
18. National Electrical Manufacturers' Association (NEMA): WC 70, KS 1, AB 1, 250, PB 1, MG 1.
19. National Electrical Safety Code (NESC)
20. National Fire Protection Association (NFPA): NFPA-130-2003.
21. Occupational Safety and Health Act (OSHA).
22. Society of the Plastics Industry (SPI).
23. Underwriters' Laboratories, Inc. (UL), UL-94HB, 6, 50, 62, 98, 360, 486, 489, 514, 1591.
24. United States Department of Transportation (DOT).

These specifications are not to be construed as supplanting any code requirements.

Any additional requirements imposed by local agencies and/or codes having jurisdiction shall be incorporated into escalator installation.

In the event of a conflict between codes, regulations, these specifications or standards, the most stringent requirement as determined by the Contractor and approved by the Authority shall take precedence unless specifically addressed herein.

- B. In addition to the Design Submittal Requirements, the Contractor shall comply with the following:
  1. Escalators shall be installed by the manufacturer.
  2. The Escalator Contractor shall obtain all permits and licenses and perform all required inspections.
  
- C. Quality Assurance:
  1. The escalator contractor shall guarantee the materials and workmanship of the apparatus furnished under these specifications and will make good any defects not due to ordinary wear and tear or improper use or carelessness, which may develop within two (2) years from date of completion of each escalator, inclusive of labor and traveling expenses. Defective work shall be repaired or replaced at no additional cost to the Authority.

2. Welding: Welding shall be performed in accordance with the requirements of AWS or CWB Welders shall produce evidence of current certification by AWS or CWB.
  3. Labeling Requirements: Every escalator shall be clearly marked with rated load and speed, manufacture serial number and the designated Authority identification.
    - a. All escalators shall be permanently numbered with number designations corresponding to the indications on the kiosk annunciator panel. A station sketch showing the escalator numbers shall be submitted for WMATA ELES Engineering. The escalators shall be numbered in sequence, starting at the north entrance left to right facing to the escalator at each station and proceeding clockwise around the station. The numbering shall proceed into the station toward the end of the platform. Corresponding numerical identification shall be affixed to the equipment in the machine rooms. The escalator numbering shall be approved by the ELES Engineer.
- D. Certification:
1. Certificates of inspection and acceptance issued by jurisdictional authority.
  2. The Acceptance Inspection (Specifications and Code) by the Office of Elevator and Escalator (ELES) Services shall take place prior to the Final Acceptance Inspection by the Jurisdictional Authority, and the escalators and associated equipment shall be free of defective material, imperfect work and faulty operation. All defective work shall be repaired or replaced at no additional cost to the Authority prior to the Final Acceptance Inspection by the Jurisdictional Authority.

### **1.03 SUBMITTALS**

Submit the following for approval in accordance with the Contract Documents and with the additional requirements as specified.

- A. Product information shall be submitted in both hard copy and electronic copy (compact disc) format, and shall include the following:
  - 1. Manufacturer's design data, material specifications, drawings, installation and maintenance instructions, and other data pertinent to the components used in the escalator systems, including, but not limited to, detailed repair data for all components, including disassembly, inspection/gauging/torque requirements, reassembly, testing and other related information. Submittals shall cover all mechanical components, operating panels and indicators and electronic equipment to control and monitor escalator control functions. Exploded view drawings shall be included to facilitate repair and maintenance functions. Calculations for sizing motors, brakes, chains, etc. shall be included to document the designs conformance with the criteria.
  - 2. Loads on supporting members, reaction points, and deflections under varying loads.
    - a. Loads imposed on the structure shall be coordinated by the Contractor and not exceed limits established by the final structural design. This requirement shall be verified, documented, and stamped by a registered Professional Engineer in the Commonwealth of Virginia in accordance with the regulations of the Virginia Department of Professional and Occupational Regulation's Board for Architects, Professional Engineers, Land Surveyors, Certified Interior Designers and Landscape Architects (APELSCIDLA Board). Supporting calculations shall be provided for record file.
  - 3. Step chain details for material, configuration, arrangement, and lubrication requirements.
  - 4. Lubricants, sealers, paints and any other potentially hazardous substances are subject to review and approval by the Authority. All necessary Material Safety Data Sheets shall be submitted.
  - 5. Truss split detail drawings, associated design calculations and split torque settings.
  - 6. Dimension of the truss including the top and bottom pit area.
- B. The contractor to provide detailed drawings that shows the dimensions, tolerance and specification that may include the material specification, hardness or electrical rating for each component that is being used. In

regards to assemblies they must provide a top level drawing with BOM and quantities with detailed material specifications and drawings with dimensional tolerances. The contractor also to provide as-built CAD models of all escalator components.

Shop drawings and samples shall be submitted in both hard copy and electronic copy (Flash Drive/CD) format, and shall include but not be limited to the following:

1. Drawings required to interface the escalator installation with other work.
2. Fully dimensioned layout in plan and elevation indicating component locations, structural supports, access spaces, and points of entry.
3. Drawings and cut sheets covering drive motor, controller, and safety devices and switches including brakes.
4. Complete layout of electrical system including motor; control panel; disconnect switches; panel boards, truss lighting, light fixtures and light switches; receptacles; and safety, surveillance, and control devices. Schematic diagrams including single line power diagram of the escalator system, control wiring diagram and sequence of operation, interface connections with remote surveillance and control system.
5. Truss reaction loads with design calculations: Signed and sealed by a structural engineer licensed in the Commonwealth of Virginia.
6. Dimension of the truss including top and bottom pit area.
7. Other drawings, reports, and samples are specified in appropriate articles of this specification section.

C. Reports:

1. Five copies of a reliability and maintainability demonstration report. This report will document compliance with reliability and maintainability requirements specified herein by means of
  - a. Inspection
  - b. Verifiable engineering analysis,
  - c. By static and dynamic testing, and
  - d. By analysis of field operational data.

The Contractor has the option to conduct test as a part of the factory "type" testing if certification of equivalent performance of the completed installation is provided by the Contractor. Prior notice shall be provided (two weeks minimum) to allow Authority representatives to witness testing and demonstrations. Submit the report no later than 90 calendar days prior to Final Acceptance. All reliability and maintainability documentation is subject to approval by the Authority.

2. Results from tests specified in Section 3.04.
3. Failure Mode and Effects Analysis: Provide five copies of a Failure Mode and Effects Analysis for all escalator safety circuits and components, including but not limited to steps, axles, brakes and step and axle rollers and any other components which could affect rider safety.

**D. Samples**

1. Three of each of the following samples shall be submitted for approval in accordance with the Design Submittal Requirements.
  - a. Stainless steel cladding: 12 inches square of thickness and finish specified.
  - b. Landing Plate: 12 inches square in the color and finish to be supplied.
  - c. Handrails: 12 inches long exposing non-separating stainless steel mesh core laminated within the handrail structure.
  - d. Comb Plate: 42 inches long.
2. One of the following samples shall be submitted for approval in accordance with the Design Submittal Requirements.
  - a. Step: Sample size adequate to show tread, riser, cleats, nosing, and black powder based baked on enamel paint.

**E. Operation & Maintenance (O&M) Manuals.**

**Manuals and Catalogs:**

The O&M Manual shall be submitted to the WMATA/ELES Engineer for the approval.

1. The maintenance and repair manuals, hardbound and indexed, shall be furnished, in a minimum of four volumes as follows:
  - a. Wiring Diagram Manual with page size of 11 inches by 17 inches.
  - b. Maintenance and Renewal Parts Catalog with page size of 8-1/2 inches by 11 inches.

Six sets of the approved manuals, escalator installation, operation instructions, troubleshooting techniques and related equipment drawings and software (all publication must be in English) – two copies of which to be delivered to the WMATA/ELES Engineer representing of the Authority prior to installation. Each binder shall has the Binder Cover and Spine Insert which contain the Station Name and Unit ID.

Submit an additional electronic copy on Flash Drive(s)/CD(s). The Information shall be saved/presented as follows:

- c. Text in Microsoft Word “.doc”, “.pdf”, or approved alternative formats.
  - d. Graphic images in ".tif" or ".dwg" AutoCAD formats.
2. All publications shall be in loose-leaf form, on 30-pound paper and with punch holes reinforced with plastic, cloth or metallic material.
  3. All covers shall be resistant to oil, moisture, and wear commensurate with their intended use. Diagrams and illustrations shall not be loose or in pockets. All printed material shall be capable of being reproduced on dry copying machines.
  4. Each escalator shall be treated as a whole and not as a grouping of disassociated parts. The material in the Wiring Diagram Manual shall be organized and indexed by the escalator classifications included in this Specification. All manual sections shall be subdivided, to the extent required by the subject matter, and shall include, but not necessarily limited to the following topics:
    - a. General system or sub-system description and operation.
    - b. Block diagrams.
    - c. Functional schematics.
    - d. Replacement and step by step adjustment procedure for all components and systems.
    - e. Recommended measurement values such as torque and pressure.
    - f. Functional wiring diagram.
    - g. Lubrication and cleaning, including frequency, methods, and trade identifications of recommended materials.
    - h. Component location and description.
    - i. Inspection and maintenance standards including wear limits, settings, and tolerances.
    - j. Installation and removal sequence.
    - k. Test and evaluation procedures.

- I. Spare parts lists and special tools.
5. The O&M manual shall only contain information related to equipment installed under this contract. Generic information that does not pertain to the equipment installed shall not be included. Scanned documents are not allowed. The fonts should be standard format. The manuals shall be prepared to help WMATA/ELES personnel who perform maintenance, service and repair on the equipment's installed under this contract.
6. The detailed contents of sealed assemblies need not be displayed but their functions must be explained and the appropriate operational specification characteristics listed as well as procedures for test and replacement.
  - a. Maintenance and Renewal Catalog and Wiring Diagram Manual shall contain all the information needed to sustain optimum operation. It shall include general familiarization material; location, function, and operation of all controls, gauges, indicators, and switches; emergency procedures; and trouble diagnosis methods.
  - b. The manual shall be logically organized with systems and elements considered in descending order of importance.
  - c. The Catalog and Manual shall provide, in convenient form, all the information needed for servicing, including lubrication, inspection, running, maintenance and adjustment, and on-line trouble diagnosis.
7. Repair and Maintenance Section shall contain a complete functional description of each component of the escalator likely to require repair and complete procedures and step-by-step guide for the repair and overhaul of the escalator and all components.
  - a. The manuals shall include all measurements for clearance, gap, and torque readings.
8. Four copies of the complete draft copy of each publication shall be submitted for approval at least 60 days prior to the date of acceptance testing of the first escalator.
9. Each year, for a period of five years, on the anniversary of the Final Acceptance date, the Authority shall be provided with the revised catalog and manual pages encompassing all changes to the appropriate escalator models, including modifications of all parts. If no changes occur, the Authority shall be informed in writing on each date the pages are due for submittal.
10. Manuals shall include the following data:
  - a. Table of Contents.

- b. Contractor's name, address and telephone number with similar data for his 24-hour service organization.
  - c. Manufacturer's name, address and telephone number, with similar data for his local representative, distributor and service agency.
  - d. Catalog, model and serial number of equipment installed. Include WMATA unit numbers where applicable.
  - e. Description of equipment.
  - f. Statement of warranty as specified.
  - g. Description of modification, service and repairs performed prior to start of warranty.
  - h. Dates warranty begins and expires
  - i. Standard starting, stopping and operating procedures for escalator sequence of operation.
  - j. Emergency and special operating procedures.
  - k. Routine maintenance procedures.
  - l. Servicing and lubrication schedule.
  - m. Manufacturer's printed operating and maintenance instructions, manufacturer's parts list, illustrations and diagrams.
  - n. One copy of each wiring diagram.
  - o. List of spare parts, prices and recommended stock quantities for routine maintenance of the equipment for one year and list of spare parts that are considered critical and for which extended time frames for acquisition would create undesirable down-time for the equipment.
  - p. List of special tools required to perform inspection, adjustment, maintenance and repair. Special tools are those developed to perform a unique function related to the particular equipment and are not available from commercial sources. One set of all special tools shall be provided for each escalator. No special tools with decaying circuits or disabling clocks are permitted.
  - q. Copy of each approved shop drawing of the equipment and system. Include drawings which show outline dimensions, weights and assembly data: do not include drawings which show manufacturing details.
11. Four sets of full-size laminated electrical wiring drawings shall be provided for each escalator.

All of the above referenced shall be provided as it pertains to the original installation and for a period of ten (10) years after final acceptance of the escalator. During a ten (10) years period, In case of any items are obsolete or no longer available from the manufacturer the Escalator Contractor shall provide the alternative products.

- F. Manufacturers recommended spare parts list.

#### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING**

- A. Deliver materials to site in original unopened moisture proof containers clearly labeled with manufacturer's name, type, grade and color.
- B. Provide setting compound and sealant materials with labels certifying compliance with specifications and that they are of the types recommended by manufacturer for this application.
- C. Store materials on pallets so as to prevent damage and moisture penetration. Materials shall be stored in a clean, dry area.
- D. Handle materials so as to prevent breakage of containers and damage to materials.
- E. Do not work with flammable materials such as polyurethane adhesive components or keep such materials on the WMATA property during revenue hours. Deliver quantities of such materials as are needed for the day's work, and remove any excess from the WMATA property before revenue hours begin. Acquire permits for the use of flammable materials as required by jurisdictional Fire Marshal.
- F. Protect setting compound and sealants from freezing or excessive heat. If necessary, provide heated, dry storage facility.

#### **1.05 SYSTEM DESCRIPTION AND PERFORMANCE REQUIREMENTS**

- A. Design Requirements:
  - 1. Escalators shall be heavy-duty type, designed specifically for the operating; loading and environmental conditions encountered in extensively used, heavy-rail transit systems and shall have a minimum design life as previously defined.
  - 2. Each escalator shall be of a 48-inch nominal width (40-inch step width) and be designed for an incline of 30 degrees from the horizontal.
  - 3. In all design, fabrication, and purchasing, the interchangeability of equipment shall be given maximum consideration.

4. The drive mechanism, step drive unit assembly, motor, steps, step chains, comb plates, handrails, handrail drive units, and any parts subjected to wear or frequent removal shall be readily and easily removable and replaceable without requiring any rigging, modification or alteration of escalator structure, station structure, or equipment.
    - a. Access for all maintenance actions must be available from the step area between the balustrade panels, from the machine room and through the landing plates.
    - b. Standard items such as, but not limited to, steps, comb plates, axles, safety devices, controllers, locks and keys, rollers, handrails shall be interchangeable within each class and may be interchangeable between classes within a single manufacturer to the greatest extent possible.
  5. On parts of equipment subject to wear and requiring periodic replacement, provide key and seat, nut, screws, or other removable and replaceable type mechanical fasteners.
    - a. Such replacements shall not diminish original structural integrity.
    - b. Use of rivets or similar type fasteners requiring physical deformation during field positioning will not be permitted.
    - c. All gaps and running openings within structural design tolerances where the escalator structure meets the surface of the finished openings shall be properly closed by the use of polyurethane sealant as specified or other approved means installed in accordance with the manufacturers' instructions.
  6. Components and materials, except for handrails and step wheels, shall be noncombustible and shall meet the requirements UL-94HB. The equipment shall be quiet and smooth running and be capable of withstanding the operating conditions hereinafter described.
  7. Surface irregularities, sharp edges, or protrusions in public and maintenance areas will not be permitted.
  8. There shall be a work area on top and bottom landing pit. This area should be a minimum of 42" X 30" starting from end of the steps.
- B. Structure Dimensions:
1. Escalators design shall be coordinated with the final architectural and structural design, and escalators shall be fabricated to fit within the structures as dimensioned on the drawings.

NOTE: That the dimensions given on the drawings are designed dimensions. The contractor shall verify all dimensional after construction of decks prior to final shop drawings, fabrication, delivery and installation of trusses.

- a. All field-verified structural dimensions which do not conform to the drawings shall be identified to the Authority so that contractor's corrective action can be reviewed and approved.
  - b. If the wellways are not available at this time for dimensional survey, the escalators shall be designed and fabricated in accordance with approved structural shop drawings.
2. Refer to the drawings showing the location of the working point placement. Note, the station construction drawings have placed the working point of all the escalators on the finished floor line, thus causing the upper and lower landing areas to slope away from the escalators.
  3. The escalators shall be installed under canopies. The Escalator Contractor shall verify the size and location of each canopy prior to the delivery of truss to insure that the fabricated escalator can be installed and also removed for future maintenance or replacement.
  4. In the event of a discrepancy, Contractor shall notify the Authority immediately, and shall not proceed with installation in the areas of discrepancy, until the discrepancy has been fully resolved, and the Authority has instructed Contractor to proceed. Failure of Contractor to report discrepancies shall constitute an acceptance of existing work as fit and proper for the execution and completion of Contractor's work.
- C. Truss Supports:
1. The station structures shall have supports of adequate strength for the truss installation at the upper and lower landings of the wellway. The supports are to be provided with I-beams or bearing plates of steel eight inches wide for the full length of the support surface, for attachment of escalator truss mounting angles by the Contractor. All angles or support bearing plates shall be galvanized paint.
  2. The loads shown on the drawings were computed for heavy-duty, transit system type escalators as specified. The escalators will have the drive motor assembly mounted within the truss or truss width dimension in the flat step and pit area, cage or wellway.

3. The total live and dead load reactions imposed by the escalator assembly, the remote machine loads, and the drive assembly reactions shown on the drawings shall be verified by the Contractor. The Contractor shall prepare calculations for the escalators and submit to the Authority for approval.
- D. Truss:
1. Verify field dimensions when possible of wellways prior to fabricating trusses. Structural trusses shall be designed and fabricated in accordance with the requirements of the most stringent applicable code, and as specified. The width of trusses shall be sufficient to afford a width of the finished escalator of not less than a nominal 40 inches between the skirt panels as defined in ASME A17.1. Deflection under full load, including 320 pounds live load per exposed step, shall not exceed 1/1000 of the intersupport distance.
  2. The truss shall be of sufficient total length to allow for the track radii between the 30 degree angle and the horizontal portion of the truss and the minimum number of flat steps. Provisions shall be made for the thermal expansion and contraction of the complete escalator assembly due to changing ambient conditions. The truss shall be fabricated by welding.
  3. Field splices, where necessary, shall be made with drive fit bolts in reamed holes. Punched holes of proper size shall be provided for attaching the balustrade securing brackets. Field modification of these holes by burning will not be permitted.
  4. The truss shall rest on the top and bottom support beams and the intermediate support recesses provided in the wellway structure.
    - a. Trusses shall be of ample strength to rigidly maintain the alignment of tracks and moving parts and shall be so designed that they will safely retain the steps and running gear, and in case of failure of the track system, retain the step mechanism within the guides and envelope of the individual truss.
    - b. Intermediate supports shall be of the stub column and beam type bolted or welded to the wellway structure. The stub columns may be welded to the truss. All intermediate supports shall be galvanized paint.
    - c. The trusses shall be supported using these supports, to suit the installation. No other attachments to the structure will be allowed.
    - d. All truss mounts, including bolts, angles, shims, bearing pads, and spring supports shall be provided and installed to properly install and align the escalator.

- e. All support points shall be shop coated with galvanized paint prior to truss installation and touched up, if required, after the truss installation.

**E. Drip Pans:**

1. Galvanized steel, welded, oil tight drip pans shall be provided in the truss, for the entire length and width and shall be of sufficient strength to support a concentrated load of 500 pounds on any portion of the drip pan. Material of pan shall be 0.125 inch minimum thickness.
2. Drip pans shall be of a sufficient size to collect and maintain, within the truss area, all oil, water and grease droppings from the step chain and all forms of loose debris that may be deposited in the drip pans from the steps at the turn-around point at the upper and lower portions of the truss.
3. An access shall be provided to the drip pans at the lower landings of all escalators for cleaning the drain catch basin.
4. The drip pans in the upper landings of escalator wellways shall be removable for cleaning, or be otherwise accessible for easy cleaning.
5. Drip pans on exterior escalators shall be designed to collect and drain off all water which may enter through the exposed portions of the escalator, including landing and floor plates. The drip pan in the upper truss section shall be sloped to drain water down the sloping portion of the drip pan to the lower pit. The upper portion of the drip pan shall not be provided with a drain outlet.
6. No transverse bracing shall be placed on the interior surface of the drip pan. Supporting elements impeding drip flow and clean down shall not be permitted.
7. A manual or mechanical method for clearing/cleaning the drip pan shall be provided. Cleaning requirements also apply to longitudinal drains pans (if used).
8. At truss splits, appropriate sealing of drip pans shall be performed.
9. Any screws at splices that protrude below the pan shall be cut flush if the area below is accessible.

**F. Tracks:**

1. Tracks shall be designed and fabricated to safely support, and retain the steps, step rollers and running gear under the maximum load requirements at the highest design speeds specified and under any lateral movement. Sections of track shall be assembled and secured together in a manner that permits easy removal and replacement of defective sections. The design shall permit easy installation and removal of mechanical components without dismantling any part of the truss or building structure.
2. The rolling surface of the track shall be a minimum of 0.12 inch (3mm) thick or of a thickness to provide equivalent strength, safety and rigidity relative to the complete track assembly.
3. Tracks shall be properly supported on trusses to provide correct alignment and smooth, even operation of the running gear. Track shall be fitted with guides to insure proper alignment of steps through the turn around.
4. The radius of the upper transitional tracks shall be determined in conformance with the following constraints:
  - a. A minimum radius of 8 feet- 6 inches for vertical rise less than 10 meters, and a minimum radius of 8 feet-10 inches for vertical rise greater than 10 meters.
  - b. The requirement for the number of flat steps is met in all cases.
  - c. Verify that track loading and wheel size is such that interaction force between each wheel and track shall permit escalator to meet the reliability and maintainability requirements specified herein.
5. The radius of the lower transitional tracks shall be a minimum of 6 feet-6 3/4 inches for Class B units and 4 feet-11 inches for Class A units.
6. It is the intent of these provisions to limit the maximum effect of acceleration on passengers due to radius of curvature of track, consistent with a design for good longevity of wheels and tracks.
7. The step roller/wheel tracks shall be sectional elements of structural steel throughout the truss, incline and transition curves at the upper and lower landings in order to restrain the lateral displacement of the steps, ensure rollers/wheels are retained in their proper position on the track and to provide a smooth ride without discernible vibration.

8. The tracks shall be constructed of drawn steel or other alloy of proper rigidity and strengths and shall be installed and supported to ensure correct alignment and smooth operation of the running gear. All tracks shall have a smooth finished track surface. Means shall be provided to positively ensure the forming of steps before the 30 degree run and flattening of the steps. The unit design shall be such that vibration levels are less than 0.4 inches per second as measured by Bruel and Kjaer model 2516 integrating vibration meter. Readings shall be taken throughout the exposed travel of steps.
- G. Escalator Enclosure:
1. On completion of all work, the finished escalator installations shall be completely barricaded and enclosed to preclude their use without permission until Final Acceptance and release for general use by the jurisdictional inspector and the Authority inspector. The enclosure shall be fabricated in a manner to allow easy access by authorized persons for maintenance, testing, and adjustment, and shall be removed when directed by the Engineer.
- H. Step Chains:
1. Two-step chains of the endless type shall be used, one on each side of the steps.
  2. Each pair of step chains shall be exactly the same length. Only precision roller fish plate chains of high grade, heat treated steel shall be used as step chains. The pins, axles, bushings and rollers shall be hardened and ground.
  3. The breaking factor of safety of a step chain defined as a ratio of chain breaking load to chain traction force, must be a minimum factor of safety of six based on a load of 320 pounds per step.
  4. Pins:
    - a. Pin diameter shall be 5/8 inches (15.875 millimeters) minimum.
    - b. Pin shall be case hardened, with tensile strength suitable for the application.
    - c. Pin pressure shall not exceed 4351 psi (30 N/mm<sup>2</sup>) for standard escalator step chain bushings or 2320 psi (16 N/mm<sup>2</sup>) for polymer non-lube bushings.
  5. Each lot/load of step chain shall be certified by the manufacturer that the step chain meets the requirements of this Contract by design, function and materials.

6. Provisions shall be made to prevent sagging or buckling of the step chains, to prevent steps from coming in physical contact with one another, and to maintain a constant distance between the step axles.
  - a. Automatic tension devices shall be provided to maintain tension under load and to compensate for wear.
  - b. Each step chain shall have a provision for individual fine adjustment of tension.
  - c. The step chains shall be designed and constructed in a manner that permits the removal of a segment, as may be required for replacement purposes.
  - d. Step chains shall be positively guided at the lower and upper landing turnarounds to prevent chordal action and resultant vibration and wear.
  - e. Material, configuration, arrangement, and lubrication requirements shall be submitted for approval.
  - f. Support wheels shall be spaced to distribute the load and to guide the step chain throughout the run, and shall be constructed of a polyurethane material, or equivalent, with a diameter sufficient to provide the reliability, maintainability, and smoothness of motion and noise level specifications contained herein.
    - 1) 4 inch nominal (100 mm) diameter wheels shall be affixed in a manner that ensures positive wheel retention but allows for replacement without dismantling chain link assemblies.
    - 2) Wheel foot print width shall equal wheel width at the hub.
- I. Steps:
  1. Step assemblies shall be cast aluminum. .
  2. The design of the steps and their various attachments shall be such as to permit ready removal of the steps at the upper and lower landings without disturbing the balustrades or dismantling any part of the step drive system.
  3. The design shall permit running the drive without steps or with a minimum of number of steps for convenience in cleaning and inspection.
  4. Color:

- a. Steps shall be aluminum color on the tread and riser surfaces on both raised and recessed portion of the surface; black riser surfaces are acceptable if approved.
  - b. On the step nose, a strip 2 inches wide on the tread and one inch wide on the riser shall be black powder based baked on enamel paint on the recessed portions only of the surfaces.
  - c. Per ASME A 17.1, there shall be demarcation lines on the step tread along the back of the step to delineate the division between steps. These lines shall be marked by a yellow strip a minimum of 1.5 in. and a maximum of 2 in. in width.
  - d. Per ASME A 17.1, there shall be demarcation lines on the step tread along the sides of the step. These side lines shall be marked by a yellow strip a minimum of 0.5 in. and a maximum of 2 inches in width.
5. Steps shall be constructed to be driven by step chains in a manner that will not transmit any of the strain in the step chain to the step.
  6. Lock washers shall be used on all tap bolts, and lock washers and lock nuts or an approved alternative shall be on all through bolts.
  7. Step guides and skirt panels shall be designed to be sufficiently adjustable to meet and hold maintenance adjustment requirements for the life of the unit. The design goal for skirt panel adjustment shall be 3/32-inch clearance between either side of step and its adjacent skirt, with a maximum allowable not to exceed 3/16-inch.
- J. Risers:
1. Risers shall be slotted and designed to interlock and mesh with adjacent step treads to minimize seizure of articles between the riser of one step and the tread of the following step.
- K. Treads:
1. Step treads shall be die-cast aluminum, cleat type, with sound deadening coating at the underside of tread, designed to assure a secure foothold and a comfortable tread surface and shall be an integral part of the step assembly.
  2. Step treads shall have 1/8 inch wide cleats on 3/8 inch centers, not less than 3/8 inch in-depth and shall be designed to mesh with the comb plates.
  3. Step treads shall have a chamfered or radius nosing of 1/8 inch at the riser edge of the tread.
  4. Casting drafts shall be eliminated by machining, grinding or other mechanical means.

L. Wheels:

1. Step wheels shall have 100 percent pure virgin polyurethane tires on a sealed hub and bearing. Step wheel bearings shall be of the ball or roller-type, factory-sealed and self-aligning. Bearings shall be rated for severe heavy-duty service, be of the best quality available, and shall be subject to the Authority approval. Four-inch nominal (100mm) diameter wheels shall be located and arranged so as to prevent tilting and rocking of the steps.

M. Comb Plate Assembly:

1. The comb teeth assemblies of the comb plate shall be of a highly wear-resistant, noncorrosive material, with an anti-slip surface.
2. Comb teeth assemblies of the comb plate shall be bright yellow in color and shall clearly contrast with any step demarcations required by code. Finish shall be baked enamel. No plastic comb plates shall be permitted.
3. Comb teeth shall be designed as removable sections, to permit easy replacement without the aid of special tools or equipment. Each assembly shall have a minimum of three and no more than seven comb teeth sections.
4. A method of fine lateral and vertical adjustment of the comb teeth sections shall be provided so that the cleats of the step treads will pass between the comb teeth with minimum clearance. The teeth shall be designed to engage the treads on the escalator steps in such a manner as to reduce to a minimum the dangers of injury to passengers, and prevent breakage and wear of comb teeth caused by interference with step treads.
5. The comb teeth shall be adjusted according to ASME A17.1, but in no case shall the penetration be less than 3/16- inch into the step tread.
6. Two individual safety switches shall be employed for comb impact device assembly on each side of the comb plate landing. One switch and a spring are for vertical force activating device adjustment and the other switch for horizontal force activating device adjustment. These two switches should have a separate spring for adjustment. The vertical tripping force and the horizontal tripping force should be able to adjust independently to maximum allowable force.

**N. Landing Plates:**

1. Landing and floor plates shall be furnished and installed by the Contractor to cover the entire areas of the upper and lower landings. A frame around the floor openings shall be provided to receive the landing and floor plates. The upper edge of the frame shall enclose the open pit space, be at the elevation of the finish floor and be contiguous with the finish floor.
2. Landing and floor plates shall be reinforced to be rigid. Exposed portions of the landing and floor plates shall be of a material and finish to harmonize with the steps and comb plates. All landing plates shall be sufficiently lightweight and removable, or hinged, for easy access to the machinery and maintenance areas below, and designed in sections of a size and weight capable of being handled by an average person. Landing plate fasteners shall be readily removable by maintenance personnel.
3. The landing plates and floor plates shall be of a wear-resistant, noncorrosive material with an anti-slip surface. The anti-slip surface shall be American Safety Technologies Inc. AS-250 or equivalent and shall be designed for a live load of 250 pounds per square foot. The landing plate shall be installed flush with the adjacent floor area. Deflection with maximum load shall not exceed applicable code. The landing and floor plates of all escalators shall be coated with AS-250, applied per written manufacturer's recommendation, black in color stopping 2 inches from the combplate.
4. Upper and lower landing plates of each escalator installed in Class A escalator shall have access provided as an integral part of the plate. The supplier shall demonstrate the adequacy of the proposed access to the satisfaction of the Authority.
5. In cases where two or more escalators are installed side-by-side, landing plates shall be designed to allow adjacent escalators to remain operational while work is being performed on an escalator.

**O. Metal Balustrades, Newel Panels, Skirt Panels and Decking:**

1. Surface panels shall be type 316 stainless steel and at least 0.075-inch (2 mm) thick. The panels shall be reinforced to withstand the specified loads/forces as specified in ASME 17.1. Skirt panels shall match the balustrade panels.
2. Decking shall be reinforced metal with material and finish to match the balustrade and skirt panels. The finish of the face side shall be as specified in the escalator materials legend.
3. Moldings, trim, baggage stops and other miscellaneous metal items shall match the surface to which they are attached.

4. Edges of the balustrade and newel panels shall be sealed against moisture and shall then be framed within a welded aluminum "U" channel except for the facing section. Sections shall be made in equal lengths for interchangeability where practical.
5. The panels shall be designed and fabricated to permit easy removal for inspection, lubrication, and adjustment of safety devices located behind the panels. Panels shall be designed to be individually removable, without the need to remove any other panel.
6. Panels shall be fully engaged and seated in place properly. The top and bottom of each panel shall be covered a minimum of ½ inch to secure the panels and shall be free of rattles.
7. Removal or replacement of the panels shall not affect the escalator mechanical operation in any way. The panels shall be removable without the use of special handling equipment, and by not more than two persons. All panels shall be securely fastened to their respective supports or mating portions to ensure a secure installation resulting in flush surface.
8. Removal of the fasteners shall be with the aid of simple tools. When the framework to which the panels are fastened is less than 1/4-inch (6.35 mm) thick, steel backup plates 1/4-inch (6.35 mm) thick shall be added with tapped holes and clearance holes where necessary.
9. All paneling, decking, and other enclosures shall be supported on the steel framework. Wood or wood products will not be permitted for use in any part of the escalator.
10. The decking between escalators and deck extensions shall be free draining and shall be designed to support a live load of 100 pounds per square foot (489.3 kilograms per square meter), without "oil canning" of the surface or a deflection of greater than 1/200 of the span.
11. Details for the fabrication and application of baggage stops shall be as shown on the drawings and shall match current system design.
  - a. Baggage stops are used only at Double Escalator applications.
  - b. The baggage stop is a stainless steel disk, 2 inches in diameter and 2 inches high, fastened to the stainless cladding between escalators by machine screws.
  - c. Baggage stops are placed every 24 inches along the plate.
12. The balustrades and decking shall be designed and installed so that the interface to the adjacent wellway surfaces does not leave openings which would be in violation of applicable codes, or offer areas of potential entrapment or infiltration of foreign substances.

13. Shear guards of material matching the decking or clear lexan shall be provided in the intersecting angle of the outside balustrades and the ceiling or soffit where required in order to comply with applicable codes.
  14. Provisions for mounting information signs at the upper and lower landings of all escalators shall be made.
- P. Neoprene Joint Filler:
1. Lubricant-adhesive: One-part polyurethane, non-staining to adjacent surfaces, as recommended by joint filler manufacturer.
  2. Joint filler: Preformed polychloroprene or neoprene joint filler, sized for joint as required; ASTM D2628.
  3. Application: Prime and lubricate both sides of joint for adhesion of filler as recommended by manufacturer. Fill joint continuously with joint filler bonded together to form continuous strip.
- Q. Cladding and Base Plates:
1. Stainless steel cladding shall be solid as specified in Section 1.05 O, with a fully adhered 3/4-inch thick core of noncombustible, sound-absorbent material and backed with galvanized sheet steel, ASTM A525M, G90 coating or better.
  2. Base plates shall be finished to match the cladding and shall be laminated to reinforced, galvanized sheet steel backing 16-gauge minimum. Where sufficient rigidity is achieved and sound decibels are met, design may omit core of sound insulation and backing.
  3. Finish panels shall be as specified on the escalator materials legend.
  4. All panels shall be secured with concealed screws and shall be of such size and weight (less than 30 pound) that one mechanic can easily remove or replace a panel with the aid of simple tools.
  5. All sections shall be made in equal length for interchangeability where practical and for removal independently of the adjacent panels.
  6. All necessary steel framework and attachments shall be included for a complete installation.
    - a. All openings shall be provided in the above panels as shown on the Contract Drawings and coordinated with the trades.
    - b. The cladding shall be designed and installed so that the interface to the adjacent wellway surfaces does not leave any openings that would be in violation of applicable codes.

R. Sealant and Accessories:

1. Primer: As recommended by sealant manufacturer; tested for non-staining and durability characteristics on samples of actual surfaces to be sealed.
2. Solvents, cleaning agents and similar materials: As recommended by sealant manufacturer.
3. Backup material: Non-staining, compatible with sealant and primer; and resilient, closed-cell foam sponge rubber, tube or rod stock, ASTM D1056, Class SC-E, Grade SCE 41 for general use, Grade SCE 44 where sealant is subject to traffic.
4. Sealant: Polyurethane; single-component, FS TT-S-227, or two-component, FS TT-S-230; Type I, self-leveling for joints in horizontal surfaces; Type II, non-sag for joints in overhead and vertical surfaces. Color shall match color of surfaces being sealed.
5. Application: Apply products in accordance with manufacturer's printed instructions.

S. Handrails:

1. Handrails shall be of the traction-drive type, and have a return of 180 degrees minimum around the newel. Handrails shall receive their motion from the main escalator drive through direct gearing and drive shaft, auxiliary drive or drive chains designed so that the handrail and steps operate at substantially the same speed in either direction of travel. Handrail speeds shall be synchronized with step speed so that there is no more than plus or minus 4-inch displacement of the handrail with respect to the step in a full run in either direction. Separate or independent handrail drives are acceptable so long as the function specified and the applicable code requirements are met. Handrail lead or trail speed shall not exceed the tolerance defined in ASME A17.1.
2. Provide methods within escalator and approved by the engineer (1) to adjust the slack and tension in the handrail and (2) for releasing tension for repair or removal of handrails. Pre-tensioning of handrail to create traction on drive is not acceptable. Driving and guiding wheels shall be compatible with the design of the underside of the handrail.
3. The handrail drive mechanism shall be designed to operate without slippage under full load condition and, at minimum, maintain no less than 30 square inches of contact with the underside of the handrails at any time.

4. The surface of the newel base adjacent to where the handrail enters or leaves shall be at an angle of 90 degrees with the surface of the handrail. The newel shall be of an extended type designed and constructed in such a manner that the handrail will enter the newel end at a point inconspicuous and difficult for the passengers to reach.
5. Handrails, handrail drive systems and guides shall be so designed and installed that the handrail cannot be physically thrown off or disengaged while running, and special design attention shall be given to the area where the handrail passes from the drive system to the guides.
6. Handrail wheels, where used, shall have a bearing material or bearings that have provision for retention of lubricant to insure satisfactory lubrication and operation.
7. Friction drive wheels and idlers, where used, shall be designed and positioned in such a manner that lubricant cannot reach the surface of the handrail. Marking and spotting of the handrail by the drive equipment will not be permitted.
8. The handrails shall be constructed with non-separating stainless steel mesh core laminated with the handrail structure so as to be resistant to the environmental conditions set forth herein and the materials vulcanized into an integral, non-separating, seamless, smooth handrail.
  - a. A specially coated finish to minimize the frictional wear to the underside of the handrail shall be provided.
  - b. Hand rails shall contain no cotton and shall comply with Fire Protection guidelines specified in Section 1.05 W. 4.
9. The handrail guides shall be continuous on the exposed portion of handrail and shall be constructed of 316 stainless steel which shall not subject to corrosion or pitting, and shall have a polished or specially coated permanent finish to minimize the frictional wear to the under surface of the handrail.
10. Anti-static rollers to prevent static electricity shocks shall be provided at both top and bottom of the escalator. The color of the handrail material shall be black. The material selected for the handrail shall not be subject to swelling or other deformation when exposed to the environmental conditions given in Section 1.05 W. 7.

- T. Drive Units:
1. Mount motors and drive mechanisms within truss envelope and/or truss width if positioned below on the floor of the upper machine room. Use single-stage worm gear or planetary gear type drive machine designed especially for moving stair service, with means for determining oil level inside the case and for draining oil, driven by an electric motor, the speed of which shall not exceed 1800 rpm.
    - a. The drive machine shall be readily accessible without use of special tools.
    - b. The design of movable carriages shall be such that freedom of movement is maintained over the life of the escalator with proper maintenance.
    - c. Provisions to access the drive motor and gear boxes individually and also to replace them individually for maintenance and repair without any special equipment are required. The motor should have a bed plate or equivalent method for easy removal during maintenance.
  2. Design shafts, where possible, for ease of assembly or disassembly, without use of keyways.
  3. If chain drive is used between motors, reduction gears, or other drive mechanism:
    - a. Design shall have provisions for tensioning chain.
    - b. Drive chain must run in a safety housing.
    - c. Manual tensioning with automatic lubrication shall be provided.
    - d. Chain drive systems, where used, shall use double or triple strand roller chains for transmitting power from the step chain sprockets.
    - e. Step chains shall be driven by sprockets connected to the drive machine with a double- or triple-strand roller chain.
  4. Drive sprockets shall directly engage the step chain. Intermediate linkages or belt drives are not permitted in the power transmission members.
  5. If carriages are required for step chain tensioning, they shall be designed for continued free movement of the carriage under varying chain tensions and with a guide system which prevents skewing or crabbing as the step chain tension is modified. Provide mechanical adjustment and spring-operated device to aid in adjustment of tension. Provide carriages with scale and pointer on accessible section of carriage frame to indicate movement and amount of adjustment available.

6. Position scale and pointer to indicate zero for initial position of carriage, prior to placing in service.
7. The use of timing belts is prohibited.
8. Provide rotating parts with means for lubrication and retention of lubricants. Use sealed bearings in those environmental conditions where entry of water or dust may adversely affect bearing performance. Bearings shall be rated for severe heavy-duty service, shall be the best quality available and shall be subject to the Authority's approval. Protect exposed moving drive elements by removable sheet metal or wire mesh guard or shield assemblies designed to allow for free air circulation.
9. Means shall be install to detect excessive movement/worn on bearings for main drive shaft and carriage. The signals to controller should not affect the operation of the escalator, but just for alarm purpose.

U. Brakes and Sequence of Operations:

1. Each drive motor shall be equipped with one motor shaft brake, which is sufficient to dynamically stop (320 pounds per exposed step) and statically hold a fully loaded escalator (674 pounds per exposed step). This load shall not include any loads imposed by an operating escalator.
  - a. The deceleration rate shall be no greater than 3 feet per second squared in accordance with the ASME A17.1 code requirement.
  - b. Deceleration rate shall be adjustable to the maximum allowed by the Code.
  - c. The stopping distance shall be at least four inches less than the distance between the first skirt panel safety switch and the comb plate.
  - d. Under no load conditions, the escalator shall stop in a nominal 10-20 inches with a unit-to-unit variation of no more than 4 inches.
  - e. Brakes shall comply with the requirements of ASME A17.1.
2. Each escalator shall have the following brakes for the stopping and locking of the moveable drive components:
  - a. A motor brake shall be provided on the motor shaft for shutting down and holding the escalator with the full specified loads upon activation of either
    - 1) Normal stop control,

- 2) Emergency stop button,
  - 3) Any safety device switch or
  - 4) Loss of power.
- b. An emergency brake shall be provided on the main drive shaft to stop and hold the fully loaded escalator if the drive chain parts.
- 1) The emergency brake shall be electrically interlocked so that when actuated it shall disconnect the motor from the line.
  - 2) When actuated, the emergency brake shall be reset by means of a separate key actuated switch.
- c. If the main drive unit is directly connected by gearing to the main drive shaft, without a chain or other means of transmitting power that is susceptible to breakage, the emergency brake will not be required. The gearing shall maintain at least 2 teeth in contact at all times.
- d. An apparatus shall be provided to mechanically lock the step chains and prevent movement at such times as repair work is performed within the truss or upon the other brakes.
- 1) This apparatus shall be a positive mechanical device that shall be manually engaged to prevent movement of the step chains.
  - 2) An electrical interlock shall prevent the escalator drive motors from starting while the apparatus is engaged.
- e. Both the motor brake and the emergency brake shall be mechanically or magnetically applied and electrically released. Brakes shall be of a fail-safe design. The Hydraulic brake is not recommended due to the hydraulic fluid entering to friction surface may affect the escalator stopping and holding capability.
- f. The design of the brakes shall provide for easy access to the brake equipment for inspection and maintenance.
- 1) The operating temperatures of the brakes shall not exceed 195 degrees Fahrenheit (90 degrees Celsius) above ambient.

- 2) Brake torque requirements shall be permanently marked on the brake. The procedure for measuring torque shall be included in the O&M manual.
- 3) The brake assembly shall be designed to provide an audible warning indication of brake pad wear (at the 80-percent level of wear) and to prevent restart of the escalator unit on the brake pad reaching an unacceptable wear level as identified by the manufacturer. (Refer to Section 1.05 V. 6. d)
- 4) The manufacturer shall provide written instructions describing field testing and field measurement of brake torque.
- 5) Friction surfaces shall be protected from oil, grease, dirt and other substances which would reduce brake friction.

V. Safety Devices:

1. Specific switches and safety devices are required to insure safety during maintenance and to shut down the escalator in an emergency.
2. A disconnect switch capable of being locked in the OFF position shall be provided in the upper pit of each escalator to prevent the starting of the escalator from any other location.
3. All safety devices shall be clearly identified and accessible for maintenance within the escalator. These devices shall be designed for easy adjustment or reset without dismantling the escalator.
4. If an escalator stops because of a malfunction or actuation of a safety device, it shall be impossible to operate the escalator until the safety hazard or malfunction has been corrected. A manual start shall be necessary if the escalator stops for any reason.
5. An EMERGENCY STOP button shall be located according to ASME A17.1 and the Code.
  - a. The emergency button shall be a momentary contact-type push button.
  - b. This emergency button shall be housed under a clear, high impact-resistant plastic cover, which shall be self-closing by means of a gravity/positive closure cover.

- c. The cover shall have clearly printed upon it, EMERGENCY STOP, in white Helvetica medium-typeface letters, 3/8-inch minimum height.
  - d. The cover shall be hinged at the top and lift from the bottom.
  - e. The emergency button shall be red in color and visible through the cover.
  - f. The cover shall be provided with a switch to set off an alarm when lifted, but it shall be necessary to press the STOP button to stop the escalator. The cover alarm switch shall be a proximity device not requiring mechanical contact to operate.
  - g. The alarm shall be continuous for five minutes while the cover is lifted or until manually silenced by the key on/off switch at the operating controls.
6. Each escalator shall be equipped with safety devices in accordance with the Code, any other safety devices appropriate to the specific design; and shall include but not be limited to the following:
- a. Over/Under Speed Device - A device which detects operating speeds of less than 80 percent or more than 110 percent of the rated speed. The device shall operate in both directions.
  - b. Step Sag Device - A device that can detect a 0.2 inch (5 mm) out-of-level condition on any step. This step sag device or a separate device shall detect step or axle/chain rollers with diameter reduced 0.2 inch (5mm) or more before steps enter a turnaround or comb plate area.
  - c. Skirt Obstruction Device
    - 1) These devices shall be installed behind the skirt panels at the upper and lower landings and intermittently along the 30 incline at distances not to exceed 20 feet.
    - 2) At both the upper and lower landings, these devices shall be located such that the escalator will stop in a distance at least four inches less than the distance between the first skirt panel safety switch and the comb plate.
  - d. Brake Lining Wear Device - A device which detects a condition when degree of brake wear is such that the brake function cannot meet the requirements of this specification. Activation of this device shall prevent escalator start until the brake has been serviced.

- e. Motor Over-Temperature Device – A PTC shall be embedded in the motor windings to detect a motor over temperature condition.
    - 1) When the PTC detects a motor over temperature, the escalator shall shut down and not be able to be restarted until the temperature of the motor has cooled to within design specifications of the motor.
    - 2) Motor Over-Temperature device shall be manually reset type to facilitate investigation of over temperature condition.
  - f. Motor Temperature Monitor - A device which shall indicate on fault-finding annunciator panel the date and time operational parameters for the motor were exceeded.
  - g. Provide a monitor/alarm to ensure notification of a disengaged brake during maintenance.
  - h. A manual locking mechanism shall be provided to secure the step chain during maintenance. This device shall be interlocked such to prevent escalator operation while engaged and may be an integral part of 1.05.V.6.
  - i. Step Upthrust – A device which detects a condition in which an article becomes wedged between the step tread of one step and the riser of another step while forming a landing. This device shall be provided at both landings.
  - j. Install skirt deflector devices using threaded steel inserts in the skirt to allow repeated removal and reinstallation.
    - 1) The length shall be the same as skirt panel sections for the straight segments to allow the skirt panel to be removed without disassembling the entire brush.
    - 2) Top and bottom radial segments with end caps and all fittings for a complete installation shall be provided.
    - 3) Fasteners for attaching the strips to the skirt panels shall be selected to be appropriate for the skirt panel construction.
7. Upon activation, devices as defined in Sections 1.05 V. 6. a through e., inclusive, shall interrupt electric power to the individual escalator motor, automatically apply the brakes and bring the escalator to a stop.

W. Operating Controls:

1. Each escalator shall have a control station (operating controls) at each landing. The control stations shall be mounted on the newels.
  2. Interlock shall be provided to require that the escalator be brought to a stop before a direction change is made.
  3. Escalators shall have key operated switches, accessible at both upper and lower landings, located on the exterior deck above the newel base. (A separate switch must be provided for direction (UP and DOWN) and stop switch; the stop key switch should be below the direction switch). Alternate locations may be used subject to approval by the Authority. The key shall be an Allen-Bradley #D018, Cylinder Model #800T-J631KC1, with 30mm switches. Each keyed switch shall be clearly and permanently labeled, including starting, stopping and direction selection.
    - a. Cylinder locks having not less than five disc combinations may be used provided keyway, tumblers, and springs are of stainless steel.
    - b. Five (5) keys shall be provided for each station.
    - c. Locks and keys shall be provided.
  4. Provided no safety devices are activated, manual escalator start from a key switch shall be possible from both landings upon restoration of power following an outage or after the emergency stop button has been inadvertently activated. In the event of escalator shut-down resulting from activation of a safety switch, a start shall be possible from either landing only upon completion of the appropriate corrective action and a manual reset at the controller.
- X. Performance Requirements:
1. Escalators shall not generate noise levels in excess of 65 dBA measured five feet above the floor or stair level at the entrance comb at either end and along the incline with escalator operating under rated load and no load.
    - a. Background noise without the escalator operating shall not exceed 49 dBA at the measurement point at the time test measurements are taken.
    - b. For multiple escalator installations the noise measurements at each installation shall be made with only the escalator under evaluation operating.
  2. All escalators shall be designed using tamper proof fastenings to the maximum degree practicable.
  3. Corrosion Protection

- a. The escalator assembly shall be designed and enveloped in a manner to avoid corrosion and galvanic action due to physical contact between metals or other causes. Trusses shall be hot dipped galvanized.
  - b. Where the use of adjoining dissimilar metals is required, the descriptions of protective measures to be employed shall be provided to avoid corrosive damage.
4. Materials of construction shall be noncombustible (as defined in ASTM E136) and the design shall produce a fire-resistant installation. Handrails shall have a flame spread rating of 76 to 200 when tested in accordance with ASTM E84. Lubricants shall be selected to obtain the highest practicable flashpoint, consistent with other requirements. Fire control means shall be non-hazardous to human life and shall be approved by the Authority.
5. In addition to the minimum requirements given in the Codes, the Contractor shall design the steps for a minimum load of 320 pounds load with an ultimate strength safety factor of eight. The steps shall carry the load under maximum, concentric and eccentric loading conditions without distortion.
6. Step Testing
  - a. Step assemblies shall be tested in accordance with ASME A17.1 STEP FATIGUE TEST requirements, Sections 8.3.11.1 through 8.3.11.6, as a minimum. The Contractor shall furnish a certification by a Professional Engineer an actual copy of the test report. The step assemblies shall be a sample test for each lot so that the manufacturer guarantees compliance with the fatigue requirements. Step castings will be permanently marked to identify casting source, casting date, assembly and installation.
  - b. Perform dynamic testing, witnessed by the WMATA representatives and, to verify the structural strength and serviceability requirements and submit certified test results. Testing shall include the tests necessary to verify the structural capacity of the step.
7. All escalators shall be designed to operate at full specified performance in temperature ranging from minus 10 degrees Fahrenheit to 140 degrees Fahrenheit dry bulb while exposed to sunlight, rain, snow, slush, debris, airborne dust, tracked on deicing substances, and maximum patron loading.
8. Controllers shall be designed to operate in a temperature range of 32 degrees Fahrenheit to 140 degrees Fahrenheit dry bulb.
9. Unintentional abuse by patrons and vandalism shall be a consideration in the design of the escalator.

## **1.06 SITE CONDITIONS**

### **A. General:**

1. During installation and until the Final Acceptance, the escalators may be subjected to more extreme environmental conditions. Furnish the amount of protection necessary, and to the satisfaction of the WMATA to prevent any damage or deterioration to the escalators during this period.

## **1.07 WARRANTY**

Warranty: Two (2) year warranty of construction shall start at Final Contract completion.

- A. The OEM shall warrant in writing that all equipment manufactured and installed under this specification, for a period of twenty four (24) months from the date of Final Acceptance by the Authority, be free of defects in design, materials, and workmanship, under normal use and service. Defective work shall be repaired or replaced at no additional cost to the Owner.
- B. The warranty shall include materials and labor necessary to correct defects.
- C. The warranty does not begin until all of the following requirements have been met.
  1. The Operations and Maintenance Manuals are accepted by WMATA.
  2. The required training has been completed to the satisfaction of WMATA.
  3. All field tests have been successfully completed.
  4. The acceptance testing has been successfully completed.
  5. The escalators are in service for passenger/public use.
  6. The State and local jurisdictions have inspected the escalators and issued the respective certificates of Operation.
  7. All spare parts have been delivered and received by WMATA.
  8. Any discrepancy identified by the ELES representative shall be repaired or replaced by the Contractor at no additional cost to the Authority.

## **1.08 OPERATION AND MAINTENANCE TRAINING**

A classroom training program shall be developed to instruct WMATA Operations and Maintenance personnel in the operation and maintenance of escalator equipment.

- A. The following training requirements shall be met:
  1. Three days of classroom plus two days hands on training on the field shall be provided for 10 students per class. Six training session for a total of 60 students is required.

2. Time and place of training will be determined by the Authority, but must be completed no later than 30 days prior to the Final Completion.
3. Training shall be organized to make optimum use of the required maintenance and operation manuals including training for replacement of all parts contained in the Parts Inventory list.
4. Training materials reflecting the final installed equipment configuration shall be submitted to support continued in-house WMATA training. Photos of actual equipment shall be included to support training materials.
5. On-site training may be included and/or supplemented with mock-up equipment, as appropriate.

**B. Scope of Work:**

1. All training, as described below, shall take place prior to Final Acceptance of equipment or materials. Operations and maintenance training may take place as a combined class by agreement of the Office of Elevators and Escalators (ELES). The minimum number of ELES employees to be trained will be 60 total with a maximum of 10 in each class. Those persons will be identified by WMATA. The contractor shall video tape all training sessions and provide WMATA/ELES with edited copy of the recording. The video shall be edited for the purpose to be used as a training guide for other WMATA/ELES mechanics.
2. At the completion of the first training session, a narrated and properly edited training video shall be submitted for the Authority on DVD or flash drive. The video shall be taken by the professional camera operator with quality image and sound track and will be used for the future trainings. The video shall cover operation of the elevator, function of the devices, maintenance, adjustment procedures and troubleshooting. The following items shall be included as minimum requirements:
  - 1) Step by step adjustment procedure on the followings:
    - 1.1 Handrail system including drive chain
    - 1.2 Comb Impact device
    - 1.3 Escalator Brake
    - 1.4 Bottom Carriage ...
    - 1.5 Drive and motor alignment
    - 1.6 Safety switch adjustment and clearance
  - 2) General overview of major items:
    - 2.1 Motor:
    - 2.2 Gearbox:

- 2.3 Bull gear and Carriage system
  - 2.4 Controller:
  - 2.5 Controller display:
  - 2.6 Brake mechanism
  - 2.7 Escalator pit
  - 2.8 Handrail system
  - 2.9 Guide rails
  - 2.10 Automatic oiler
  - 3) Daily operation and sequence of operation
  - 4) Replacement and Installation of components:
    - 4.1 Brake
    - 4.2 Balustrade panels
    - 4.3 Escalator steps
    - 4.4 Handrail Drive chain
    - 4.5 sensors
  - 5) Proper step and chain guide adjustment
  - 6) Verification of safety circuit
  - 7) Maintenance procedure and Frequency of maintenance
  - 8) Proper access of pit and step band
  - 9) Proper test of over/under speed operation
  - 10) Proper lubrication of components
  - 11) Troubleshooting techniques
  - 12) Proper clearance check between the skirt and balustrade panels.
3. Operations training shall be tailored specifically to the furnished and installed equipment, and designed to teach the day-to-day operation of all equipment. The training shall be sufficient to bring personnel to a level of operating proficiency such that routine vendor support is not needed.
4. Maintenance Training shall be tailored specifically to the furnished and installed equipment, and designed to develop the knowledge and skills required to maintain all item(s) delivered. Maintenance training shall be subdivided into two major levels as follows:
- a. System Level Maintenance Training, covering:
    - 1) Theory of operation of the system and its major components.
    - 2) System configuration.
    - 3) Preventative maintenance, consisting of written procedures and schedules for the periodic maintenance of all equipment.

- 4) Written and validated inspection procedures and a system-level trouble-shooting guide (to the lowest field-replaceable unit).
  - b. Shop Level Maintenance Training, covering:
    - 1) Detailed theory of operation to module, board, and/or device level.
    - 2) Component level troubleshooting and component replacement.
    - 3) Testing and alignment procedures of repaired units.
- C. Deliverables:
  1. The following course materials shall be delivered by the Contractor, according to the following specifications:
    - a. An Instructor's Guide containing all the information and direction necessary for the instructor to make an effective presentation. It shall include adequate guidelines to conduct a comprehensive training program. Individual lessons within the course shall be organized as separable blocks (or modules) which may be taught as a unit. In some instances, the same module may be used in more than one course. The Instructor's Guide shall contain, as a minimum:
      - 1) Discussion of student prerequisites (if any).
      - 2) Program overview.
      - 3) A statement of overall program goals.
      - 4) Lesson plans (a session-by-session outline containing the following):
        - a) Student learning objectives, stated in measurable terms.
        - b) Overview of each lesson.
        - c) Suggested instructional methods/learning activities.
        - d) Required equipment and resources. Special training equipment, test equipment or special tools required for maintenance training shall be supplied by the Contractor and delivered to the Authority's representative after completion of the course.

- e) Evaluation Device(s), (written and/or practical tests) designed to measure the extent to which students have met the learning objectives with an answer key for each of the tests developed.
- b. A Student Manual including all materials for the student to interact in the learning situation. It shall contain, as a minimum:
  - 1) Program overview and introduction.
  - 2) Statement of overall program goals.
  - 3) Learning objectives, stated in measurable terms, that specifically describe desired behaviors or knowledge to be gained.
  - 4) A fully developed prose treatment (not outline format) of content presentation, developed in the same modular format as the Instructor's Guide.
  - 5) Illustrations, charts, photos or other graphics of actual system components, as needed to enhance content presentation.
  - 6) The training manuals shall be prepared and submitted for approval prior to training. The training manuals shall include procedures for adjustment and replacement of all electrical and mechanical components, and a troubleshooting guide.
- c. Audio-visual Aids consisting of:
  - 1) A narrated video of not less than 90 minutes duration to include, but not limited, to the following:
    - a) General overview of major features.
    - b) Daily operations.
    - c) Maintenance procedures (lubrication, adjustments, critical measurements, etc.).
    - d) Frequency of maintenance procedures.
    - e) Parts replacement, safety device, lighting, etc.
    - f) Verification of safety circuits methods of accessing and preserving computerized functional data if required.



5. Testing. Instructors must give written and/or practical tests as a measuring device to determine knowledge transference. Tests shall use a multiple-choice or short answer format, and have been validated in a pilot course or by some other means agreed to by the Authority. Whenever possible, a practical hands-on test shall be developed to demonstrate the transference of operational/mechanical skills.

## **1.09 SPARE PARTS AND SERVICE FACILITY**

At the expiration of the warranty requirements of the General Provisions, the Contractor shall provide a spare parts and service facility in the United States at no additional cost to the Authority from which all manufactured parts and components of the equipment furnished and installed under this Contract can be obtained for an additional five years. If product source is another vendor, Contractor shall include name and address of other vendor.

- A. Spare Parts and Special Tools:
  1. This provision requires the furnishing of a Recommended Spare Parts and Special Tools List based on manufacturer's recommendations; defines criteria to be used in developing spare parts recommendations; defines the manner of identifying spare parts on the list and the labeling and identification of spare parts upon delivery; and the timing of delivery of spare parts.
  2. Escalator parts list shall be grouped by system and subsystem for stocking identification and the list shall contain the following information for each item listed:
    - a. Component name and Part number(s)
    - b. Manufacturer's name
    - c. Model number(s)
    - d. A blank column for WMATA's part number
    - e. Manufacturer's recommended quantity (see Section 1.09 A. 3, below)
    - f. Anticipated annual usage
    - g. Unit price
    - h. Available packaging
    - i. Special storage and handling requirements
  3. The manufacturer's recommended quantities shall be based upon the following reliability, usage and lead time considerations:

- a. Wear: Components which may be expected to require replacement under normal maintenance schedule and operations, such as mechanical parts subject to continuous operation within the projected mean time between failure levels.
  - b. Consumables or Expendables: Components which are consumed, used up, destroyed, or upon failure, are otherwise made unusable for their intended purpose and are economically unrecoverable except for inherent scrap value.
  - c. Recoverable or Repairable: Components which, upon failure, are capable of being repaired or remanufactured to a serviceable, operational condition and maintained available for use within their initial intended purpose.
  - d. Long Lead: Components which are not available at short notice from commercial distributors or within 48 hours from the manufacturers, such as specifically made or selected components.
4. Cross referencing: Where replacement components are common to more than one system or subsystem, include a cross reference and indexing system in the replacement components list:
  5. Non-Unique parts: In all components lists, items which are not unique to the system and have been manufactured by others shall be identified by the manufacturer's name and part number.
  6. The Contractor shall propose and provide a spare parts inventory to be approved by the Engineer and provided to the Authority not less than 90 days prior to scheduled completion, equal in value to seven percent of the cost of each elevator.
- B. The Authority will provide shipping instructions, with WMATA part numbers for each item. The parts shall be shipped to the locations as directed by the Authority. Shipping documents shall identify the Contract number, manufacturer's part number, quantity, unit price and WMATA part number.
1. Spare parts shall be properly packaged or crated so as to prevent damage during shipment and long-term storage. An individual packing slip shall be included inside the package or crate.
  2. Spare parts shall be the same in all respects as their counterparts furnished as a part of the assembled equipment to be delivered.
  3. Parts furnished in accordance with this provision are WMATA spares, separate and distinct from any Contractor obligation to replace parts, components or assemblies under any warranty provision.

4. Parts lists contained in Operations and Maintenance Manuals provided under the Contract shall include assigned WMATA part numbers.
  5. A Manufacturer's Recommended Spare Parts List shall be provided. Parts to be provided shall be based on the criteria described herein and require Authority approval and shall be provided prior to Final Acceptance.
  6. Any Special Tool(s) used including, but not limited to, troubleshooting, maintaining the elevator, software and/or hardware shall be provided as part of the spare parts to the Authority. Any tools provided shall be the same as those issued to the Adjuster and equivalent members of the subcontractor's staff.
- C. Security of Machine Rooms:
1. The Contractor shall be responsible for the security of the contents of each machine room. The Contractor shall control access to that room, and ensure that it shall remain secure at all times until the completion of the Contractor's interim maintenance obligation.

#### **1.10 SPECIAL TOOLS**

- A. A complete set of special tools and instruments necessary for troubleshooting, maintenance, repair and making all adjustments on every part of the elevator installation, including software and hardware shall be furnished for each escalator and delivered to the Engineer as part of the spare parts inventory. Tools that are designed specifically for tasks associated with elevator inspection, maintenance and repair or that are required for these tasks, and are not readily available through normal purchasing channels are defined as special tools.
- B. Any "Special Tool/ equipment" that is required to troubleshoot, maintain, adjust, and test the system; the tool/equipment shall remain operational for the life of the equipment.
  - a. Provide all special tools and equipment necessary for making all system adjustments to the controller and other equipment. A programming unit, approved by equipment manufacturer (OEM) such as a new laptop with 4GB memory, 15-inch display and DVD drive, with all software packages required to setup and program all equipment in the elevator system shall be provided, one per station or location. Software shall be provided for the display unit, DeviceNet, motor drive, if applicable, and any other programmable devices, as well as for the controller PLC. Any hardware or software required for configuring, programming and or communicating to controller or any parts of the escalator shall be submitted to ELES engineering. Using the provided laptop, the contractor shall demonstrate loading, downloading (programming)

any and all software that is required for the escalator for all operating needs. This includes display, PLC and any I/O controls. All special tools shall be new and to be provide with casing. No special tools with decaying circuits or clocks are permitted.

- C. Keys: Provide ten (10) sets of keys per escalator to operate all keyed switches and locks prior to completion of the first unit.

### **1.11 AUTHORITY COORDINATION:**

The escalators shall not be in service for passenger/public use until all of the following requirements have been met.

- 1) The Operations and Maintenance Manuals have been approved and received by WMATA.
- 2) The Training and Student Manuals as well as video record of all training sessions have been approved and received by WMATA
- 3) The required training has been completed in accordance with this specification.
- 4) All field tests have been successfully completed.
- 5) The acceptance testing has been successfully completed.
- 6) All spare parts have been delivered and received by WMATA.
- 7) All Special Tools/Equipment and Software have been delivered and received by WMATA.
- 8) All discrepancies identified by the WMATA's CEI (Certified Elevator Inspector) representative shall be completed.

## **PART 2 – PRODUCTS**

### **2.01 MANUFACTURERS**

- A. All escalators shall be the product of a single of three manufacturers.
  1. KONE TransitMaster 180
  2. Schindler (9700 series at Dulles Airport Station)
  3. ThyssenKrupp 'Victoria'
  4. Approved Equal

### **2.02 MATERIALS**

- A. Except where product conformance to specific standards is indicated, and in ASME A17.1, manufacturer's standard materials and equipment may be used in escalator construction, subject to approval by the Authority. Materials cited below are intended to establish the standard of quality for comparable materials if used by the manufacturer. Noncombustible materials shall meet the requirements of the National Fire Protection Association (NFPA), Fire Protection Handbook.
- B. Structural Steel:

1. Rolled Steel Sections, Shapes, and Rods: ASTM A36.
  2. Tubing:
    - a. Cold formed: ASTM A500.
    - b. Hot formed: ASTM A501.
  3. Sheet Steel: ASTM A653, Grade B, zinc coated.
- C. Stainless Steel:
1. Shapes and Bars:
    - a. ASTM A276, Type 304 or 301 for non-exposed components, and Type 316 for all finish panels and exposed components.
  2. Plate, Sheet, and Strip:
    - a. Over 1/8 inch, ASTM A264 with ASTM A240, Type 316 on ASTM A36 base
    - b. Under 1/8 inch, ASTM A167, Type 304, or Type 316 for all finish panels and exposed components.
  3. Pipes and Tubes: ASTM A312, Type 304, in accordance with the following:
    - a. Welded connections: Schedule 10 minimum.
    - b. Screwed connections: Schedule 40S minimum.
    - c. Press fits: Schedule 5S minimum.
- D. Cast Aluminum: ASTM B108, Alloy ANSI 356.0, T6 or comparable materials meeting the strength and performance requirements specified.
- E. Extruded Aluminum: ASTM B221, Alloy 6061, T6.
- F. Fasteners:
1. Provide bolts, nuts, washers, screws, rivets, and other fastenings necessary for proper erection and assembly of work in accordance with ASTM A325 or ASTM A490. Fasteners shall be compatible with materials being fastened, comply with buy America requirements, and shall be tested and certified based on appropriate sampling.
  2. For exposed fasteners, ensure that fasteners match adjacent material in appearance, finish, and color, and are countersunk to achieve a smooth, uniform surface, unless otherwise indicated. In any case, surfaces exposed to passengers shall be snag free. If screws are used in an exposed location, use tamperproof screws to the maximum extent possible, otherwise use Phillips flathead type.
    - a. Fasteners shall be compatible with materials being fastened.

- b. Fasteners shall be furnished with self-locking nuts or retaining rings (spring washers, toothed disks).
  - b. Fasteners shall be equal to or of greater corrosion resistance than the most corrosion resistant metals being fastened.
- G. Welding Material: AWS D1.1, type required for structural steel materials being welded.
- H. Welder's qualifications shall be certified in accordance with AWS D1.1 or equivalent, internationally recognized standard.
- I. Neoprene joint filler: As specified in paragraph 1.05.P.
- J. Handrail material: As specified in paragraph 1.05.S.
- K. Sealers, Paints, Coatings, Lubricants and Other Similar Materials:
  - 1. The least hazardous material or substance that will effectively perform the required function shall be selected. Submit MSDS information for all potentially hazardous materials, for approval.
- L. Balustrade shall be made of the following materials:
  - 1. All locations shall be used Stainless Steel
- M. Decking, Newel and Skirt Panels:
  - 1. Stainless Steel
- N. Outer Cladding Panels:
  - 1. All locations shall be use Stainless Steel

## **2.03 EQUIPMENT**

- A. Electrical:
  - 1. Electric equipment for all escalators shall be designed, selected, and fabricated in accordance with NEC, NEMA, IEEE, and ANSI standards as applicable, and as specified herein. All equipment including motors, controllers, switches, indicators, circuit breakers, panelboards, lighting, heating, wiring, conduit, boxes and other appurtenances for proper installation and operation of the escalators shall be furnished and installed.
    - a. One 480/277-volt, 3-phase, 4-wire, or 480-volt, 3-phase, 3-wire, 60-Hertz power feeder will be provided in each wellway by others, and terminated in a junction box in the upper pit. Power feeder will be sized to include the total load of combined escalator drive systems, controls, and heating. The Contractor shall provide necessary power distribution from the junction box to the individual escalators, including all disconnect switches, wiring, and electrical equipment necessary to make complete and operable escalator systems.

- b. One auxiliary 208/120-volt, 3-phase, 4-wire, or 120-volt, 1-phase, 2-wire 60-Hertz feeder for lighting and receptacles will be provided in each wellway by others, and terminated in a junction box in the upper pit. The feeder is used for escalator balustrade lights except as noted below for the emergency feeder.
- c. One 120-volt, single-phase 2-wire, or 208/120-volt, 3-phase, 4-wire, or 208/120-volt, 1-phase, 3-wire 60-Hertz emergency feeder will be provided by others, and terminated in a junction box in the upper pit. Emergency feeder shall be used as necessary for maintenance service lights, comb lights, and step demarcation lights, and 20 percent of the other escalator lights.
- d. Equipment grounding conductors with each of the three escalator feeders will be provided by others and terminated in the junction box. The equipment grounding conductors shall be provided from the junction boxes for all feeders and branch circuits as shown and required. Electrical equipment shall be provided with a minimum of two ground paths. One path shall be a green, insulated equipment-grounding conductor. The second path shall be a connection, to grounded metallic items using metallic fasteners, metallic conduit and/or bonding jumper. Provide a #6 AWG insulated grounding conductor attached to each truss and running back to the main feeder junction or tap box and spliced to the equipment grounding conductor run with the feeder wires. On escalator, bond exposed metallic items, ac equipment enclosures and lighting fixtures to grounded escalator metallic structure with metallic fasteners as shown. Only escalator parts shall be used the ground bond or ground bar located inside the escalator truss.
- e. All necessary steps shall be taken to ensure the flow to ground of accumulated static electricity, by means of metallic rollers or other appropriate means installed at appropriate locations to prevent potential at all times at all points along the handrails.
- f. Grounding and bonding all parts of the escalator metallic structure, truss, equipment and raceway shall be in accordance with the applicable requirements of the NEC and the codes and regulations of the jurisdictional authorities.
- g. All wires in controller or junction boxes shall be identified and a permanent label shall be placed to match with

terminals number. The terminals shall have permanent labels. Wires to relays or connected any other devices must be marked and identified. Wires shall have insert labeling and heat shrank.

2. Temporary Power Supply
  - a. The Contractor will provide temporary power for Contractor's use.
3. Conduit Boxes and Fittings:
  - a. All wiring for escalator equipment and control devices is in GRS conduit or liquid-tight flexible conduit.
  - b. Rigid conduit and fittings shall be UL-approved galvanized steel conforming to the requirements of UL 6 and ANSI C80.1. The minimum size shall be 3/4-inch for power circuits and one-inch for control circuits. Power and control circuits shall be in separate conduits.
  - c. Liquid-tight flexible conduit shall conform to the requirements of UL 360 and consist of a flexible hot dip galvanized steel core spiral wound with continuous copper ground built in the core for sizes up to 1-1/4 inch and a neoprene jacket overall. Sizes 1-1/2 inches and above shall be installed using a separate ground wire. Fittings for flexible conduit shall be watertight and shall conform to the requirements of UL 514B.
  - d. Outlet boxes shall be watertight, stainless steel for exterior units and galvanized malleable iron, cast iron or ductile iron for interior units conforming to the requirements of UL 514A. Wiring device cover plates shall have weatherproof construction. Junction and pull boxes shall be non-metallic NEMA 250 Type 4X conforming to the requirements of UL 50 and UL 514A and having screw covers with liquid-tight gaskets.
  - e. Provide NEMA 250 Type 4X waterproof fittings, watertight hubs and appurtenances as required by the installation to preclude the entry of water or moisture into the system.
  - f. Junction Boxes with electrical circuit boards and/or terminal blocks shall not be installed inside the step band. All junction boxes shall be NEMA 4X and shall have easy access for maintenance.
  - g. All boxes shall be accessible without removal of steps and installed behind removable balustrade panels as recommended.



- d) Chlorosulfonated polyethylene, or cross-linked polyolefin.
  - i) Tensile strength, minimum pounds per square inch: 1,800. Tensile strength, minimum percentage of unaged value: 100.
  - ii) Elongation at rupture, minimum percent: 150. Elongation at rupture, minimum percentage of unaged value: 80.
  - iii) Aging requirements: After 168 hours in air oven test at 100C, plus or minus one degree Celsius.
  - iv) Oil immersion: 18 hours at 121C, plus or minus one degree Celsius, ASTM D471, Table 1, No. 2 oil:
    - (a) Tensile strength, minimum percentage of unaged value: 80.
    - (b) Elongation at rupture, minimum percentage of unaged value: 80.
- e) Jacket materials other than cross-linked polyolefin complying with NEMA WC 70. Jacket material free of PVC and PVC-based compounds.
- 6) Flame retardancy: Single-conductor and multiple-conductor cable demonstrating flame retardancy in accordance with the following:
  - i) Single-conductor cable and individual conductors of multiple-conductor cable passing vertical flame test in accordance with UL 1581 and/or NEMA WC 70. Cable size for testing: 14 AWG.
  - ii) Single-conductor cable and individual conductors of multiple-conductor cable, passing vertical tray flame test, using ribbon gas burner in accordance with IEEE 1202. Multiple-conductor cable passing vertical tray flame test using ribbon gas burner in accordance with IEEE 1202.

- 7) Applied voltage testing:
  - a) Single-conductor cable and individual conductors of multiple-conductor cable to be given applied ac voltage dielectric strength test, after six-hour water-immersion test.
  - b) For single-conductors of multiple-conductor cable, conduct tests prior to assembly as multiple-conductor cable.
  - c) Test procedures:
    - i) Polyethylene insulated conductors: In accordance with NEMA WC 70.
    - ii) Other conductors: In accordance with NEMA WC 70.
- d. Single-Conductor Cable:
  - 1) Insulated with ethylene-propylene-rubber with non-metallic jacket orunjacketed filled cross-linked polyethylene. UL-labeled Type RHW or XHHW.
  - 2) Color coding: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.
- e. Multiple-Conductor Cable:
  - 1) Individual conductors:
    - a) Number of conductors: As required.
    - b) Construction: Complying with one of the following:
      - i) Insulated with ethylene-propylene-rubber, with or without nonmetallic jacket.
      - ii) Insulated with composite compound of ethylene-propylene-rubber and polyethylene, UL Class EPCV, without outer jacket.
      - iii) Insulated with filled cross-linked polyethylene without jacket.
  - c) Phase and neutral conductors: Individually insulated.
  - d) Neutral conductors: Same size as phase conductors.

- e) Bare ground conductors: Sized in accordance with the NEC, unless otherwise shown.
- f) UL-listed as Type RHW or XHHW.
- 2) Conductors assembled with nonwicking, flame-retardant filler to form cable of circular cross section.
- 3) Metallic-sheath: Provide one of the following:
  - a) Size 1AWG and larger:
    - i) Interlocked aluminum tape armor.
    - ii) Continuous corrugated aluminum sheath conforming to NEMA WC 70.
  - b) Size 2AWG and smaller: As specified for 1AWG and larger or continuous smooth aluminum sheath conforming to NEMA WC 70.
- f. Multiple-conductor cable provided with overall nonmetallic jacket as specified.
- g. Cable UL-listed as follows: Metallic-sheathed cable: Type MC, suitable for wet and dry locations.
- h. Color coding:
  - 1) Power cables: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.
  - 2) Control cables: In accordance with NEMA WC 70.
- 5. Fixture Wire: UL 62, with the following additional requirements:
  - a. Type: To suit temperature rating of lighting fixture, minimum 90C
  - b. Conductor: Stranded copper conductor 16AWG or larger.
- 6. Bare Conductor: ASTM B3 or B8 annealed copper conductor; 8AWG and larger, Class B stranded.
- 7. Connectors, Terminal Lugs and Fittings:
  - a. In accordance with UL 486A.
  - b. For 10 AWG and smaller conductor cable: Tin-plated copper pressure connectors with nonflammable, self-extinguishing insulation grip with temperature rating equal to that of conductor insulation.
  - c. For 8 AWG to 4/0 AWG conductor cable: Tin-plated copper compression connectors and terminal lugs with insulating sleeve or heat shrinkable insulator for insulation grip.

- d. For 250 KCMIL and larger conductor cable: Long barrel double-compression tin-plated copper connectors and terminal lugs with two-hole pad.
  - e. For multiple-conductor cable: Watertight aluminum fittings with stainless steel pressure ring and set screws or compression cone for grounding of aluminum sheath of Type MC cable.
  - f. Terminal lugs used for bonding connections to metallic structures shall be installed on bare/uncoated metallic surfaces to assure minimum contact resistance.
8. AC Drive Motors: Motors shall have TEFC enclosures and be rated for inverter use on 480 VAC, three-phase, 60-Hertz power. The follow characteristics shall also be provided:
- a. Insulation of all windings shall be impregnated and baked to prevent absorption of moisture and oil. The insulation resistance between motor frame and windings shall not be less than one megohm. The motor windings shall stand a dielectric test of twice the normal voltage plus 1000 RMS volts of 60 Hertz, alternating current for one minute. Insulation shall be Class F.
  - b. Motor characteristics shall include: heavy gauge steel and cast iron frames, ball bearings, inverter spike resistant windings, low-loss electrical grade lamination steel, dynamic balancing for vibration no greater than half the NEMA vibration standard, continuous duty rating, service factor of 1.15 and have a rated efficiency at full load of greater than 91%.
  - c. Motor leads in the conduit box shall have the same insulation class as the windings. Motor lead wire shall be rated 125 C and shall be sized for 105 C at the motor nameplate amperes at 1.0 Sf per EASA recommendations. Leads shall be securely labeled.
  - d. The motor shall be provided with a ring or other suitable lifting means. A sliding base shall be provided for motors other than direct coupled.
  - e. Motors shall be provided with a compression type grounding lug, the same size as motor leads, mounted in the conduit box by drilling and tapping into the motor frame or by a double ended silicon bronze cap.
9. Controller:
- The controller shall utilize an Allen Bradley PLC incorporating the CompactLogix 1769 L32E based PLC module , or approved equal.

The controller, the variable-voltage variable frequency (VVVF) motor drive as well as any brake controller shall be located in a readily accessible Escalator machine room. The controller shall be mounted in a NEMA 4X stainless steel air-conditioned cabinet within the controller room, and include all surfaces being painted, drip-proof venting, and lockable doors. The door of the cabinet shall have a sealed window placed over the fault indicator board within. Controllers shall include the PLC components, control relays, fault indicator, and all other functions of escalator controls.

- a. Variable-Voltage Variable-Frequency Drive: The escalator shall be started and continue to run with drive motor power provided by an appropriately sized variable voltage, variable frequency AC motor drive with regenerative drive. Motor contactors shall be installed to meet code requirements when running off a solid state drive. Accommodation shall be made to set a second maintenance-operation speed in the solid state drive. The VVVF drive and drive motor shall be capable of over speeding the escalators by 40% for test purposes. There shall be no bypassing of the solid state motor drive for normal operation or maintenance operation. The drive and associated components can be housed in a separate NEMA 4 enclosure.
- b. PLC Escalator Control: The Allen Bradley CompactLogix 1769 L32E controller shall provide logic for all required operation of the escalator including control of the VVVF drive, braking control, safety device responses, maintenance operation and control inputs from key switches.
- c. All controller enclosures shall be NEMA 4X rated. All enclosures shall be provided with strip heaters controlled by a humidistat mounted within the enclosure.
- d. The top side of the controller enclosure shall not be drilled for any reason, liquid tight and any other connectors to the controller shall be installed half way below the controller or at the bottom side of the controller.
- e. The controller space shall have adequate lighting.
- f. Specific capabilities shall include:
  1. The CPU module must provide DH-485 and/or RS-232 communication ports. In addition, the contractor shall install an Allen Bradley network interface module, (model 1761-NET-AIC, or

approved equal) beside the PLC in the controller and provide 24 VDC power to the module. The Allen Bradley PLC will be used for remote monitoring capabilities into WMATA established engineering monitoring network. All required coordination for wiring and programming on the PLC and the DH-485 network shall be made with WMATA ELES Engineering. Contractor shall pull all Remote Monitoring cables to the interface in the escalator controller from the pull box in the upper or lower pit area.

2. The Programmable Controller shall have one serial port open to support accessibility to ladder logic and provide data to the remote monitoring network.
3. The exclusive Allen Bradley DH485 protocol data port will transmit data from the escalator controller to the station or facility data concentrator. The contractor shall provide a controller data interface to a DH 485 network located in the escalator controller room. Data cables in an existing controller or in the escalator controller room shall be retained and connected into the new controller and available for connection to the controller DH485 interface. If DH485 cabling is not available, the contractor shall run Belden 9842 cable or approved equal, to connect the controller into the monitoring DH485 network as directed by WMATA. The DH 485 controller interface shall be programmable for data rates up to 115 Kbps. The interface shall allow other nodes such as other elevator and escalator to be readily incorporated into the DH 485 network.

If not already installed in the station or facility, a data concentrator PLC shall be installed using an Allen Bradley MicroLogix 1400 or SLC5/05 PLC per station to function as data concentrator to consolidate data from all controllers in the station. The software for the data concentrator shall receive controller data over the local monitoring DH 485 network and provide formatted data to the AEMS RTU through an RS232 link. The data concentrator shall provide an Ethernet port for interfacing with the WMATA wide area network. A data concentrator connection to the WMATA wide area network shall be provided.

4. The signals shall be active when the listed status is present as it is in the escalator control computer. The signals shall be 24 Vdc from an independent power supply provided in the escalator controller cabinet or external enclosure by the manufacturer or the installer. Analog signals shall be connected in a 20 mA current loop configuration to analog inputs on the added PLC. An area of 18 inches by 10 inches shall be available inside the controller or in an external enclosure - on the side is acceptable - that allows a unit 10 inches deep to be mounted. An Allen Bradley type MicroLogix 1400 PLC with 24-volt input modules for 32 inputs shall be supplied by the manufacturer or the installer. The CPU module must provide DH-485 and Ethernet communications ports. In addition, the contractor shall install an Allen Bradley network interface module, (model 1761-NET-AIC, or equal) for interfacing into the local remote monitoring DH485 network beside the PLC in the controller and provide 24 vdc power to the module. The output signals from the MCE or equivalent shall be wired from the terminal strip to the PLC inputs indicated in the Signal List table. PLC power and signal returns shall be wired into the PLC. The PLC power shall come from 120VAC provided by the car lighting supply in the escalator controller.

- 1) The controller PLC shall use integrated programming, error checking, communications setup, ladder-type software package that shall be supplied by the Contractor.
  - a) Five copies of the annotated ladder listing with flowchart of the PLC software shall be provided in electronic format and in hardcopy.
  - b) One programming/monitoring device, such as an appropriately setup laptop, with necessary software and cables shall be provided for each station.
- 2) Provide battery backup – 2 year minimum.

- a) PLC memory and programs shall be retained in non-volatile memory such as an Allen Bradley 1747-M13 module or approved alternative.
- 3) Modules, such as input, output, communication and analog, shall be slot type and compatible with the PLC processor I/O structure.
  - a) Each module shall be provided with a removable wiring terminal strip so that modules may be changed without removing associated wiring.
- 4) The power supply shall be suitable for operation on 120 VAC, single phase power.
  - a) Power supply capacity shall be a minimum of 150 percent of the connected load.
- 5) As a minimum, status, faults and analog data as listed in the tables for the remote monitoring interface shall be available from the serial port. Some of this data may be available in the tables of data for the two fault displays.
- 6) When on Inspection, the control system, variable frequency drive and drive components shall be capable of being set to various running speeds including over speeding the escalator by 40%.
- 7) No circuit boards, other than those incorporated in the lower balustrade display or in transducers for speed monitoring, shall be located in the truss or balustrade areas of the escalator.
  - a) All circuit boards and terminals for escalator safety, indicator and control devices shall be located in the controller area.
- 8) Screw type compression terminal blocks rated for 20 amperes minimum shall be used for all power circuits and 10 Amp minimum terminal blocks for control and indicating lights.
  - a) All wiring shall be stranded conductors of sufficient current carrying rating, color coded and permanently identified at all terminations.
  - b) A maximum of three wires shall be terminated at any terminal.

- c) All wiring jumpers, taps or multiple wire connections shall be located on a terminal; tee taps, wire nuts or conductor splices shall not be utilized.
- d) All controls shall operate at 120 volts or lower, AC or DC.
- e) Control power shall be obtained from integral dry type control transformers.
- 9) All wiring internal or external to the controller shall be stranded copper, matching existing AWG size or size 18 AWG minimum, moisture resistant, flameproof, and oil resistant insulated conductors.
  - a) All terminations at devices and terminals shall utilize insulated type crimp connectors, terminal strip, phoenix or similar devices.
  - b) All terminals shall be identified with wire numbers which correspond to wiring diagrams.
  - c) Wiring shall be laced and tied or contained in wiring trough at terminal blocks.
  - d) All conductors shall be identified with embossed tubing sleeves at each terminal and heat shrink.
  - e) All terminations shall be made within boxes at terminal strips.
- 10. Air Conditioning:

Provide an independent air conditioning unit for each new controller to maintain manufacturers recommended operating temperatures. Condensate from the air conditioning unit must be piped to a suitable drain.
- 11. Fault and Status Display:
  - a. One fault and status displays shall be provided for each escalator to visually indicate the activation of specified safety devices.
    - 1) The panel shall be constantly active.
    - 2) The panel should be located in the controller enclosure visible with controller door closed.
    - 3) The controller display shall indicate operating status when no fault is displayed.
    - 4) An Allen Bradley PanelView Plus 6,

EZAutomation or ELES Engineering approved equal, fault/status display/interface shall be provided in the controller cabinet. Control system timers and other setup criteria shall be programmable through this unit. All fault, status and setup data shall be stored in the controller CPU module.

- b. The fault and status display shall provide the capability to store:
  - 1) 99 activations of any and all safety devices
  - 2) 99 events of a minimum of 125 different error or event codes
  - 3) 99 entries of the escalator travel distances in inches or millimeters after application of the brake(s)
  - 4) 99 entries of motor current draw in five minute increments.
  - 5) The display shall have the capability to download faults to a flash drive and upload the program from a flash drive or other memory device without the need for a laptop.

All data points shall be date and time stamped.

- c. Stack memory shall be used so that, when full, the oldest data point is overwritten as new data is accumulated.
  - d. Events to be stored include, but are not limited to, internally detected error codes, operational mode selection, start up, power down, and run direction including items listed in the table above.
    - 1) The fault displays shall use definitive word descriptions at the controller panel.
    - 2) The display shall only display the root cause of the shutdown when it occurs.
  - e. The Contractor shall provide test plans for approval and shall satisfactorily demonstrate all local and remote functions of the fault and status displays and the remote monitoring data retrieval system prior to Final Acceptance.
12. Disconnect switches shall be provided and installed in the space where the controller is located as required by code.
- a. Disconnect switches shall be the following: UL 98, NEMA KS 1, heavy-duty, quick-make/quick-break switching

mechanism with operating handle external to enclosure, with positions labeled ON and OFF, defeatable interlock to prevent opening of enclosure door when switch is ON. The disconnect and any other boxes shall have a permanent label to identify specific unit.

- b. Enclosures shall be NEMA 250 Type 4X stainless steel for all escalators.
- c. Controllers shall be interlocked so that all drives shall be disconnected in the off position and cannot be inadvertently started.
- d. A disconnect switch shall be provided to disconnect all ungrounded power feeders for each motor in accordance with NEC paragraphs 620-51 and 620-91.
- e. Label disconnect switches in accordance with the NEC.
- f. The main line disconnect shall be located inside the machine room near the machine room access door and easily reachable.

**13. Circuit Breakers and Panel Boards**

- a. Circuit breakers shall be the following: NEMA AB 1, UL 489, molded-case, bolt-on quick-make/quick-break, mechanically trip-free switching mechanism, with thermal trip for inverse time delay overcurrent protection and magnetic trip for instantaneous short-circuit protection. Designed to carry continuous rating in ambient temperature of 40 degrees Celsius.
- b. Panelboards shall be the following: UL 50, NEMA PB 1, latch and handle in accordance with UL 50, minimum side gutter size of four inches, bus bar of 98-percent-conductivity copper with contact surfaces silver-plated or tin-plated, rating of neutral and ground buses equal to phase bus rating, neutral bus mounted on insulated block, neutral and ground buses equipped with integral mechanical connectors, one-inch high engraved plastic nameplate with 1/2-inch high letters on black and attached with stainless steel fasteners.
- c. Enclosures shall be NEMA 250 Type 3R for mezzanine to platform escalators in underground stations and panelboard in NEMA 250 Type 4X box for all other escalators.

14. Switches, Indicators and Controls
  - a. All switches, indicators, and controls and their respective housings and fittings shall be suited for the operations and environmental conditions specified in Section 1.05 of these Specifications. Those components and fittings that may come in contact with water or dust environment, and in other ways are not protected, shall be in NEMA 250 Type 4X enclosures.
  - b. Indicator lights, two with red lenses, two-inch diameter Plexiglas 2423 or approved alternative, and two with two-inch diameter green lenses, Plexiglas 2092 or approved alternative, shall be provided at the upper and lower landings of each escalator to indicate to approaching passengers the direction of travel of the escalators.
  - c. One red and one green light shall be located on the right hand side of each escalator landing. A green light shall indicate that the escalator is moving away from the landing being approached. A red light shall indicate that the escalator is moving toward the landing being approached. Each green and red pair may be a single fixture with dual lamps. Red light lens shall be equipped with the international no entry symbol silhouetted over the red lens.
  - d. Indicator lights shall be vandal-resistant with easily replaceable long-life LED lamps. Lens shall be held secure and resist external pressure.
  - e. Shop drawings showing complete details shall be submitted to the Authority for approval.
15. A protective rubber mat shall be installed for the main and AC drive controller cabinets.
  - a. Floor mat of solid construction, ¼ inch thick with beveled edges shall be placed in front of the permanently mounted electric equipment in escalator machine room/control spaces and escalator pits. Rubber mats shall be noncombustible.
16. Electric power receptacles shall be furnished and installed in the upper and lower pits and along the escalator trusses as well as escalator machine room. .
  - a. Each receptacle shall be duplex, of specification grade, ground fault circuit interrupter type, resettable at the receptacle; waterproof; grounded; and rated for 120 volts at 20 amperes.

- b. The receptacles in the pits shall be surface-mounted on the walls, not less than 30 inches from the floor.
  - c. The receptacles mounted along the escalators shall be mounted directly on a truss member at the location at minimum 15-foot intervals.
  - d. A receptacle shall be mounted near the remote control panel.
17. All maintenance lighting shall be furnished and installed with quick start type PL LED type and LED strip lighting as required for complete illumination of working spaces and specified areas within the escalator machine room, the interior of the escalator and its immediate surroundings.
- a. The escalator machine room shall have illumination of 19-foot candles minimum. The light switch shall be on the lock-jamb side of the access door.
  - b. Upper and lower pits shall have internal lighting of 15-foot candles minimum.
  - c. Separate panel circuits shall be provided for pit lights and stair and truss lights.
  - d. A separate vapor-tight service light with quick start type PL LED compact fluorescent lamp shall be furnished, installed, and connected to the emergency lighting circuit to illuminate the entry.
  - e. A main light switch of specification grade shall be located at the entry to the pit.
  - f. Provide maintenance lighting for the remote control panel.
18. Electric Heating
- a. Electric heaters shall be provided where required to permit sustained performance and maintenance of all escalators exposed to the outside environment.
  - b. Wellways shall be equipped with thermostatically controlled heaters to maintain a wellway temperature of 50F.
  - c. Heaters shall be provided to maintain the handrail steps, comb plates, landing plates and floor plates free of ice and snow while the escalators are running or idle. Heaters and mounting devices shall be of corrosion resistant materials.
  - d. Boxes associated with the heater shall be installed so that their covers are easily accessible and unobstructed by other components. No boxes shall be installed inside the

step band. Boxes may be installed behind the removable balustrade panels.

19. Escalator Lighting Fixtures

- a. The built-in escalator lighting fixtures shall be furnished and installed complete with all conduit, wiring, and accessories.
- b. Fixtures/light box assemblies shall be UL-listed and labeled and shall be as shown and specified. LEDs lightings and associated parts shall be replaceable without a requirement to disassemble the balustrade or other parts of the escalator.
- c. Type CST, Continuous Strip balustrade and cladding lighting fixture shall be enclosed and recessed and shall deliver a minimum of five foot candles on any portion of the step treads.
  - a) The fixtures shall be suitable for wet locations.
  - b) Individual lighting fixtures along the length of the balustrade may be acceptable so long as specified foot candles are provided on the steps.
  - c) Lamps/ LED stripe shall be compatible with the fixtures.
  - 2) The housings shall be fabricated of steel, welded all around.
    - a) The housings shall have a lens opening width of 4 inches.
    - b) The housings in the balustrade must slip over the skirt, be mounted securely to the escalator truss and provide structural reinforcing of the skirt.
    - c) The interior finish shall be baked aluminum enamel (BAE) with curved, interior reflectors for maximum light distribution.
    - d) The bezel plate trim shall be attached to the escalator with tamper proof screws, and designed to fit securely against the balustrade and cladding with suitable gasketing to prevent light leakages and the intrusion of dust or moisture into the fixture.
    - e) Bezel trim finish plates shall match the adjacent material and finish.

- 3) The lenses shall be white polycarbonate.
- 4) LED strip light shall be enclosed, the lights shall be UL listed and waterproof. Contractor shall submit the manufacture of the light and detail information to WMATA-ELES engineering for approval. The lighting shall have minimum life of 50,000 hours.
  - a) The ballast shall be electronic, instant start, high frequency type rated 0 to 300EF and shall be installed under/within the housing, under the lamp, for easy removal and installation, and to maintain the continuity of the lighting strip.
  - b) All fixtures shall be hardwired to the branch circuits, protected by GFCI in the panel.
  - c) Wiring outside of the light boxes shall be in galvanized rigid conduit or liquid-tight flexible metallic conduit.
  - d) Wiring inside shall be in rigid pipe or liquid-tight flexible metallic conduit.
  - e) Each light box shall be electrically grounded by means of the equipment grounding conductor from the branch circuit. Additionally, each light box is to be electrically bonded to adjacent light boxes by means of a green jumper wire sized per overcurrent protection.
  - f) Light box assemblies shall be grounded and personal protected against shock hazard by means of a ground fault circuit interrupter which has a sensitivity of not more than 5 mA.
  - g) The fixtures shall be configured with gasketed hand holes at each end.
  - h) The balustrade lighting must be electrically independent of the operation of the escalator.
- 5) Wiring shall be configured to insure that each step has lighting from at least one side at all times. Ground escalator lighting fixtures to equipment grounding bar associated with ac power feeder by using separate insulated annealed copper grounding conductor, size governed by NEC paragraph 250-95.
  - d. Step demarcation lights (located below the steps at both landings) shall be in accordance with ASME A17.1.

- e. No joints or splices shall be permitted in wiring except at outlets. Tap connectors may not be used. All terminations shall be made within boxes at terminal strips or devices. All wiring shall be run in conduit.
20. Fixtures, Bodies, Reflector Plates, Channels. End Caps and Castings.
- a. Except as shown otherwise, materials for fixture bodies, reflector plates, channels, end caps, and castings shall be as follows:
    - 1) Steel for Type CST fixtures shall be precision die-formed of not less than 16-gauge prime cold-rolled steel with anti-rust primer and baked enamel finish all over or painted surface of equivalent durability.
    - 2) Fixture bodies, reflectors, channels, end caps, and castings shall be so formed as to prevent buckling or distortion. Reflector plates shall conceal all wiring and be easily removable by one man without special tools. Reflector plate fastening device shall be of rugged construction and provided with an approved grounding bond to the fixture. At least two wire clips shall be provided in the wiring channel for support of wiring. Wiring channel shall be UL-listed.
    - 3) All construction seams and joints shall be continuous-welded and ground smooth before finishing. Fixtures shall have mechanically self-retaining neoprene gaskets where shown or specified.
    - 4) Dissimilar metals shall be jointed in a manner to preclude electrolytic corrosion.
21. Ballasts shall be hybrid electronic, high frequency or electronic, instant start, high frequency type rated 0E to 300EF.
22. The lamps shall be furnished and installed by the Contractor as specified.
- a. All lamps shall be guaranteed for 90 days after Final Acceptance and the Contractor shall replace those lamps which fail during this guarantee period within eight hours after request by the Authority.
23. Lenses and Diffusers:

- a. All lenses and diffusers shall be of one-piece construction made of polycarbonate plastic, 0.125-inch minimum thickness.
    - 1) The plastic shall be non-flammable as determined by ASTM D635, "Flammability of Self-Supporting Plastics".
    - 2) The plastic shall not change color materially when lighted by 4500 degree Kelvin fluorescent lamps.
    - 3) The plastic shall show no yellowing apparent to the naked eye after 500 hour exposure to lamp source under conditions identical with those existing in the fixture in which it is to be used.
  - b. The light transmission range for the clear polycarbonate sheet shall be from 82 to 89 percent.
  - c. The plastic shall be non-electrostatic or the finished parts shall be treated with an anti-static wax. The wax shall not affect or alter the optical properties of the fixture.
24. All lampholders shall have a glazed porcelain body-type with nonferrous metal components and be of heavy-duty design. Incandescent lamp holders shall have a mechanical self-retaining neoprene jacket to provide a dustproof seal between bulb and socket.
25. Latch and release mechanism, hinges, pins and other operating parts of the fixtures, screws, or other assembly and mounting parts shall be manufactured of stainless steel, precision quality, positive in operation and rugged in construction.
- a. All exposed hardware to be same material and finish as adjacent balustrades or cladding.
  - b. All springs shall be heavy-duty stainless steel.
  - c. All operating hardware shall be self-retaining.
26. Seismic Loads
- In accordance with VA-USBC 2006, all structures shall be designed to resist the effects of earthquake motions.

## **2.04 ACCESSORIES**

- A. Smoke Detection

1. Fire and smoke detection devices which will shut off all entering escalators will be furnished and installed by other trades. An interface terminal box shall be furnished and installed. A 4-inch by 4-inch electrical box and flex conduit into the control panel shall be furnished and installed. The ¾-inch conduit into the 4-inch by 4-inch electrical box will be provided by other trades.
2. Location of terminal box to be coordinated with applicable trades. Interconnecting wiring between the fire and smoke alarm panel and terminal box will be furnished and installed by other trades.
3. Coordination shall be done with all applicable trades to allow installation of the equipment as required and make operational checkout within the wellway.
4. The fire and smoke alarm system shall be interfaced with the escalator controller in such a way that upon activation of the fire or smoke alarm, only entering escalators shall be stopped. Once stopped, escalators shall be capable of being reversed and started in an exiting direction only. Non-running escalators shall be capable of being started only in the exiting mode.

**B. Smoke Detection Control Relays**

1. Relays energized from the fire detection system shall be ordinary acting relays enclosed in polycarbonate dust covers. The relays will be provided by other trades.
2. Contacts interfacing the escalator control equipment shall be electrically compatible with the equipment they are serving.

**C. Kiosk Escalator Remote Surveillance and Control**

1. The kiosk contains an annunciator panel provided by trade communications which displays escalator status. An interface terminal box shall be furnished and installed by the Contractor in the upper or lower pit. Location of terminal box to be coordinated with the appropriate trades. Interconnecting wiring between the kiosk annunciator panel and terminal box will be furnished and installed by other trades. Coordination by the Contractor among trades is required to ensure the kiosk panel reports escalator functions correctly.
2. The following status indications and control functions shall be furnished for inclusion on the annunciator panel:
  - a. Indication of direction of travel (two modes).
  - b. "Out of Service" indication.
  - c. A provision for flashing the "Out of Service" indication to indicate that the escalator has stopped due to the activation of any safety device.

3. Coordination of design shall be done with the Contractor, and the specified devices necessary to provide a complete electrical installation shall be furnished and installed. All necessary wire and conduit runs from the escalator control circuits to the interface box shall be furnished and installed, and final connection to the appropriately identified terminals shall be made. All work shall be in accordance with all applicable codes and regulations.
- D. Kiosk Status Interface Contacts: All contacts wired to the interface terminal box shall be metal-to-metal dry contacts and shall be capable of carrying and breaking a maximum resistive load of one ampere at 24 volts DC. Contacts shall be hermetically sealed or otherwise protected from deleterious effects from the environment in which they are installed.
- E. Comb Plate Lighting Fixture
1. Each escalator shall be equipped with LEDs light fixture.
  2. Fixture housings may be constructed of die cast aluminum alloy and be equipped with two cable entries to facilitate through wiring. Fixtures shall be UL listed as suitable for wet locations. A polycarbonate high density, UV stabilized, impact resistant diffuser shall be sealed to the housing with extruded closed cell ethylene propylene diene terpolymer (EPDM) gasketing and held in position by the housing frame. The housing frame shall be secured by tamper proof set screws. A full opal lens shall be provided. An electrically applied baked enamel finish shall be provided on aluminum surfaces. Finish shall meet or exceed all AAMA requirements for 5,000-hour salt exposure. The interior of the housing body shall be white enameled.
  3. Fixture shall be "Quality Lighting" ST-9-0 or approved alternative. Each fixture shall be hardwired to the branch circuit. Separate aluminum from dissimilar metals and ground fixtures.
- F. Signs and Illuminated Indicators
1. The signs, including escalator cautions signs at the upper and lower landings, both illuminated and unilluminated, which attach to the escalator, as required for the proper and safe unattended operation of the escalators, shall be furnished and installed.
  2. One portable sign shall be provided for each landing for all escalators. The signs shall be reversible with both sides finished in brown porcelain conforming to Federal Standard 595A, Color 20040.
  3. Camera-ready artwork will be furnished by others for application in porcelain; one side of each sign shall bear the words PLEASE USE OTHER ESCALATOR in white letters. Signs shall be durable, easily stored, and designed for attachment to support means provided in all escalator balustrades.

4. Signs and illuminated indicators shall conform to all applicable ADAAG requirements.
  5. All escalators shall be permanently numbered at the top and bottom right hand newels with number designations corresponding to the indications on the kiosk annunciator panel. A station sketch showing the escalator numbers shall be submitted for WMATA ELES Engineering. Number escalators in sequence, starting at the north entrance (left to right, looking UP from bottom) of each station and proceeding clockwise around the station. The numbering shall proceed into the station toward the end of the plate form. Corresponding numerical identification shall be affixed to the equipment in the machine spaces. Markers for newels shall be constructed of 15 MIL, transparent, non-glare General Electric Lexan or approved alternative. Adhesive shall be 3M hi-performance #468 double thick adhesive or approved alternative, heat-laminated to the marker. Numbers shall be sub-surface screen printed and vandal resistant. Markers shall be laser die cut with rounded corners for increased durability and vandal resistance.
- G. Locks and Keys:
1. All key switches shall be of the tumbler or cylinder type.
  2. An Allen Bradley 30 mm key switch with D018 key, Cylinder Model #800T-J631KC1 shall be used.
  3. Keys shall be stamped with the inscription "TRANSIT AUTHORITY - DO NOT DUPLICATE" and with visual key control data.
  4. Five keys shall be supplied with each escalator.
- H. Drain System
1. Floor type drains will be provided in all outside entrance escalator machine rooms and/or pits or both by other trades. Drain pans to the floor drains shall be connected and suitable grease traps provided per applicable EPA regulations. Access for cleaning grease traps and floor drains shall be provided.

2. Provisions shall be made for the capture and containment of oil/grease from the escalator. The oil/grease shall be captured either by a longitudinal drain pan under the length of each escalator drive chain or by the escalator drain pan itself. A method of cleaning both the longitudinal drain pan (if used) and the escalator drain pan itself shall be provided. A method of accessing and emptying the interceptor(s) shall be provided. The interceptor(s) shall be constructed of stainless steel equal to the gauge and strength of the escalator drain pan. The interceptor(s) shall consist of a 2 inch elevated drain, outer container, and internal gate(s). The oil/grease storage capacity of the interceptor shall be 2 fluid quarts per escalator drive chain handled. The interceptor(s) shall fit into the escalator pit without modification to the pit.
3. Retractable or non-retractable ladder shall be installed in the pit of each escalator, where the pit extends more than 35 in. below the sill.
  - I. Electrical Interlock
    1. Where indicated on the contract drawings, the Contractor shall provide gate limit switches and the necessary wiring to prevent escalator operation in the direction leading toward the gate if the gates are not fully open. The interlock shall not preclude escalator operation in a direction moving away from the gate. The required connections to the escalator circuits shall be made.

## **2.05 FINISHES**

- A. Stainless steel: For cladding finish exposed to view, use manufacturer's Standard No. 4 satin polished finish. Stainless steel shall be finished to match adjacent escalator surface.
- B. Aluminum castings and extrusions: Manufacturer's standard commercial mill finish.
- C. Galvanized: For sheet steel, use ASTM A653 as applicable with coating designation of G185. For other galvanizing, use ASTM A385 and ASTM A123. For touch-up galvanizing, use zinc dust coating conforming to MIL PRF 26915. Galvanizing process shall not result in a loss of metal ductility.

## **PART 3 – EXECUTION**

### **3.01 PREPARATION**

- A. General

1. The Contractor shall become thoroughly familiar with the related work and shall coordinate and schedule escalator delivery and installation with the work of others and the site availability schedule. The Authority shall be notified of intended delivery dates no less than 30 days prior to the dates. No deliveries shall be made without prior approval of the WMATA.
2. The dimensional survey of wellways shall be conducted prior to fabrication, delivery and installation of trusses. The Authority shall be notified immediately of all field-verified structural dimensions which do not conform to the drawings so that the Contractor can take corrective action. If the wellways are not available at this time for dimensional survey, the escalators shall be designed and fabricated in accordance with approved structural shop drawings.

**B. Structure**

1. The structural elements required to support the escalators and to withstand the forces and loads resulting from use of the escalators will be provided in accordance with the requirements shown on the drawings. The escalators shall be designed, fabricated, and installed to be compatible with the structures and equipment room spaces as designed, and in accordance with the current version of ASME A17.1 except as modified by these specifications.

**C. Alterations**

1. Alterations of any structures or systems necessary to accommodate the escalator installation and maintenance such as cutting of walls, floors, and repairs as required, shall be submitted to the Authority for approval and such work performed at no additional cost to the Authority.

### **3.02 INSTALLATION**

**A. General**

1. Entrance escalators shall be installed under canopies. The size and location of each canopy shall be verified prior to the delivery of truss to insure that the fabricated escalator can be installed.
2. The station construction drawings have placed the working point of all the escalators on the finished floor line, thus causing the upper and lower landing areas to slope away from the escalators. The drawings shall be referred to showing the location of the working point placement.

**B. Controller Room Equipment:**

Escalator controller room shall be 168 sq.ft. minimum.

1. Clearance around equipment in each machine room shall comply with provisions of all applicable codes. The ASME A17.1 code requirements for the machine room clearances shall be applied in addition to the code specified clearances for escalator machine room/control room.
2. Equipment in escalator machine room shall be arranged so that replaceable items can be removed for repair or replacement without the need to dismantle or remove other equipment components in the same machine room.
3. Drive controller and main controller enclosures shall be right-or left-hand as required to provide necessary work space around the equipment in machine room.
4. Any component attached to the controller shall have a minimum clearance of 18 inches from the side(s) of the component requiring access for maintenance and free air circulation.
5. Layout shall be designed to allow safe access to controllers and minimize piping bends and provide ease of access for service and repair.
6. Upon approval, one set of plastic or laminated electrical diagrams of each escalator shall be provided. The diagrams shall be mounted in an aluminum channel frame with Lucite cover and waterproof fiberglass backing and installed adjacent to the appropriate controller.
7. A permanent rubber floor mat of solid construction, 1/4-inch thick, shall be provided with beveled edges in front of the permanently mounted electric equipment in escalator machine room/control spaces and escalator pits. Rubber mats shall be noncombustible as defined in 1.01 B. 5. Rubber mats shall be inches wider than the controller on all sides
  - a. The Resistance range shall be  $1 \times 10^4 < 1 \times 10^6$  and shall meet ANSI/ESD requirements.
  - b. The rubber mat shall be the width of the controller plus 12".
  - c. The length of rubber mat shall be a minimum of 24".
  - d. The rubber mat shall be a 1/4" thickness and beveled at each end.
8. Controller rooms must be air conditioned and heated to maintain an ambient temperature of 50<sup>0</sup>F to 90<sup>0</sup>F degrees and a relative humidity between 35% to 50%. The Air Conditioner shall be Split System. The heating system for the machine room is also a built in system. A forced removal should be done by moving the air from the room to the outside of the building to keep an air exchange through the

equipment room. Intake and exhaust vent should not be located close to each other.

9. Machine room lighting shall provide an illumination level of 19fc minimum at the floor when measured at any location in the room.
  10. Machine Room Emergency Lighting: Maintained Emergency lighting fittings shall be provided in each elevator machine room.
    - a. There shall be a minimum of one maintained lighting fixture.
- C. Install controllers and electrical panels outside the pit or truss area in environmentally protected areas such as a machine room or a purpose built control space which meets the requirements, and ensure that these components are protected from water and de-icing salts.
1. All controllers and electrical panels shall be mounted on strut channels to hold the enclosures away from the wall. The strut legs should be at least 1 ¼" deep.
- D. A metal cabinet of suitable size shall be provided in each machine room for the storage of special tools and necessary spare parts. The cabinet shall be mounted on legs or a pedestal, a minimum of 4 inches off the floor. A Mobile Tool Storage Cabinet with wheels is not allowed.
- E. Miscellaneous Work by Other Trades
1. The furnishing and installing of electrical and non-electrical signs for escalators, which are not a part of the escalator.

### **3.03 FIELD QUALITY CONTROL**

- A. Provide a quality control program for approval by the Authority.

### **3.04 DEMONSTRATION**

#### **A. General**

1. Before an escalator is put into interim service, that escalator, or one of the same rated load and type shall be tested with full design load in accordance with ASME A17.1 and ASME A17.2. These design loads shall include all above rated loads including, but not limited to, a static load of 674 pounds per exposed step, a live load of 320 pounds per exposed step in the downward direction and 300 pounds live load in the upward direction. The tests shall be conducted either in the Contractor's plant or after installation in the presence of the Authority or their designated representative after the installation is completed. The tests shall demonstrate to the satisfaction of the Authority that all the requirements of this Contract have been complied with. Applicable provisions of the Code Practices for Inspections of Escalators, ASME A17.2, Part III (and supplements) shall apply. Additional testing shall not be required if the supplier has previously provided WMATA with an escalator of the same rated load and type, and successfully passed the required testing.
2. The testing shall satisfy the requirements of the local jurisdiction and this specification.
3. Every escalator shall be marked with the rated load and speed for which that size and type has been tested and approved. Such markings will be accepted in lieu of actual tests at the installation.
4. After installation, each escalator shall be tested without load by the Contractor in the presence of the WMATA shall include tests as follows:
  - a. The over speed protection device shall be tested by operating the escalator at the speed which trips the overspeed device. Verify compliance with Code requirements.
  - b. The handrail tension malfunction device shall be tested manually.
  - c. The broken chain protection shall be tested by operating the escalator at rated speed and tripping the broken chain device by hand.
  - d. The device providing against sudden and unusual strains on the step chains shall be tested by operating the device by hand.

- e. All push buttons, starting switches, relays, interlocks, and controls required in connection with the work shall be inspected and tested to prove that the complete escalator functions properly under any and all conditions of operation within the limits specified.
  - f. Brakes and driving machinery shall be tested for operating efficiency, ease of adjustment and temperature limits. Test and record brake torque.
  - g. The device which removes power and stops the escalator in the event an article becomes wedged between the comb plate and a step tread.
  - h. The device which removes power and stops the escalator in the event an object is carried into the handrail entries.
  - i. The device which removes power and stops the escalator in the event either handrail breaks, stops, fails to travel on escalator start-up or the handrail tensioning device fails.
  - j. The devices installed behind the upper and lower landing skirt panels which remove power and stop the escalator in the event the skirt panels are forced away from the steps.
  - k. All AC conductors before being connected shall withstand a 1,000 volt D.C. megger test, the voltage being applied between each conductor and ground for a minimum of 1 minute. Each conductor shall show an insulation resistance to ground of not less than 2 megohms.
  - l. Instruments, electric power, other necessary facilities and all labor required for the tests specified herein shall be furnished by the Contractor at no additional expense to the Authority. All test data shall be certified.
  - m. Noise level as specified in paragraph 1.05.
  - n. Vibration level as specified in paragraph 1.05.
- 5. Inspections: A Final Acceptance inspection shall be conducted by WMATA Representatives prior to acceptance inspection by the AHJ.
  - 6. All malfunctions and deficiencies revealed by the tests shall be immediately corrected by the Contractor at no additional cost to the Authority.
  - 7. Performance Guarantee: Should any of these tests identify any defects or evidence of poor workmanship, any variance or noncompliance with the requirements of the specified codes, ordinances or these specifications, the following work and or repairs shall be complete at no expense to the Authority.

- a) Replace equipment that does not meet code or specified requirements.
- b) Perform work and furnish labor, materials and equipment necessary to meet specified operation and performance.
- c) Perform and assume cost for re-testing required by Governing Code Authority and the Authority to verify specified operation and performance.

8.

### **3.05 PROTECTION**

- A. The Contractor shall be responsible for the security of the contents of each machine/controller room. The Contractor shall control access to that room, and ensure that it shall remain secure at all times until the completion of the Contractor's interim maintenance obligation.
- B. Do not proceed with remainder of the work until the demonstration, installation, procedures and personnel are approved.

### **3.06 MAINTENANCE:**

The Contractor shall perform full maintenance service for a period of two years on each escalator in accordance with the manufacturer's maintenance manual and WMATA ELES maintenance program prior to WMATA providing permanent maintenance. The period of maintenance shall begin after test(s) and Provisional Acceptance of each escalator and shall extend to the scheduled date of Final Acceptance for all units in the same facility plus a period of two years. In no case shall the interval between inspections and testing be greater than one month. The maintenance service during the warranty period shall be provided by fully trained escalator mechanics. The maintenance tasks shall include, but not limited to, the following:

- a. Inspection of completed installation and periodic testing to maintain the escalators in completely operable condition.
- b. Contractor shall provide support for periodic, accident and incident, PM compliance inspections.
- c. Lubrication of parts, and the protection of the equipment.
- d. Replacement of defective parts at no additional cost to the Authority.
- e. Annual clean down of the escalator and wellway enclosure is required. Make necessary arrangements with Authority in order to minimize any inconvenience.
- f. Contractors performing maintenance are responsible for all service, repair work and emergency call. The contractors shall provide unlimited service during revenue hours and twenty-four (24) hour (including Holidays) emergency call back service at no additional cost.

- 1) Provide twenty (24) hour (including Holidays) emergency service during the maintenance period consisting of a prompt response (within 1 hour) to emergency request by phone or otherwise from Authority or designated representative if an escalator is inoperable or in case of injury or potential injury to persons.
  - 2) Unlimited service callbacks are included with a required response time of one (1) hour (included Holidays).
- g. Periodic maintenance (based on WMATA schedule) shall be performed off peak hours to minimize service interruption.
- h. Reporting: Detailed monthly records of tasks performed including names of individuals performing the tasks, date and time performed, and other pertinent data. In addition, the reports are to be provided in an electronic format acceptable to WMATA's needs.
- i. Contractor performed maintenance shall follow the WMATA Office of Elevator and Escalator Operations procedures, schedules and check charts.
- j. Within three (3) months prior to the termination of this contract, the Authority or his designated representative(s) shall make a thorough maintenance inspection of all equipment covered under this contract. The contractor shall provide personnel to remove, test, and operate equipment as necessary. All deficiencies found as a result of this inspection shall be corrected by the Contractor as required in this agreement with no additional cost to the Authority.

### **3.07 REMOTE MONITORING SPECIFICATIONS:**

- A. Allen Bradley DF1 or industry standard Modbus protocol shall be provided to transmit data from the Elevator/Escalator controller to the Authority's AEMS RTU computer control and data system. The Design-Builder shall provide a controller data interface to a DH-485 network located in the Elevator /Escalator machine room. The DH-485 controller interface shall be programmable for data rates up to 115Kbps. The interface shall allow other nodes such as other Elevator or Escalators to be readily incorporated into the DH-485 network. The controller data interface shall include one Allen Bradley SLC PLC per station to function as a data concentrator to consolidate data from all the controllers in the station. The software for the data concentrator shall be as specified by the Authority. The data concentrator shall receive controller data over the DH-485 data network and provide formatted data to the AEMS RTU through a RS 232 link. This data transmission may be accomplished by a separate PLC controller integrated into the control system.
- B. The Elevator /Escalator control system shall automatically initiate the transmittal of data when data is requested by the Authority's AEMS system and continue until all data is received by the AEMS RTU in the station AC switchboard room. The Authority will perform final integration of the data in the AEMS system.

- C. The Contractor shall also provide the required hardware to download data from any fault finding annunciator panel to a supplied laptop PC being utilized at the Elevator/Escalator location. The provided software shall permit the downloading and storage of data on the supplied laptop PC from multiple fault finding annunciator panels.
- D. The Contractor shall install an Allen Bradley network interface module, (model 1761-NET-AIC, or approved alternative) beside the PLC in the controller and provide 24 VDC power to the module. The Allen Bradley PLC will be used for remote monitoring capabilities into WMATA established engineering monitoring network.
  - 1. Contractors shall provide all the wiring and program the PLC to communicate with station data concentrators on the DH-485 network. Coordination can be made with WMATA ELES Engineering.
  - 2. The Contractor shall pull all remote monitoring cables to the interface in the escalator controller from the remote monitoring network going back to WMATA's Automated Energy Management System (AEMS) remote terminal unit (RTU).
  - 3. Provide Ethernet communication between the elevator machine room and WMATA's communication room. The communication port shall be located less than 6' from the controller and shall have minimum of two ports for data communication.

## **1. ESCALATOR REMOTE MONITORING DATA SPECIFICATION**

### **Overview**

The design of the WMATA escalator & elevator monitoring system shall include a data concentrator PLC to gather data from the escalator control PLC's over an Allen Bradley DH 485 network. The QEI RTU shall read data from the WMATA data concentrator PLC via an RS 232 serial connection to a 1746-BAST module using Allen Bradley DF1 protocol. See figure 1.1 for reference. This specification defines data to be presented by the WMATA data concentrator PLC to the QEI RTU. The WMATA data concentrator PLC station shall poll the escalator & elevator controller(s) periodically for data and format the data into blocks within the WMATA data concentrator. An Ethernet TCP/IP connection is available at the Data concentrator PLC for future connection. The data concentrator PLC has been designed to collect data from up to (10) escalators and/or elevators. The data concentrator PLC is to be mounted into the existing QEI RTU enclosures and powered by a 120 VAC source from within the RTU. For Metro stations where more than (10) escalators and elevators are present additional data concentrator PLC's will be required.

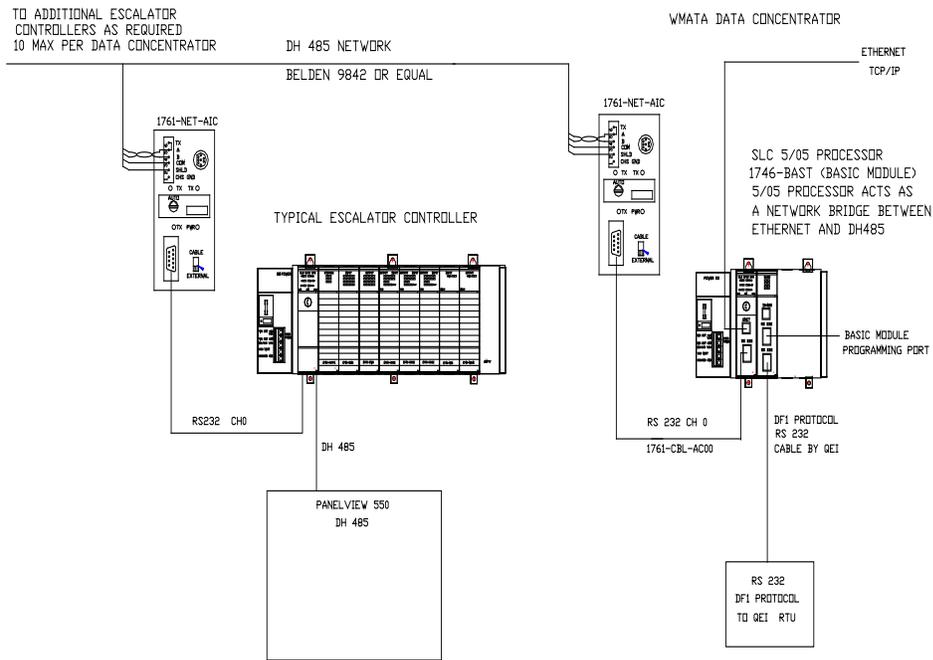


Figure 1.1

**2. Data Concentrator PLC Data File Assignments.**

The WMATA data concentrator PLC shall store data for up to (10) escalators and/or elevators in any combination as defined in table 2.1.

**Table 2.1**

Escalator DH485 node #	Elevator DH485 node #	Status bits File	Analog Data File	DC PLC MSG file#	DC PLC MSG buffer file#
1		N20	N21	N81	N101
2		N22	N23	N82	N102
3		N24	N25	N83	N103
4		N26	N27	N84	N104
5		N28	N29	N85	N105
6		N30	N31	N86	N106
7		N32	N33	N87	N107

8		N34	N35	N88	N108
9		N36	N37	N89	N109
10		N38	N39	N90	N110
	11	N40	N41	N121	N141
	12	N42	N43	N122	N142
	13	N44	N45	N123	N143
	14	N46	N47	N124	N144
	15	N48	N49	N125	N145
	16	N50	N51	N126	N146
17		N52	N53	N127	N147
18		N54	N55	N128	N148
19		N56	N57	N129	N149
20		N58	N59	N130	N150
Data Concentrator PLC (DC)	25	N80	N79		

Each data file shall begin with word 1 (example: escalator #1 status bits begin with N20:1 and end at N20:20)

The data concentrator PLC communication ports shall be configured as follows.

**Channel 1**

Driver: Ethernet  
IP Address: TBD  
Subnet Mask: TBD  
Gateway Address: TBD

**Channel 2**

Driver: DH485  
Baud Rate: 19.2K  
Node Address: 25

1756-BAST basic module communication ports shall be configured as follows.

**Port 1:** Programming port

Settings -- 19,200 Baud, No parity, 8 bits, 1 stop bit, No handshaking

**Port 2:** DF1 port

Settings -- 19,200 Baud, No parity, 8 bits, 1 stop bit, No handshaking

DF1 – Op Code 19 (Full Duplex, NHS, ER, Enable DPD, CRC error checking,

Timeout = 50

Retries = 3

RTS on delay = 20 msec

RTS off delay = 20 msec

Module address = 10

**DH485 Port** – Not Available

**3. Data Format**

Data Concentrator status in File N80 per table 3.0

**Table 3.0 Data Concentrator Status Bits**

WORD	BIT	DATA TYPE	DESCRIPTION	"0" STATE	"1" STATE
1	0	BOOLEAN	Spare		
	1	BOOLEAN	Data Concentrator PLC Battery Status	FAULT	NORMAL
	2	BOOLEAN	Data Concentrator Basic Module Battery Status	FAULT	NORMAL
	3	BOOLEAN			
	4	BOOLEAN			
	5	BOOLEAN			
	6	BOOLEAN			
	7	BOOLEAN			
	8	BOOLEAN			
	9	BOOLEAN			
	10	BOOLEAN			
	11	BOOLEAN			
	12	BOOLEAN			
	13	BOOLEAN			
	14	BOOLEAN			
	15	BOOLEAN			

WORD	BIT	DATA TYPE	DESCRIPTION	"0" STATE	"1" STATE
2		BYTE	Data Concentrator checksum byte1		
3		BYTE	Data Concentrator checksum byte2		

Words 4 through 20 of the Data Concentrator status file (N80) are unused.

The Data Concentrator Analog data file (N79) is unused.

**Escalator data:**

Two 20 word (40 BYTE) blocks of data shall be developed for each escalator one block for status bits and one block for analog data. Table 3.1 defines the format of data for status bits. Table 3.2 defines the format for analog data.

**Table 3.1 Escalator Status Bits**

WORD	BIT	FAULT TYPE	DESCRIPTION	"0" STATE	"1" STATE
1	0	NON-LATCHED	AC OVERLOAD SENSOR FAULT(OCR)	FAULT	NORMAL
	1	NON-LATCHED	BRAKE WEAR LIMIT SENSOR FAULT	FAULT	NORMAL
	2	STATUS	BRAKE PICKED SWITCH (BK)	SET	NOT SET
	3	LATCHED	BROKEN STEP FAULT	FAULT	NORMAL
	4	LATCHED	BROKEN HANDRAIL FAULT	FAULT	NORMAL
	5	LATCHED	BROKEN STEP CHAIN FAULT	FAULT	NORMAL
	6	LATCHED	COMBPLATE IMPACT FAULT	FAULT	NORMAL
	7	NON-LATCHED	HANDRAIL ENTRY GUARD FAULT	FAULT	NORMAL
	8	NON-LATCHED	HIGH WATER	FAULT	NORMAL
	9	LATCHED	HANDRAIL OVER/UNDER SPEED FAULT	FAULT	NORMAL
	10	LATCHED	MAIN DRIVE CHAIN SENSOR FAULT	FAULT	NORMAL
	11	LATCHED	NON-REVERSAL SWITCH FAULT	FAULT	NORMAL
	12	NON-LATCHED	SKIRT IMPACT SENSOR FAULT	FAULT	NORMAL
	13	LATCHED	STEP LEVEL SENSOR FAULT	FAULT	NORMAL
	14	LATCHED	STEP UPTHrust SENSOR FAULT	FAULT	NORMAL
	15	STATUS	GATE SWITCH FAULT	FAULT	NORMAL

WORD	BIT	FAULT TYPE	DESCRIPTION	"0" STATE	"1" STATE
2	0	LATCHED	MISSING STEP SENSOR FAULT	FAULT	NORMAL
	1	NON-LATCHED	MOTOR OVERTEMPERATURE FAULT	FAULT	NORMAL
	2	NON-LATCHED	24 VDC POWER SUPPLY (C3+)	FAULT	NORMAL
	3	STATUS	BALUSTRADE STOP SWITCHES	FAULT	NORMAL
	4	STATUS	BREAK WEAR 80% SENSOR	FAULT	NORMAL
	5		FAULT LATCHED	FAULT	NORMAL
	6		FAULT NON-LATCHED	FAULT	NORMAL
	7	STATUS	FIRE & SMOKE RELAY	FAULT	NORMAL
	8	STATUS	INSPECTION	NORMAL	INSPECT

	9	STATUS	PIT STOP SWITCHES	FAULT	NORMAL
	10	STATUS	RUNNING UP	NOT-RUN	RUNNING
	11	STATUS	RUNNING DOWN	NOT-RUN	RUNNING
	12	STATUS	ESCALATOR SLC 5/03 LOW BATTERY	FAULT	NORMAL
	13	STATUS	ESCALATOR SLC 5/03 COMM. ACTIVE	FAULT	NORMAL
	14	STATUS	ESCALATOR SLC 5/03 LOCAL/REMOTE STATUS	REMOTE	LOCAL
	15	STATUS	ESCALATOR SLC 5/03 RUN/PROG STATUS	PROG	RUN

WORD	BIT	FAULT TYPE	DESCRIPTION	"0" STATE	"1" STATE
3	0	STATUS	OUT OF SERVICE	FAULT	NORMAL
	1	LATCHED	STEP ROLLER DEGRAGATION	FAULT	NORMAL
	2	LATCHED	AXLE ROLLER DEGRAGATION	FAULT	NORMAL
	3	LATCHED	AC DRIVE FAULT	FAULT	NORMAL
	4				
	5				
	6				
	7				
	8				
	9				
	10				
	11				
	12				
	13				
	14				
	15				

Words 4 through 20 are unused.

**Table 3.2 Escalator Analog Data**

WORD	DATA TYPE	MIN VALUE	MAX VALUE	UNITS	SCALE FACTOR	DESCRIPTION
1	INTEGER	0	2047	FPM	X1	HANDRAIL 1 SPEED
2	INTEGER	0	2047	FPM	X1	HANDRAIL 2 SPEED
3	INTEGER	0	2000	AMPS	X10	DRIVE MOTOR CURRENT
4	INTEGER	0	2047	INCHES	X10	BRAKE STOPPING DISTANCE
5	INTEGER	0	2047	FPM	X1	STEP SPEED
6	INTEGER					FAULT CODE
7	INTEGER					
8	INTEGER					
9	INTEGER					
10	INTEGER					
11	INTEGER					

12	INTEGER					
13	INTEGER					
14	INTEGER					
15	INTEGER					
16	INTEGER					
17	INTEGER					
18	INTEGER					
19	INTEGER					
20	INTEGER					

Note: All analog values are multiplied by 16 in the data concentrator to bit shift left 4 bits to align with QEI's 12 bit analog data types.

A note on communication loss

A 60 second watchdog timer is coded into each escalator file. If communications are lost between the data concentrator and the escalator controller for more than 60 seconds the watchdog timer will timeout. When the timer has timed out the communications loss bit will be reset (0) to indicate the communications loss condition.

#### **4. Time and date sync**

The QEI RTU shall provide clock synchronization to the WMATA data concentrator PLC every 5 minutes. Table 4.1 defines the address and data format of the clock registers in the WMATA data concentrator PLC. The data concentrator PLC shall set the escalator controller date and time every day at 3 AM.

**Table 4.1**

FUNCTION	ADDRESS	FORMAT
YEAR	N13:10	4 DIGITS
MONTH	N13:11	2 DIGITS
DAY	N13:12	2 DIGITS

HOUR	N13:13	2 DIGITS 24 HOUR
MINUTE	N13:14	2 DIGITS
SECOND	N13:15	2 DIGITS

#### **4. Data Concentrator PLC Program**

The data concentrator PLC includes code to monitor up to 10 escalators. Each escalator has an independent code file and a configuration bit. If an escalator is to be monitored the configuration bit must be set corresponding to the DH485 station address of the escalator controller. If the configuration bit is reset (0), the status and analog data table values for the escalator or elevator will be set to 0.

The configuration bits are as follows.

Escalator Configuration Bit	DH485 Address of Escalator Controller	Elevator Configuration Bit	DH485 Address of Elevator Controller
B9:0/1	1	B9:1/1	11
B9:0/2	2	B9:1/2	12
B9:0/3	3	B9:1/3	13
B9:0/4	4	B9:1/4	14
B9:0/5	5	B9:1/5	15

B9:0/6	6	B9:1/6	16
B9:0/7	7	B9:1/7	17
B9:0/8	8	B9:1/8	18
B9:0/9	9	B9:1/9	19
B9:0/10	10	B9:1/10	20

- 5. Data Concentrator Gateway IP addresses.  
The Data concentrator PLC acts as a gateway between the Ethernet and DH485 networks. The PLC contains a list of IP addresses, known as the routing table which will be allowed access to the DH485 network. The routing table will contain 20 addresses.

Station	IP Address
1	TBD
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	

14	
15	
16	
17	
18	
19	
20	

**END OF SECTION**

## DIVISION 15 - MECHANICAL

15070	VIBRATION ISOLATION
15075	IDENTIFICATION OF MECHANICAL EQUIPMENT AND PIPING
15080	INSULATION
15120	COMPRESSION TANKS
15125	PIPING CONDUIT
15135	MISCELLANEOUS PUMPS
15185	CHILLED WATER PUMPS
15186	WATER TREATMENT SYSTEM
15205	PIPING SYSTEMS
15410	PLUMBING FIXTURES
15444	DRAINAGE PUMPING SYSTEM
15445	SEWAGE EJECTORS
15480	DOMESTIC WATER HEATERS
15625	CHILLERS
15640	COOLING TOWERS
15725	VENTILATING UNITS AND HEATING EQUIPMENT
15733	AIR CONDITIONING UNITS - CHILLED WATER COOLED
15734	WATER COILS
15735	SELF-CONTAINED AIR CONDITIONING UNITS - PACKAGED
15736	KIOSK MECHANICAL WORK
15737	AIR-COOLED SPLIT-SYSTEM AIR CONDITIONING UNITS - AIR COOLED SPLIT SYSTEM
15765	HEATING EQUIPMENT
15806	AIR CONDITIONING PYLONS
15810	DUCTWORK

**DIVISION 15 - MECHANICAL (CONT.)**

15825	SOUND ATTENUATORS
15830	FANS
15850	OUTLETS AND GRILLES
15865	FILTERS
15900	CONTROL EQUIPMENT
15950	SYSTEM BALANCING AND TESTING

**END OF SECTION**

## SECTION 15070

### VIBRATION ISOLATION

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing vibration isolation for mechanical equipment and piping.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities
  - 2. ASTM: A123.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Design for concrete inertia block and structural-steel bases. Include tabulation of design data on isolators including actual deflection; outside diameter; free, operating and solid heights of isolators; method of attachment; bolt sizes; and type and sizes of anchor plates.
- B. Certification.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. General Requirements:
  - 1. Vibration isolators selected to produce uniform loading and deflection even when equipment weight is not evenly distributed; steel components hot-dip galvanized after fabrication in accordance with ASTM A123.
    - a. Types of vibration isolators:
    - b. For equipment and piping:
      - 1) Floor-mounted: Spring isolators.
      - 2) Ceiling-suspended: Suspension-type isolators.
  - 2. Spring isolators for floor-mounted equipment:
    - a. Free-standing, laterally stable without housing, complete with minimum 1/4-inch thick neoprene, acoustical friction pad in series with spring element.
    - b. Leveling bolts and adequate facilities for bolting to equipment and supporting structure using isolation washers.
    - c. Coil outside diameter: Not less than 0.8 of operating height of spring.
    - d. Horizontal stiffness: Not less than 0.8 of vertical stiffness.
    - e. Springs designed to have additional 50-percent capacity beyond rated load.
    - f. Springs designed so that ends remain parallel during and after spring deflection to operating height.
    - g. Vibration isolators selected for lowest operating speed of equipment.
    - h. Built-in adjustable limit stops with isolators provided for equipment of operating weight different from installed weights, to prevent rising of equipment when weight is removed and for equipment exposed to wind. Limit stops not to be in contact during normal operating conditions.

- i. Welding of springs to load-plate assembly for vibration isolators with capacities of 6,000 pounds or less is prohibited.
    - j. Vibration isolators with capacities of 6,000 pounds or less are permitted use of cups or other positive means for restraining springs.
  - 3. Suspension-type isolation hangers for ceiling-suspended equipment:
    - a. Combination of spring and neoprene in series.
    - b. Spring made of stable steel.
    - c. Encased in structurally stable steel bracket.
    - d. Spring diameter large enough to permit 15-degree angular misalignment of rod connecting hanger to equipment without rubbing on box
    - e. Designed to provide complete support for suspended units upon failure or rupture of isolator.
  - 4. Inertia bases:
    - a. Furnished by vibration-isolator manufacturer.
    - b. Complete with steel-reinforced concrete cast into welded structural-steel channel frame, mounting templates and brackets for vibration isolators with thickness equal to eight-percent minimum of longest base dimension.
    - c. Structural-steel work: Section 05500.
  - 5. Concrete equipment subbases (housekeeping pads)
    - a. Concrete: Sections 03100, 03200 and 03300.
    - b. Concrete subbases not less than four inches high provided for floor-mounted equipment. Subbases resting on structural floor and reinforced with steel rods interconnected with reinforcing bars of floor by means of tie bars hooked at both ends.
    - c. Clearance between subbases and inertia bases: Two inches minimum.
    - d. Subbase concrete: Class 2500, Finish No. 4.
  - 6. Snubbers:
    - a. As recommended by manufacturer of vibration isolator.
    - b. Compatible with vibration isolators provided.
- B. Isolation-Unit Types and Deflection:
  - 1. Fans, ventilating units, evaporation units and air-conditioning units: Floor-mounted and ceiling-suspended.
    - a. Spring isolators designed for a minimum of 1.5 inches deflection.
    - b. Snubbers: Where shown.
  - 2. Pumps:
    - a. Base-mounted pumps on inertia bases.
    - b. Inertia bases shaped to include base elbow supports for connected piping and at least 1-1/2 times weight of supported equipment or a minimum base thickness of eight percent of longest base dimension, whichever results in greater weight.
    - c. Springs with minimum deflection of 1.5 inches under imposed static load.
  - 3. Chillers:
    - a. Vertically restrained spring isolators designed for 1.5 inches minimum deflection. Inertia bases if recommended by chiller manufacturer.
  - 4. Self-contained air-conditioning units:
    - a. Spring-isolators designed for a minimum of one-inch deflection except through-wall units.
  - 5. Remote air-cooled condensing or condenser units:
    - a. Isolators: As specified for self-contained units.
  - 6. Cooling towers:
    - a. Steel beams mounted on vertically restrained spring isolators designed for 1.5 inches minimum deflection.
    - b. Rails: Acceptable, if performance requirements for spring isolators specified for cooling towers are met.

- c. Height of steel beams designed to support loads and eight-percent minimum of longest span between isolators.
- 7. Air compressors:
  - a. Temperature-control compressors: Spring isolators designed for 1.5 inches minimum deflection.
- 8. Piping:
  - a. Ceiling-suspended piping: Combination spring and neoprene in shear element hangers as specified for ceiling-suspended equipment. Springs designed for 1.5-inch minimum deflection. First two isolation hangers of each pipe connected to equipment to have deflection equal to equipment isolation-support deflection.
  - b. Floor-mounted piping isolated by spring isolators with one-inch minimum static deflection. First two spring isolators of each pipe connected to equipment to have deflection equal to equipment isolation-support deflection.
- 9. Grout: Section 03300, premixed shrinkage-compensating grout.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION:**

- A. Install vibration isolators where shown as recommended by the equipment manufacturer.
- B. Mount mechanical equipment on vibration isolators to isolate equipment from structure.
- C. Jack bases and equipment into position and wedge or block before vibration isolators are loaded.
- D. Use isolator leveling bolts for final leveling of equipment after equipment is in operation.
- E. Springs installed so that ends remain parallel during and after deflection to operating height.
- F. Mount snubbers as close to vibration isolators as practicable.
- G. Grout void between pump bases and inertia-base concrete.
- H. Piping connected to equipment isolated from structures as follows:
  - 1. Condenser-water piping in its entirety.
  - 2. Chilled-water piping: Piping connected to equipment, mounted on vibration isolators or suspended with vibration hangers, isolated for a distance of 50 feet from equipment. Piping with installed length less than 50 feet isolated in its entirety only when connected to equipment provided with vibration isolators.
  - 3. Compressed-air piping: Connected to compressors for a distance of 50 feet from compressor. Piping with installed length less than 50 feet isolated in its entirety.

**END OF SECTION**

## SECTION 15075

### IDENTIFICATION OF MECHANICAL EQUIPMENT AND PIPING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing nameplates and tags on mechanical equipment and apparatus.
- B. Related Work Specified Elsewhere:
  - 1. Field painting: Section 09920.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Samples:
    - a. Labels and tags in each size.
  - 2. Documentation:
    - a. Charts for valves; include valve identification number, location and purpose.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. Nameplates: Laminated plastic.
- B. Tags: 18-gauge stainless steel.
- C. Identification Plates: Bronze, Authority-furnished.

#### PART 3 - EXECUTION

##### 3.01 IDENTIFICATION:

- A. Equipment and Apparatus:
  - 1. Label equipment and apparatus with one-inch high white letters engraved on 1-1/2 inch high, black, laminated-plastic nameplates securely fastened to metal panels, showing function and unit number of item.
  - 2. Identify devices including transducers, controls and switches by means of 1/2-inch high white letters engraved on one-inch high, black, laminated plastic nameplates identifying manufacturer and function of equipment.
    - a. Provide same type nameplates on front cover for each pilot light and for mode-of-operation selector switches. Label positions of mode-selector switches AUTOMATIC/OFF/EMERGENCY EXHAUST/EMERGENCY SUPPLY for subway-ventilation fans, and LOCAL/TRACK 1/LOCAL TRACK OFF/REMOTE for jet fans..
  - 3. Nameplates for components located in fan-control cabinets to show symbol used on schematic diagram to represent component. Label fan-control cabinet terminals using same symbols and identification corresponding to that shown on schematic diagram.
- B. Piping:

1. Stencil legends and bands on piping showing service and direction of flow as specified in Section 09920.
  2. Color coding of exposed piping and terminatings of piping is specified in Section 09920.
- C. Valves:
1. Identify valves with 1-1/2 inch diameter, 18-gauge stainless-steel tags.
  2. Designate appropriate service on each tag with 1/4-inch stamped black-filled letters and valve number with 1/2-inch stamped black-filled numbers.
- D. Orifice Flange and Venturi Tube:
1. Identify each orifice or venturi tube with integral tab or stainless-steel tag.
  2. Stamp on tag differential multiplier, orifice bore, rate of flow and equipment served.

### **3.02 INSTALLATION:**

- A. Cement nameplates with permanent adhesive on equipment and apparatus.
- B. Affix labels to surface of control and switch boxes by means of sheet-metal rivets. Cement labels to surface with permanent adhesive when rivets cannot be used.
- C. Fasten tags securely to valves, orifice flange, venturi tube with brass jack chain, so as to permit easy reading.
- D. Mount valve charts in aluminum frames with clear Lucite front cover in locations as directed.
- E. Fire-Protection and Suppression System:
1. Stencil legends on piping as shown to identify service and direction of flow.
  2. Stencil vent-shaft and fan-shaft identification as shown on piping adjacent to angle hose valves in tunnels.
  3. Stamp information on Authority-furnished identification plates as shown and fasten to sleeve on siamese fire-department connections for tunnel systems as shown.

**END OF SECTION**

## SECTION 15080

### INSULATION

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing insulation.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. NFPA: 90A.
  - 3. ASTM: C240, C534, C552, C1071, E84.
  - 4. FS: HH-I-558.
  - 5. MS: MIL-A-3316, MIL-B-19564, MIL-C-19565, MIL-C-20079.
  - 6. SMACNA: HVAC Duct Construction Standards – Metal and Flexible
- B. Each item listed in UL Building Materials Directory.
- C. Fire-Hazard Ratings:
  - 1. Determine fire-hazard ratings in accordance with ASTM E84.
    - a. Insulation, fastener, and jacketing materials, except flexible cellular plastic for expansion joints: Not exceeding 25 for flame spread, 50 for fuel contributed and 50 for smoke developed.
    - b. Use of flameproofing and fireproofing treatments for the purpose of achieving specified fire-hazard ratings for insulation not meeting specified requirements is prohibited.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings.
  - 2. Certification.

##### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Label each item with manufacturer's name and brand designation, referenced specification number, type, class and thermal and acoustical rating as applicable.
- B. Ship each type of insulation and accessory materials securely packaged and labeled for safe handling in shipment and to avoid damage.
- C. Store materials in secure and dry storage facility.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. External Ductwork Insulation with Vapor-Barrier Facing:
  - 1. Insulation:
    - a. Rigid board for exposed ductwork:
      - 1) Thickness: One inch.

- 2) Density: Three pounds per cubic foot.
- 3) Vapor-barrier facing: As specified, factory-applied.
- 4) FS HH-I-558, Form A, Class 2.
- b. Flexible duct wrap for concealed ductwork:
  - 1) Thickness: Two inches.
  - 2) Density: 1.5 pounds per cubic foot.
  - 3) Vapor-barrier facing: As specified, factory-applied.
  - 4) FS HH-I-558, Form B, Type I, Class 6.
- 2. Vapor-barrier facing: foil-reinforced kraft paper.

B. Internal Ductwork Insulation:

- 1. Optional materials:
  - a. Flexible insulation:
    - 1) Thickness: One inch.
    - 2) Density: Three pounds per cubic foot.
    - 3) Smooth coating on inside.
    - 4) ASTM C1071 and NFPA 90A.
  - b. Fibrous-glass insulation:
    - 1) Thickness: One inch.
    - 2) Density: Three pounds per cubic foot.
    - 3) Perforated, galvanized-sheet metal inner lining, lining as specified.
- 2. Minimum normal incidence sound absorption coefficients based on insulation thickness of one inch:

Cycles per second	125	250	500	1000	2000	4000
Coefficient	0.11	0.22	0.60	0.85	0.82	0.91

- 3. Maximum increase in friction loss of air due to duct insulation: 15 percent at 2,000 feet per minute velocity.

C. Piping Insulation:

- 1. General:
  - a. Vapor-permeance resistance:
    - 1) Maximum vapor permeance: 0.5 percent by volume.
    - 2) Vapor-permeance ratings for piping insulation determined in accordance with ASTM C240.
- 2. Chilled-water piping insulation:
  - a. Rigid premolded cellular glass: Covered with aluminum jacket 0.016-inch thick; ASTM C552.
  - b. Rigid premolded insulation sleeving: Thermal-pipe and tube covering, mineral fiber, industrial-type covered with aluminum jacket 0.016-inch thick; ASTM C552, all-service jacket.
  - c. Insulation for buried or embedded pipe: As specified or rigid polyurethane, one-inch thick, ASTM C552.
- 3. Insulation for pump discharge lines, force sewer mains and hot/cold potable-water piping:
  - a. Pipe, valves, flanges and fittings: As specified for chilled-water piping except insulation to consist of one layer, one-inch thick.
  - b. Insulation not required on embedded or buried pipe.
- 4. Refrigerant-piping insulation:
  - a. As specified for chilled-water piping except insulation to consist of one layer, one-inch thick.

D. Chilled-Water Pump Insulation:

- 1. Rigid premolded cellular glass: Two inches thick, ASTM C552.

- E. Chiller Insulation:
  - 1. Insulation:
    - a. Semi-rigid fibrous-glass board: 1-1/2 inches thick; FS HH-I-558, Form A, Class 1.
    - b. Cellular glass, rigid blocks or boards: Two inches thick; ASTM C552.
  - 2. Vapor-barrier coating: Resistant to fire and water; MS MIL-C-19565, Type 1.
  - 3. Fire-resistant lagging adhesive: MS MIL-A-3316, Class 1.
  - 4. Metal bands for securing insulation in place: Type 316, stainless steel, minimum thickness 0.016 inches, minimum width 1/2 inch.
  - 5. Glass cloth: MS MIL-C-20079, Type I, Class 2.
- F. Air-Separator Insulation:
  - 1. As specified for chilled-water pump.
- G. Compression-Tank Insulation:
  - 1. As specified for chiller.
- H. Expansion-Joint Insulation: Flexible unicellular, ASTM C534, one-inch thickness, two layers.
- I. Wire Mesh: Galvanized wire, 22-gauge, one-inch mesh welded.
- J. Corner Beads: Galvanized steel, 26-gauge, 2 1/2-inch wings.
- K. Rigid-Insulation Adhesive and Sealer: Cold-applied, nonhardening asphaltic-type, in accordance with MS MIL-B-19564.
- L. Vinyl-Emulsion Mastic: As recommended by manufacturer of rigid insulation.
- M. Bore Coating: Anti-abrasive vinyl-base type as recommended by manufacturer of rigid insulation.
- N. Sheet Metal Duct Lining: Galvanized sheet metal, 22 gauge, perforated with 3/32-inch holes on 3/16-inch centers, with 22-percent open area.
- O. Fabric Pipe Jacket: Prefabricated laminate containing 10-by-10 asphalt-impregnated glass fabric and aluminum foil one-mil thick, sandwiched between three layers of bituminous mastic, for use on embedded or inaccessible piping.
- P. Metal Pipe Jacket:
  - 1. Galvanized sheet steel, 24 gauge (U.S.S.) having Z-type longitudinal joint seam.
  - 2. Aluminum alloy, 0.016-inch thick, mill-finish, having Z-type longitudinal joint seam.
- Q. Insulation-Hanger Shields: Aluminum alloy, minimum 0.050-inch thick, mill-finish, covering bottom 180 degrees of pipe insulation, lengths as follows:

Pipe Sizes/Inclusive	Shield Length
1/2 inch to 2 inches	6 inches
2-1/2 inches to 6 inches	9 inches
6 inches to 12 inches	12 inches

**PART 3 - EXECUTION**

**3.01 APPLICATION OF INSULATION:**

- A. General:
1. Do not apply insulation until all surfaces to be covered are clean, dry and free of foreign materials, such as oil, grease, rust, scale and dirt.
  2. Apply only clean and dry insulation.
  3. Install insulation in accordance with manufacturer's recommendations as a minimum requirement.
  4. Provide complete moisture and vapor seal wherever insulation terminates against metal hangers, anchors and other projections through insulation on cold surfaces.
  5. Provide continuous insulation through sleeves and openings except pipe sleeves piercing exterior walls, floors and ceilings below ground level.
  6. Stagger joints with respect to adjacent butt joints.
  7. Unless otherwise shown, insulate the following:
    - a. Platform and mezzanine air-conditioning supply ductwork.
    - b. Ancillary-area air-conditioning ductwork, supply and return, except ductwork within air-conditioned space.
    - c. Ancillary-area heating ductwork, ventilating ductwork and combined heating and ventilating ductwork, supply and return except ductwork within heated space.
    - d. Outside-air intake ductwork.
    - e. Exhaust-air ductwork between automatic damper on discharge side of fan and louver, except underplatform and dome exhaust-air ductwork where insulation is not required.
  8. The Contractor has the option of applying insulation internally or externally, except for the following required internal applications:
    - a. Where shown.
    - b. Insulated ductwork exposed to weather.
    - c. Air-conditioning pylons.
    - d. Air-conditioning ductwork under platform.
- B. External Ductwork Insulation:
1. Install insulation continuously through openings provided for passage of ductwork and unbroken over seams, angles, hangers and other accessories.
  2. Do not use scrap pieces of insulation to make up full-length sections. Eliminate voids by refitting or replacing insulation.
  3. Rigid board for exposed ductwork:
    - a. Fasten to duct with mechanical fasteners spaced 12 inches to 18 inches on center, with minimum of two rows on each side of duct.
    - b. Secure with washers firmly embedded in insulation.
    - c. Seal joints, breaks and punctures with fire-resistant vapor-barrier coating reinforced with a three-inch wide vapor-barrier strip.
  4. Flexible duct wrap for concealed ductwork:
    - a. Adhere to duct with fire-resistant adhesive in sufficient quantities to prevent sagging.
    - b. Secure insulation tightly to the ducts with Type 316 stainless-steel insulation bands spaced 12 inches maximum center-to-center.
    - c. For duct widths over 30 inches, secure on underside of duct with mechanical fasteners on 18-inch centers.
    - d. Butt insulation, overlap joints with vapor-barrier facing two inches minimum; seal with fire-resistant vapor-barrier adhesive.
    - e. Seal breaks and punctures with vapor-barrier strip and coating.
- C. Internal Ductwork Insulation:
1. Install insulation in accordance with manufacturer's recommendations based on velocity and duct dimensions and SMACNA HVAC Duct Construction Standards -- Metal and Flexible.

2. Where insulation has perforated galvanized-sheet-metal inner lining, fill space between liner and outer duct, leaving no void spaces or unlined sections.
  3. Do not use scrap pieces of insulation to make up full-length sections. Eliminate voids by retrofitting or replacing insulation.
  4. Apply adhesives, where required, in accordance with manufacturer's recommendations.
  5. Increase both width and height dimensions of duct by two inches from dimensions shown.
- D. Chilled-Water Pump Insulation:
1. Rigid premolded cellular glass: Two inches thick, ASTM C552.
- E. Piping Insulation:
1. Chilled-water piping:
    - a. Insulation thickness:
      - 1) Rigid premolded cellular glass:
        - a) Pipe sizes four inches and smaller: Install two layers of one-inch thick insulation on supply and return piping, valves and fittings.
        - b) Pipe size five inches and larger: Install one layer of two-inch thick insulation on supply and return piping, valves and fittings.
      - 2) Rigid premolded insulation sleeving: Install one layer of two-inch thick on supply and return piping, valves and fittings as follows:
        - a) IPS sizes: 1/2 inch through 30 inches.
        - b) Copper tubing: 1/2 inch through 6-1/8 inches.
  2. Pump discharge lines, force sewer mains and potable-water piping:
    - a. Install insulation on pump discharge lines, force sewer mains, hot and cold potable-water piping, valves, flanges and fittings conforming to insulation installation specified for chilled-water piping except that insulation consists of one one-inch thick layer.
    - b. Asphalt-paper inner jacket not required.
  3. Refrigerant-piping insulation:
    - a. Install insulation consisting of one layer, one-inch thick and finished as specified for chilled-water piping.
  4. Embedded or inaccessible-piping insulation:
    - a. Install insulation consisting of layers or thickness specified for usage specified.
    - b. Provide inner jacket of prefabricated-fabric pipe jacket.
    - c. Coat exposed surface of fabric pipe jacket with protective plastic film and inner surface with special-release paper.
    - d. Apply jacket of galvanized steel over inner jacket.
    - e. For flanges, valves and other fittings, apply aluminum jacket with paper backing or asphalt adhesive over galvanized-steel jacket. Secure by means of straps as specified.
    - f. Over elbows provide mitered insulation covered with aluminum jacket material.
- F. Application of Insulation on Pipe Saddles:
1. Cut two-inch thick piece of premolded pipe insulation of same material as used on piping, slightly larger than void formed by outer pipe circumference and pipe saddle.
  2. Press insulation into void by hand pressure, so that both ends project slightly beyond each end of saddle.
  3. Cut ends of insulation flush with saddle ends.
  4. Use of filler, adhesive or other material to fill voids or imperfections in insulation is prohibited.

- G. Expansion Joints for Piping Insulation:
1. Install expansion joints in both horizontal insulation and vertical runs of piping on centers not to exceed 50 feet.
  2. Install joints one-half inch wide and fill with cushioning material in accordance with insulation manufacturer's recommendations.
- H. Insulation for Anchors:
1. Insulate anchors which are secured directly to cold piping as specified for a minimum distance of eight inches from surface of pipe insulation and sufficient to prevent sweating.
- I. Application of Chilled-Water Pump Insulation:
1. Install two-inch thick insulation as complete unit or in sections, constructed so that insulation can be removed and replaced without damage.
  2. Fit insulation snugly against pump without voids.
  3. Bevel curved surface edges to provide tight joint.
  4. Provide metal insulation covers with metal fasteners, supports, frames and membranes.
- J. Application of Chiller Insulation:
1. Insulate water-cooler shell, water boxes of water cooler, exposed suction piping and cold gas-inlet connection to hermetic-unit motors.
  2. Exposed suction piping: As specified for chiller-water piping
  3. Cooler shell:
    - a. Cut and miter insulation to fit contour of surface. Secure in place with bands not over 12 inches on center. Stagger and seal joints with vapor-barrier mastic.
    - b. Apply tack coat of adhesive conforming to MS MIL-A-3316, Class 1, at 60 to 70 square feet per gallon by spray or brush. Embed glass cloth into wet coating, smoothing to remove wrinkles. Overlap seams at least two inches. By spray or brush apply finish coat of lagging adhesive to entire fabric surface at rate of 60 to 70 square feet per gallon. Apply finish coat not later than one hour after tack coat.
  4. Removable heads and water boxes:
    - a. Cover removable heads and water boxes with galvanized-steel box, 22-gauge minimum, constructed as complete unit or in sections. Construction to permit removal and replacement of covers without damage to insulation.
    - b. Line metal covers with insulation of type and thickness used for cooler shell. Impale insulation on weld pins and secure with speed washers.
    - c. Seal voids and joints with vapor-barrier mastic to prevent infiltration of moisture in space between insulation and metal cover.
- K. Application of Air Separator Insulation:
1. As specified for chilled-water pump.
- L. Application of Compression-Tank Insulation:
1. As specified for chiller.

**END OF SECTION**

**SECTION 15120**  
**COMPRESSION TANKS**

**PART 1 - GENERAL**

**1.01 DESCRIPTION:**

- A. This section specifies providing compression tanks complete with fittings and appurtenances.

**1.02 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
  2. ASME: Boiler and Pressure Vessel Code.

**1.03 SUBMITTALS:**

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings:
    - a. Complete catalog information and shop drawings including piping diagrams.

**PART 2 - PRODUCTS**

**2.01 PRODUCTS AND MATERIALS:**

- A. Compression Tank:
1. Compression tank diaphragm type.
  2. Black-steel, welded plate with rustproof coating on exterior, capacity as shown.
  3. Designed for working pressure of 125-psig minimum; meeting ASME Boiler and Pressure Vessel Code.
  4. Diaphragm made of butyl, replaceable.
  5. System connection forged steel.
  6. Factory precharged to 12 psig.
  7. Provided with charging valve and drain plug.
- B. Nameplates:
1. Securely attached plate on each tank showing manufacturer's name, model number and serial number.

**PART 3 - EXECUTION**

**3.01 INSTALLATION:**

- A. Install equipment and appurtenances within space provided and locate for easy servicing.
- B. Provide concrete pad, bracket supports, saddles and hangers for tanks.

**END OF SECTION**

## SECTION 15125

### PIPING CONDUIT

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing complete factory-fabricated piping conduit and control-air piping conduit.
- B. Related Work Specified Elsewhere:
  - 1. Piping systems: Section 15205.
  - 2. Insulation: Section 15080.
  - 3. Raceways, boxes and cabinets: Section 16130.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ANSI/ASME: B31.1.0.
- B. Source Quality Control:
  - 1. Prior to shipment, test carrier pipes at 800 psi until found leak-free.
  - 2. Test prefabricated-conduit sections and fittings at 15-psi air at the factory to ensure compliance with specified requirements and to prove weldtight.
- C. Inspection:
  - 1. Upon delivery to job site, visually inspect each section of prefabricated conduit to determine shipping damage, thickness of coating, necessary air space, bond of coating to conduit and conformance to specified requirements. Reject material not in conformance with special requirements or which displays shipping damage beyond that permitted by these Specifications.
  - 2. Coating test:
    - a. After visual examination and prior to installation, perform coating dielectric-integrity test in accordance with manufacturer's instructions for test equipment.
    - b. Test equipment:
      - 1) Silicone-rubber, electric wire-brush or coil-probe type providing 10,000 peak volts plus-or-minus five percent.
      - 2) Audible alarm or buzzer to sound upon detection of holiday or void in coating.
      - 3) Sealed case to avoid tampering or adjustment in the field.
      - 4) Calibration by manufacturer at six-month intervals or at such times as peak voltage is questionable.
      - 5) Furnish manufacturer's certification of date of calibration and peak-voltage setting.
      - 6) Indication of state of battery charge.
  - 3. Repair of voids:
    - a. If voids detected by the above methods were caused by improper handling, and are such that the areas of patches extending a minimum of two inches from the outer periphery of the void total less than 100 square inches for sections of conduit up to 20 feet in length, or less than 200 square inches for sections up to 40 feet in length, the section may be repaired.
      - 1) Perform repairs using specified coating; repeat testing procedure.

- b. Remove from job site sections requiring patches larger than specified and replace with new conduit sections.
- 4. Perform inspections in the presence of the Engineer. Provide samples of coating and coating material for laboratory analysis when directed.

### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings.
  - 2. Certification:
    - a. Manufacturer's certification that installation has been made in accordance with manufacturer's recommendations and published instructions and meets specified requirements.

## PART 2 - PRODUCTS

### 2.01 PRODUCTS AND MATERIALS:

- A. Prefabricated-Piping Conduit:
  - 1. Welded-piping conduit, factory-insulated armored piping, welded as specified for steel piping in Section 15205.
  - 2. Outer conduit: Steel, four-gauge minimum.
  - 3. Insulation consisting of two one-inch layers of cellular glass as specified in Section 15080 except insulation jacket consisting of outer wrap of asphalt-impregnated, fibrous-glass reinforced, asbestos pipeline felt, spirally wound under tension.
  - 4. Adequate air space between outer conduit and pipe insulation permitting expansion and contraction of piping without resulting damage.
  - 5. Outer conduit coated on inside with six mils minimum unmodified catalytic polyamide or versamid-cured epoxy.
  - 6. Outer conduit coated on outside with minimum 20-mil epoxy reinforced with two layers of fibrous-glass cloth. Outer coating consisting of iron-oxide zinc-chromate catalyzed primer, chromium-oxide catalyzed finish coat and asphaltic bituminous-mastic final coating.
    - a. Coating cured at 180F for one-hour minimum.
    - b. Final asphaltic coating: Machine-coated high-melting-point asphalt, 3/16-inch minimum, with interposed layer of fibrous-glass screen, plus one final outer wrap of asphalt-impregnated, fibrous-glass reinforced, asbestos pipeline felt, applied under tension.
  - 7. Iron-oxide zinc-chromate catalyzed primer as follows:
    - a. Primer containing 60-percent minimum solids after mixing two components but before reduction.
    - b. Solids: Iron-oxide pigment 1.50 to 2.00 pounds per gallon, containing minimum of 75-percent ferric oxide.
    - c. Zinc chromate: 0.50 pound per gallon minimum and magnesium silicate 1.5 to 2.0 pounds per gallon.
    - d. Vehicle portion of primer consisting of 65-percent epoxy resin (450 - 525 epoxide equivalent) and 35-percent resinous nitrogen containing curing agent with not more than five percent of vehicle as stabilizers and flow-control agents. Finish coat to contain not less than 60-percent solids after mixing two components but before reduction.
    - e. Use pigment which consists of two pounds per gallon of chromium oxide with the addition of not more than three percent of pigment as dispersant and suspending agents.

8. Finished-coat vehicle of 65-percent epoxy resin (450 - 525 epoxide equivalent) and 35-percent resinous-nitrogen curing agent with not more than five percent of vehicle as stabilizers and flow-control agents.
  9. Conduits incorporating the following features:
    - a. Pipe-support guides.
    - b. Watersheds, welded pipe only.
    - c. Leak plates:
      - 1) Equip conduits with steel leak plates of type and size shown.
    - d. Anchors: As shown.
    - e. End and gland seals:
      - 1) Equip terminal ends of conduit with seals of type and size shown.
      - 2) Equip seals with drain and vent openings located diametrically opposite on vertical centerline of mounting plate. During fabrication install plugs for drain and vent openings. Plugs to remain in place during shipment and installation.
    - f. Expansion loops:
      - 1) Factory-fabricated of casing, couplings, insulation and piping identical to that specified for straight runs.
      - 2) Designed and installed to ensure complete drainage.
      - 3) Designed with allowable-stress limits in accordance with in ANSI/ASME B31.1.0, for type of pipe used.
      - 4) Shipped to job site in maximum size sections feasible in order to minimize number of field joints.
    - g. Loop casing:
      - 1) Sized to contain pipe movement without crushing insulation or causing other damage.
      - 2) Eccentric reducers and increasers, or welding collars serving same purpose, used to allow drainage through loop.
      - 3) Welding collars not lighter than conduit casing and not less than 10 gauge.
- B. Control-Air Piping Conduit:
1. PVC: Section 16130.
- C. Conduit Monitoring System:
1. Control unit: Provided only in cases where conduit is buried or when approved.
    - a. Wall-mounted, liquid-tight, hinged cover.
    - b. Leak warning light, allowing reset by depressing, mounted on front cover.
    - c. Pressure gauge, mounted on front cover, indicating conduit internal pressure, covering conduit internal-pressure range of five to eight psi.
    - d. Compression fittings for gas inlet and gas outlet: 3/8-inch copper tubing.
    - e. Gas regulator capable of adjustment from zero psig to 20 psig.
  2. Copper tubing: 3/8-inch as specified by manufacturer of monitoring system.
  3. Source of dry nitrogen gas not to exceed 100 psi.
  4. Relief valves capable of being set for 15-psig maximum, blowoff piping, conduit vents, conduit drains: As specified by the manufacturer.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION:**

- A. Excavation:
1. Remove rock encountered during excavation for installation of prefabricated-piping conduit to minimum overdepth of four inches.

2. Backfill overdepth with aggregate for subgrade foundation as specified in Section 02535.
- B. Installation:
1. Install prefabricated piping conduit, including expansion loops and conduit monitoring system, in accordance with manufacturer's recommendations and under personal supervision of manufacturer's representative.
    - a. Locate monitoring unit in refrigeration-equipment room.
  2. Fabricate field joints to match factory fabrication and perform testing as specified.
  3. Clean and sandblast steel surfaces prior to coating.
  4. Apply coating to match factory-applied coating and perform testing as specified.
- C. Backfill:
1. Backfill after installation and testing in accordance with Section 02320, with the exception that 1/4 inch used as maximum particle size.
  2. Backfill with specified material in six-inch layers, rammed, to one-foot minimum cover.

### **3.02 FIELD QUALITY CONTROL:**

- A. Install prefabricated-piping conduit under personal supervision of manufacturer's qualified field-service representative.
- B. Field Testing:
1. Prior to application of coating and before backfilling, test conduit sections and joints for leaks by application of 15 psig for one-hour minimum.
  2. Repair leaks in accordance with manufacturer's recommendations and retest until approved.
  3. After application of coating and prior to backfill, perform coating tests as specified on exterior surfaces including field joints.
  4. Repair coating voids to restore full dielectric integrity to system or replace conduit section and repeat testing procedures.
  5. After backfilling, test conduit system by application of 15 psig for eight hours minimum
  6. Locate and repair leaks detected by loss of gas pressure and retest until approved.
  7. Ventilate air space in conduit with heated air at rate of two cfm. Continue until cool mirror located at exit port exhibits no fogging.
  8. Charge to five psig and close off plugs.
  9. Set monitoring system according to manufacturer's instructions for unattended surveillance.
  10. Submit copy of installation and inspection report.

**END OF SECTION**

## SECTION 15135

### MISCELLANEOUS PUMPS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing pumps, complete with motor drives and controls, except drainage pumping systems, chilled-water pumps and condenser-water pumps.
- B. Related Work Specified Elsewhere:
  - 1. Piping systems: Section 15205.
  - 2. Raceways, boxes and cabinets: Section 16130.
  - 3. Wire, cable and busways: Section 16120.
  - 4. Motors: Section 16225.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. UL, NEMA 250.
- B. Source Quality Control:
  - 1. Select pumps based on capacity, total dynamic head and electrical characteristics shown.
  - 2. Test pumps at 1-1/2 times working pressure.
  - 3. Balance impeller statically, dynamically and hydraulically.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements specified for each:
  - 1. Shop Drawings.
  - 2. Certification.
  - 3. Operation and Maintenance Manuals:
  - 4. Submit for each pump.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIAL:

- A. General Requirements:
  - 1. In design and purchase of equipment, provide for interchangeability of subassemblies, parts, motors, starters and relays.
- B. Hot-Water Circulating Pump:
  - 1. Type: Centrifugal, single-stage, single-suction, in-line, hydraulically balanced and electric-motor-driven.
  - 2. Minimum capacity: As shown.
  - 3. Operating speed: 1,750 rpm.
  - 4. Designed in accordance with the following:
    - a. Standards of Hydraulic Institute.
    - b. Pump supported by piping system.

- c. To permit complete servicing without severing pipe connection.
    - 5. Construction: Bronze, with stainless-steel or heat-treated steel shafts, with the following additional requirements:
      - a. Bearings: One of the following:
        - 1) Ball bearings, frictionless with permanent grease lubrication.
        - 2) Sleeve bearings, oil-lubricated.
      - b. Roller bearings, with oil reservoir.
    - 6. Casing: Suitable for working pressure of 125 psig.
    - 7. Seals: Mechanical, designed and guaranteed for long life in hot-water systems operating at 250F.
    - 8. Motors: As specified in Section 16225.
- C. Submersible Sump Pump:
  - 1. Type: Automatic, electric-motor-driven, centrifugal, wet-pit, close-coupled.
  - 2. To include single-phase, hermetically sealed, capacitor-start motor with built-in overload protection, upper and lower bearing factory-sealed, grease-lubricated ball-type, common shaft of stainless steel, Type 316, and sealed pump cable with neoprene cover and flexible armor. Motors to have cooling characteristics permitting continuous operation in totally submerged, partially submerged and non-submerged condition.
  - 3. Casing: Close-grain cast iron, volute-type.
  - 4. Impeller: Cast bronze, enclosed or semi-open, with vanes and back shroud, dynamically balanced.
  - 5. Intake protected with slotted cast-iron or perforated steel intake strainer with effective free area sufficient to prevent cavitation and poor efficiency.
- D. Liquid-Level Control:
  - 1. Simplex submersible, single-phase unit, one of the following:
    - a. Integral with pump, designed for direct switching of single-phase pumps, complete with ON/OFF, adjustable-level float switches.
    - b. Completely independent, designed for direct switching of single-phase pumps and consisting of control box, contactor and ON/OFF level float switches.
      - 1) Control box of heavy-duty plastic having three-prong male plug for plugging into standard three-wire grounded power-supply outlet; grounded female socket into which cable from pump motor is plugged and heavy-duty contactor with 90-ampere lock-rotor rating for direct switching of motor load.
      - 2) Float switches for ON and OFF level switching connected to control box with extra-flexible, neoprene-jacketed electrical cable. Float switches UL-listed. Floats strapped to discharge pipe at required ON and OFF levels. Mercury switch with molybdenum contacts sealed in each double-walled float enclosure. Float enclosure of heavy-duty rigid plastic, resistant to attack by inorganic salt solutions, alkalis and mineral acids.
  - 2. Duplex submersible, single-phase unit. Completely independent, designed for direct switching of two single-phase pumps and consisting of duplex control box, contactors, alternator, and ON/OFF and emergency-level float switches.
    - a. Weatherproof, UL-listed, steel control box with gasketed removable cover containing contactor with 90-ampere lock-rotor rating for each pump, electric-alternator circuit and control-circuit fuse. Pump starting alternated at ON level on successive cycles. Second pump starts at EMERGENCY level if inflow exceeds capacity of first pump or is inoperative.
    - b. Float switches for ON, OFF and EMERGENCY level switching, connected to control box with extra-flexible, neoprene-jacketed electrical cable. Float switches UL-listed. Floats strapped to discharge pipes at required ON, OFF

and EMERGENCY levels. Mercury switch with molybdenum contacts sealed in each double-walled enclosure. Float enclosure of heavy-duty rigid plastic, resistant to attack by inorganic salt solutions and mineral acids.

- c. Alternator:
  - 1) Electric, automatic.
  - 2) Designed to alternate pumps on each successive cycle of operation and to operate both pumps automatically when one pump is unable to handle flow.
  - 3) Enclosure for electrical components: NEMA 250, Type 1.
- E. Wiring:
  - 1. Control panel: Completely wired at the factory prior to shipment.
  - 2. Wiring and conduit: Sections 16130 and 16120.
- F. Nameplates:
  - 1. Securely attached to each major item of equipment. In each case, show manufacturer's name, model number, serial number, electrical and operating characteristics.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION:**

- A. Fit equipment and appurtenances within space provided and make readily serviceable.
- B. Provide hangers and anchor bolts required for proper installation of equipment as recommended by manufacturer.
- C. Install in accordance with manufacturer's instructions.

#### **3.02 FIELD QUALITY CONTROL:**

- A. Ensure that connections are secure and watertight.
- B. Test system through five complete operating cycles.
- C. Ensure that pump and motor operate without noticeable vibration.

**END OF SECTION**

## SECTION 15185

### CHILLED WATER PUMPS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION

- A. This section specifies providing chilled-water and condenser-water pumps, complete with motor drives.
- B. Related Work Specified Elsewhere:
  - 1. Insulation: Section 15080.
  - 2. Vibration isolation: Section 15070.
  - 3. Motors: Section 16225.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. NEC.
- B. Design Criteria:
  - 1. Select pumps based on capacity and total dynamic head shown.
- C. Source Quality Control:
  - 1. Test pumps at 1-1/2 times working pressure.
  - 2. Balance impeller statically, dynamically and hydraulically.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings.
  - 2. Certification.
  - 3. Operation and Maintenance Manuals.

##### 1.04 JOB CONDITIONS:

- A. Safety Requirements:
  - 1. Properly guard belts, pulleys, chains, gears and other rotating parts to prevent danger to personnel.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. General Requirements:
  - 1. In design and purchase of equipment, provide for interchangeability of items of piping equipment, subassemblies, parts, motors, starters and relays.
- B. Casings:
  - 1. Close-grained cast iron, volute-type.
  - 2. Horizontal or vertical split case with flanged suction and discharge, designed for optimum-velocity change and hydraulic balance.

3. Openings tapped for suction and discharge gauges, suction chamber, discharge-volute venting and casing drainage.
  4. Sections of casings bolted and doweled to permit access to impeller without removal of piping and to provide exact positioning at assembly, after inspection or replacement of parts.
  5. Split bearing brackets bolted and doweled for perfect alignment of rotor, wearing rings and bearings.
- C. Impeller:
1. Enclosed, double suction, cast bronze, one-piece.
  2. Secured to shaft by key and locking collars for exact alignment.
  3. Exterior surfaces machined.
  4. Interior surfaces and water passages deburred and hand-finished.
- D. Casing Wearing Rings:
1. Bronze, renewable-type, locked to prevent rotation.
- E. Shafts:
1. Solid, Alloy S30300 stainless steel.
  2. Sized to provide maximum 0.002-inch deflection at face of stuffing box.
- F. Mechanical Seals:
1. Single, inside-mounted, selection based on pressure, temperature, speed and shaft diameter.
  2. Seal parts:
    - a. 150 psi with shaft diameter to three inches:
      - 1) Temperature range: 40F to 225F.
      - 2) Shaft sealing member: Buna rubber.
      - 3) Rotating sealing member: Carbon.
      - 4) Metal parts of seal: Brass.
      - 5) Stationary sealing member: Nickel-alloy iron.
      - 6) Spring: Stainless steel.
    - b. Above 150 psi: As specified for 150 psi with shaft diameter to three inches, except stationary sealing member fabricated of tungsten carbide.
- G. Glands:
1. Mechanical seal, flush-type, drilled and tapped to provide clear, filtered liquid flush to seal face with separate stainless cyclone separator.
  2. Fabricated of stainless steel, factory-mounted and piped for each seal.
- H. Bearings:
1. Grease or oil lubricated, designed for 150,000 hours average life.
  2. Bearing housings enclosed and protected from dirt and water.
- I. Coupling:
1. Flexible, nonlubricated, pin and bushing.
- J. Coupling Guard:
1. Fabricated steel-housing enclosure bolted to base plate.
- K. Bedplate:
1. Structural steel, ribbed for rigidity and with minimum five-inch diameter grout holes.
  2. Drip collection chamber provided with ½-inch IPS connection at low point of bedplate.
  3. Drilled and tapped to accommodate pump, motor and coupling guard.
- L. Motors: Section 16225 with the following additional requirements:

1. Sized for nonoverloading operation under all conditions on pump curve.
  2. Four-pole, squirrel-cage induction, dripproof and fully guarded.
- M. Flexible Connection:
1. Reinforced-rubber-type or contour-molded reinforced-Teflon-type with flanged ends at inlet and outlet of pump.
  2. Reinforcement: Monel or stainless-steel rings.
  3. Designed for 150 percent of maximum working pressure.
- N. Vibration Isolators: Section 15070.
- O. Nameplates:
1. Securely attached on each pump showing manufacturer's name, model number and serial number.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION:**

- A. Fit equipment and appurtenances within space provided and make readily serviceable.
- B. Provide foundation for proper installation of equipment.
- C. Construct subbases for equipment in accordance with Section 15070.
- D. Insulate pumps as specified in Section 15080.
- E. Make final alignment on pump and motor coupling prior to operation.
- F. Mount pumps on vibration isolators where shown.
- G. Ensure that pump and motor operate without noticeable vibration after installation.

**END OF SECTION**

## SECTION 15186

### WATER TREATMENT SYSTEM

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing complete and operable water-treatment systems for chilled-water and condenser-water systems.
- B. Related Work Specified Elsewhere:
  - 1. Piping systems: Section 15205.
  - 2. Insulation: Section 15080.
  - 3. Vibration isolation: Section 15070.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. NEMA: 250
- B. Design Criteria:
  - 1. Design automatic water-treatment systems to minimize corrosion and prevent fouling of components.
    - a. Chilled water: Select chemicals for control of corrosion, scale and algae that are not toxic to humans in concentrations found in operating system.
    - b. Condenser water: Design a non-chemical water treatment system to minimize scale and reduce biological growth in the circulating chiller condenser -cooling tower water system. The system shall use permanent magnetic technology and copper silver electrode assembly to reduce scale and biological growth respectively.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings.
    - a. Complete catalog information and shop drawings for material and equipment including wiring and control diagram.
  - 2. Certification.
    - a. Manufacturer's certified test reports.
  - 3. Documentation:
    - a. Water analysis:
      - 1) Water-sample analysis. Submit prior to introducing chemicals into systems.
    - b. Chemical-quantity requirements:
      - 1) Submit calculations showing total quantities of various chemicals required for two years operation of water-treatment systems
      - 2) Base quantity of chemicals for 2,000 full-load operating hours per annum for designed tonnage and average of five cycles concentration of condenser water.
    - c. Chemical-quality requirements:
    - d. Submit chemical formulae and descriptions or generic names of materials used.

- e. Prior to acceptance, submit toxicity data of water treatment complying with applicable codes and regulations of jurisdictional authorities.
- f. If required by the jurisdiction, submit their approval of chemicals proposed for use
- 4. MSDS approval by WMATA SAFE:
  - a. Submit Manufacturers' Safety Data Sheets (MSDS) for approval by WMATA's Safety Office (SAFE) for use by WMATA personnel and for use in the WMATA system.
- 5. Operation and Maintenance Manuals.

**1.04 JOB CONDITIONS:**

- A. Safety Requirements:
  - 1. Store and handle chemicals so as to prevent danger to personnel.

**1.05 FIELD SERVICE:**

- A. Engage services of specialist for two years from day air-conditioning system is first put into normal and continuous operation to supervise and train plant-operating personnel in correct water treatment. Specialist to be certified by water-treatment system manufacturer as qualified in operation of system provided.
- B. Specialist's services to include the following:
  - 1. Supervision of pretreatment, startup and adjustment of automatic water-treatment systems.
  - 2. Minimum of six inspections, at startup and during cooling season for water analysis and to analyze and recommend changes in treatment as operating conditions vary during adjustment period.
  - 3. Inspections at not greater than five-week intervals and additional inspections upon request from the Authority.

**1.06 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Ship products securely packaged and labeled for safe handling in shipment and to avoid damage and distortion.
- B. Label each item with manufacturer's name, brand, reference specification, type, class and other pertinent information as applicable.
- C. Supply dry chemicals in waterproof bag or containers weighing maximum of 100 pounds.
- D. Supply liquid chemicals in thirty-gallon polyethylene-lined steel drums or five-gallon plastic pails.
- E. Ship chemicals which are not used for initial startup to Authority-designated storage facility.
- F. Store products in a secure, dry storage facility.

**PART 2 - PRODUCTS**

**2.01 MATERIALS:**

- A. General Requirements:
  - 1. In design and purchase of equipment, provide for interchangeability of items of piping equipment, subassemblies, parts, motors, starters and relays.
- B. Condenser-Water Treatment:

- C. HydroPlex as manufactured by Quantum Magnetic System (QMS), Inc., Cleveland, Ohio. Equipment shall include, but not limited to the following
1. Electrode:
    - a. Copper Silver Alloy Type.
      - 1) Low voltage direct current, max. 60 watts per electrode assembly.
      - 2) Quick disconnect electrical connection.
      - 3) Adjustable duty cycles.
      - 4) Minimum 1 month before cleaning and 1 year before replacement.
      - 5) A quick disconnect designed for removal without using special tools.
    - b. Solid removal:
      - 1) Cyclone type separator, capable of removing particles larger than 200 microns.
      - 2) Equipped with automatic purge valve capable of removing all solids from the system during purging cycle.
      - 3) Provide a manually adjusted throttling valve between the centrifugal device and the automatic purge valve. This valve shall be a gate valve or approved equivalent of the same pipe diameter as the automatic purge valve.
      - 4) Union fittings shall be supplied on both sides of the automatic purge valve and also and also both sides of the manual throttling valve for ease of valve removal.
    - c. Magnets for scale removal:
      - 1) An integral part of the piping system. Clamp-on type will not be acceptable.
      - 2) Effective operating life 50 years minimum.
    - d. Pump:
      - 1) Single stage, end suction, centrifugal type, capable of delivering minimum of 200 gpm at the designed pressure discharge.
      - 2) Pump and motor mounted on common steel base.
      - 3) Pump fitted with ball bearings and double mechanical shaft seal.
      - 4) Pump motor: Manufacturer's standard motor suitable for intended use.
      - 5) One spare part/repair kit provided with pump.
    - e. Valves, pipe and fittings:
      - 1) Valves shall be bronze construction, solder or threaded ends type, rising stem and rated at minimum 150 psi.
      - 2) Pipe, ASTM B88 Type K, Hard drawn; Fittings, ANSI B16.22.
    - f. System cabinet:
      - 1) Size to contain electrode assembly, Cyclone separator, Magnets, Flow meter, Pressure gauges and all associated plumbing, electrical wiring and controls.
      - 2) Cabinet shall be NEMA 4 rating, suitable for indoor and outdoor installations.
      - 3) Cabinet shall be provided with openings for electrical conduit and piping.
      - 4) Provide cabinet with one-inch drain at the bottom to be piped to the nearest floor drain.
    - g. Other equipment:
      - 1) A 30-gallon surge tank of corrosion-resistant construction.
      - 2) Copper test kit as manufactured by Hach Pocket Colorimeter (Catalog No. 46700-19) or approved equal.
      - 3) Conductivity meter as manufactured by Orion Quikcheck Pocket meter (Catalog No. OR914026, Model 116) or approved equal.

- D. Chilled-Water Treatment:
  - 1. Pot-type chemical feeder:
    - a. Designed and constructed for 150-psig water working pressure.
    - b. Chemical feeder: Minimum capacity, 12 gallons.
    - c. In accordance with applicable codes and regulations for unfired pressure vessels.
  - 2. Chemicals: Furnish chemicals supplied for chilled-water system treatment in accordance with the following performance standards:
    - a. Corrosion inhibition:
      - 1) Carbon steel: Less than or equal to 1.0 mil per year.
      - 2) Copper and copper alloys: Less than or equal to 0.10 mil per year; chemical mixture to contain copper-corrosion inhibitor and buffering agents to maintain system pH at 7.0 to 8.5.
    - b. Scale inhibition: Maintain system free of scale deposit.
    - c. Inhibitor to be compatible with permanent glycol-based water solutions.
    - d. Containing no chromates or acids; providing colorless solution when mixed with water.
- E. Name Plates: Securely attached to each major item of equipment showing manufacturer's name, model number and serial number.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION:**

- A. Fit equipment and appurtenances to space provided and make readily serviceable.
- B. Provide foundations, platforms and hangers for proper installation of equipment.
- C. Provide concrete subbases for equipment conforming to the requirements of Section 15070.
- D. Provide waste connections for water-treatment equipment as specified in Section 15205.
- E. Insulate piping and equipment in accordance with Section 15080
- F. Install condenser water treatment as per manufacturer's recommendation.

#### **3.02 APPLICATION AND PERFORMANCE:**

- A. Control chemical feed automatically in direct proportion to makeup-water flow as measured by water meter.
- B. Control bleed-off flow rate automatically by timer.
- C. Adjust composition of recirculated water chemically to control scale and corrosion without use of chromates or acids.
- D. Condenser water treatment capable of operating as high as 10 standard units.
- E. Capable of operation in the system with total dissolved solids ranging from 150mg/l to 10,000 mg/l.

#### **3.03 FIELD QUALITY CONTROL:**

- A. Chemical Tests:

1. Perform chemical analysis of condensing and chilled-water system at startup of cooling tower.
2. Determine chemical status of water in accordance with specified requirements.
3. Upon approval of treatment, add chemicals and operate systems for 48 hours.
4. Analyze solution at end of 48-hour operation and submit complete report.
5. Report deficiencies in treatment to the Engineer.
6. Perform total of six tests for condensing and chilled-water system during each operating year at intervals of not less than five weeks.

**3.04 ADJUSTING AND CLEANING:**

- A. Prior to testing equipment, flush piping systems with chemically treated water to remove scale, slag, dirt, oil, grease and foreign material.
- B. Remove and hand-clean low points and strainers.
- C. Install fine cloth around strainers during initial circulation to remove silt finer than normal strainer mesh.

**3.05 CHEMICAL SUPPLY:**

- A. Supply quantity of chemicals required for two years' operation, based upon 2,000 full-load operating hours per year for designed tonnage of refrigeration plant.

**END OF SECTION**

## SECTION 15205

### PIPING SYSTEMS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing piping, fittings, valves, drains, specialties and supporting devices.
- B. Related Work Specified Elsewhere:
  - 1. Water distribution system: Section 02515.
  - 2. Sanitary sewer: Section 02535.
  - 3. Firestopping: Section 07841.
  - 4. Field painting: Section 09920.
  - 5. Stray current and cathodic protection: Section 13110
  - 6. Corrosion control testing system: Section 13115.
  - 7. Fire protection, suppression and alarm: Section 13905.
  - 8. Identification of mechanical equipment and piping: Section 15075.
  - 9. Insulation: Section 15080.
  - 10. Grounding and bonding: Section 16060.

##### 1.02 QUALITY ASSURANCE:

- A. Qualifications of Welder: Section 05120.
- B. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. The Model Plumbing Code.
  - 3. ASSE Standards.
  - 4. AWWA Standards.
  - 5. ASME Code for Unfired Pressure Vessels.
  - 6. ANSI/ASME: A21.15/C115, B16.1, B16.3, B16.5, B16.9, B16.11, B16.18, B16.22, B16.39, B31.1, Z21.22.
  - 7. ANSI/AWS: A5.8, E8016, E8018.
  - 8. CISPI: HSN 85.
  - 9. FS: A-A-1192, SS-C-153C, WW-P-51F, WW-P-460D, WW-P-501, WW-U-516B, WW-U-531, WW-V-51F.
  - 10. MSS: SP-58, SP-67, SP-70, SP-80.
  - 11. PDI: WH-201.
  - 12. ASTM: A53, A74, A105, A126, A234, A276, A395, A536, B32, B61, B62, B88, B150, B280, B306, F709.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Complete catalog information and shop drawings for material and equipment.
    - b. Submittals include, but are not limited to, the following:
      - 1) Pipes and piping layout, including locations of hangers and supports.
      - 2) Pipe hangers and supports.
      - 3) Valves.

- 4) Cleanout deck plates and wall plates.
  - 5) Escutcheons.
  - 6) Gauges.
  - 7) Expansion joints, guides and anchors.
  - 8) Air eliminators.
  - 9) Pipe sleeves.
  - 10) Drains.
2. Certification:
- a. Certificates from manufacturers verifying the following:
    - 1) That pipe-joint gaskets and lubricants are satisfactory for use with pipe and fittings specified.
    - 2) That expansion joints are designed and tested as specified.

**1.04 JOB CONDITIONS:**

- A. Do not perform welding when the temperature of base metal is less than zero degree F.
- B. Do not perform welding when surfaces are wet from rain, snow, ice or during periods of high wind unless operator and work are properly protected.

**PART 2 - PRODUCTS**

**2.01 PRODUCTS AND MATERIALS:**

- A. General Requirements:
  - 1. In design and purchase of equipment, provide for interchangeability of items of piping equipment, subassemblies and parts.
- B. Piping:
  - 1. Cast-iron soil pipe and fittings:
    - a. Inside of or embedded within structures: ASTM A74, Class SV, uncoated.
    - b. Passing through underground structural elements or buried below or outside structures: ASTM A74, Class XH, uncoated.
    - c. Pipes, including embedded pipe crossing structural contraction joints, provided with modified bell and spigot joints with molded-neoprene elastic compression gaskets.
    - d. Gaskets: CISPI HSN 85.
    - e. Pipe and fittings manufactured with spigot ends plain and beveled.
    - f. Bells modified to receive gaskets.
  - 2. Steel pipe and fittings:
    - a. Seamless piping: ASTM A53, Types Grade B, hot-dip galvanized, Schedule 40, provided for the following applications:
      - 1) Waste and drainage piping and fitting, 2-1/2 inches and smaller where embedded or otherwise inaccessible.
      - 2) Dry vents where embedded or otherwise inaccessible.
      - 3) Chilled-water and condenser-water supply and return embedded or otherwise inaccessible.
    - b. Fittings for chilled water, condenser water: ASTM A234 and ANSI/ASME B16.9 for dimensions and tolerances but not chemical properties.
    - c. Flanges: ASTM A105 and ANSI/ASME B16.5 for dimensions and tolerances.
    - d. Fittings and flanges furnished with properties equal to or greater than that of adjacent pipe.
  - 3. Ductile-iron pipe and fittings:
    - a. Embedded or otherwise inaccessible piping: ANSI/ASME A21.15/C115, 250-pound pressure class.

- b. Piping for sewage-ejector discharge, drainage-pump discharge, interim pumps and for water service from point of connection to inside of structure: ANSI/ASME A21.15/C115, 250-pound pressure class, flanged.
    - 1) Flanges: ANSI/ASME B16.1.
  - c. Pipe coated on outside with bituminous coating and lined with cement mortar of twice standard thickness specified for pipe size used.
    - 1) Cement-mortar lining having a seal coat of nontoxic, taste and odor-free bituminous material.
  - d. Neoprene gaskets furnished for joints.
4. Copper tubing and fittings:
- a. Copper tubing for potable water and for control air where embedded or otherwise inaccessible: ASTM B88, Type K, hard-drawn.
  - b. Provide copper tubing for potable water, control air and pneumatic sewage-ejector compressed air where accessible: ASTM B88.
    - 1) Potable water and control air: Type M.
    - 2) Potable water and control air installed in conduit: Type K, annealed and lengths of piping 100 feet or less continuous without joints.
    - 3) Pneumatic sewage-ejector compressed air: Type K, hard-drawn.
  - c. Fittings for potable-water piping: ANSI/ASME B16.22.
    - 1) Fitting wall thickness after forming not less than that of adjacent piping.
  - d. Fittings for control-air piping: Wrought copper, solder joint except at apparatus connections where brass compression fittings furnished.
  - e. Maximum pressure drop for high-pressure control-air mains: Five psi per 1,000 feet, with minimum 1-1/2 cubic feet per minute of 75-psi air flowing for each single station served and one cubic foot per minute for chilled-water plant.
    - 1) Minimum size for high-pressure control-air mains connecting chiller plants and underground stations: One-half inch ID, 5/8-inch OD.
  - f. Control-air piping graded to low points and each low point provided with 3/8-inch drain cock.
  - g. Solder joints: Lead-free 95.5-percent tin, 4.0-percent copper and 0.5-percent silver with non-corrosive flux; ASTM B32.
5. Copper drainage tube (DWV) and fittings:
- a. Seamless tubing: ASTM B306, No. 122 for drainage, waste, and vent piping and fittings.
6. Copper tubing for refrigerant service:
- a. Seamless copper tubing: ASTM B280 for refrigeration service.
  - b. Fittings: Pure wrought copper, recessed solder joint, ANSI/ASME B16.18.
  - c. Solder joints: Brazing filler metal in accordance with ANSI/AWS A5.8 and the following:
    - 1) Copper to Copper - 12-percent Sil-Foss (no flux 1300F).
    - 2) Copper to Copper - 6-percent Dyna-Flow (no flux 1350F).
    - 3) Copper to Steel - 45 silver solder (white flux 1150F)
7. Condensate-drain pipes:
- a. Hard-drawn copper: ASTM B88, Type L.
8. Unpolished stainless-steel drip pans:
- a. Provided under water, waste or condensate-drain piping which run over transformer vaults or electric motor starters.
  - b. Each drip pan provided with one-inch drain.
9. Black-steel seamless pipe and fittings:
- a. Exposed chilled water, condenser-water supply and return piping: ASTM A53, Standard Weight Schedule 40.
  - b. Pipes 1-1/2 inch and smaller connected with socket-weld fittings or screwed fittings.
  - c. Pipes two inches and larger connected with welded fittings.

- d. Pipes larger than 12 inches in diameter: Minimum 3/8-inch wall.
  - e. Threaded-pipe fittings: FS WW-P-501, Type I, Class B.
  - f. Welding fittings made of same schedule or weight classification as the pipe.
    - 1) Factory-made welding fittings.
    - 2) Mitered joint elbows and field-made reducers will not be permitted.
  - g. Butt-welded fittings larger than 1-1/2 inches: ANSI/ASME B16.9.
  - h. Socket-welding fittings: ANSI/ASME B16.11.
  - i. Flanges for welded piping system: ANSI/ASME B16.5, forged steel, welded-neck type, 150-pressure class.
  - j. Black-steel pipe and fittings for drainage in aboveground structures as specified in a., except Weight B piping furnished.
10. Unions:
- a. 1-1/2 inch and smaller: Threaded, ASME B16.39, Type A or B to match piping.
  - b. Two inch and larger unions: ASTM A126, Class B, flanged.
    - 1) Two, 2-1/2 and three-inch union flanges: Steel, FS WW-U-531 or of cast iron, ANSI/ASME B16.1, 125-pound class.
  - c. Four inch and larger union: Forged steel, 150-pound class, slip-on weld-neck flanges, ANSI/ASME B16.5.
  - d. Nonferrous-piping unions: Brass, FS WW-U-516B.
11. Cleanouts:
- a. For cast-iron bell-and-spigot pipe: SVCI, ferrule caulked into cast-iron fittings and extra-heavy brass tapered screw plug with recessed head.
  - b. For wrought-iron pipe: Extra-heavy brass plug in drainage fitting.
  - c. Floor cleanouts: Cleanouts turning up through architecturally finished floors made by means of a long-sweep ell or Y and adjustable ABS housing with secured, scoriated, round satin-brass cover.
  - d. Wall cleanouts: Cleanout plugs furnished with solid head tapped for 1/4-inch brass machine screw to secure coverplate. Coverplate to be polished-brass round access plate secured to plug with countersunk screw.
  - e. For threaded pipes: Bronze, FS WW-P-460D, Class A.
  - f. Furnished with adjustable recessed head in floor and where shown.
  - g. Except for test openings, cleanout plugs for pipes up to four inches to be same size as pipe.
  - h. On pipe sizes five inches and larger, cleanout plugs to be of four inches and pipe reduced to plug size with bushing.

C. Valves:

- 1. Gate valves two inches or smaller:
  - a. MSS SP-80, Type 2, Class 150.
  - b. Bronze with threaded ends, rough bodies and finished trim.
  - c. Materials except handwheels: ASTM B61.
  - d. Furnished with malleable-iron hand wheels.
- 2. Gate valves 2-1/2 inches and three inches:
  - a. MSS SP-70, Type 3, Class 125, OS&Y flanged end, Type I, Class 2, cast-iron bodies and bonnets.
  - b. Seat rings, disc, disc guide and stem furnished in bronze.
  - c. Outside stem and yoke (OS&Y), flanged-end connections and malleable-iron hand wheels.
- 3. Gate valves four inches and larger:
  - a. MSS SP-70, Type 2, Class 125, OS&Y, flanged end, cast-iron bodies and bonnets.
  - b. Seat rings, disc, disc guide and stem furnished in bronze.
  - c. Outside stem-and-yoke type and cast-iron hand wheels.
- 4. Globe, angle and check valves:
  - a. Two inches and smaller:

- 1) WW-V-51F, Class B.
  - 2) Bronze with threaded ends, rough bodies and finished trim.
  - 3) Materials except hand wheels: ASTM B61.
  - 4) Globe and angle valves furnished with malleable-iron hand wheels.
  - 5) Check valves four inches and larger:
    - a) Swing-type valve seat, with iron or steel body and cap and flanged-end connections.
    - b) 150-pound class, renewable arm, disc assembly and seat ring with bronze trim.
    - c) Outside arm and weight for pump discharge check valves.
5. Valves for copper piping:
- a. Gate valves with solder ends: MSS SP-80, Type 2, Class 150, Bronze, Type 1, Class B.
  - b. Gate valves with flanged ends: MSS SP-80, Type 2, Class 150, Bronze.
  - c. Globe, angle and check valves with solder or flanged ends: FS WW-V-51F, Bronze, Class B.
6. Pressure-reducing valves:
- a. Direct-acting type in which diaphragm and spring act directly on valve stem.
  - b. Constructed to ensure that delivered pressure does not vary more than one psi for each ten-psi variation in inlet pressure.
  - c. Wearing parts readily renewable.
  - d. Valves two inches and smaller designed for working pressure of 250 psi, brass construction except yoke connecting valve body to separate diaphragm chamber having brass cover and assembled with brass bolts.
  - e. Valves larger than two inches designed for minimum 125 psi, iron bodies and bronze trim.
  - f. Adjustable to any outlet pressure.
  - g. Gate valve and union on both inlet and outlet connections.
  - h. Provided with bypass one pipe-size smaller than main water line.
  - i. Stem-mounted pressure-reducing valve gauges, 3-1/2 inch dial, solid brass or stainless steel case and connections with T-handle stops.
  - j. Pressure-reducing valve strainer: Brass, removable without disconnecting piping.
    - 1) Strainers two inches and smaller: Brass, bodies designed for minimum working pressure of 250 psi.
    - 2) Strainers 2-1/2 inch and larger: Iron bodies designed for minimum working pressure of 125 psi
7. Pressure-temperature relief valves:
- a. Temperature-and-pressure-actuated type, adjustable, bronze, single disc with bottom guide to ensure proper seating.
  - b. Body, disc and base: Bronze, ASTM B62.
  - c. Spring and stem: Steel.
  - d. Lever: Malleable iron.
  - e. Pressure range from three psi to 250 psi rated and tested under ANSI/ASME Z21.22.
  - f. Temperature range: To 400F.
8. Automatic flow-control valve:
- a. Individually selected by manufacturer to automatically limit rate of flow to design capacity, regardless of system fluctuations.
  - b. Selected to regulate flow within five percent of nameplate rating of system in which installed. Maximum operating differential between body tappings necessary for control not to exceed two psi.
  - c. Self-cleaning, cartridge-piston type with stainless-steel variable-area orifices.
  - d. Designed for minimum of 125 psi or 150 percent of system working pressure, whichever is greater.

- e. Tamperproof with body tapplings for connecting instruments for verifying flow-control performance.
  - f. Threaded or flanged connections as required for pipe fittings.
  - g. Furnished with valve kit consisting of 1/8-inch by two-inch minimum size nipples, shutoff valves located outside of insulation and hose fittings for use with measuring instruments.
9. Refrigerant valves: UL listed.
10. Balancing cocks:
- a. Resilient-faced, eccentric-plug type designed for minimum of 125 psi or 150 percent of system working pressure, whichever is greater.
  - b. Six inches and under, wrench-operated; eight inches and over, operated by worm or spur gear.
11. Line Strainers:
- a. Water strainers, Y or basket-type, 1-1/2 inches and smaller: ASTM A126, Grade B, iron bodies with screwed connections.
  - b. Two inches and larger: ASTM A126, Grade B, iron bodies with flanged-end connections.
  - c. Designed for minimum of 125 psi or 150 percent of system working pressure, whichever is greater.
  - d. Stainless-steel or Monel screens as follows:
    - 1) Perforations:

Strainer size	Perforation size
3/4-inch to two-inch inclusive	1/32 inch
2-1/2 inch to six-inch inclusive	1/16 inch
Eight-inch to 12-inch inclusive	1/8 inch
Over 12 inches	5/32 inch

- 2) Free area of screen minimum three times area of strainer inlet pipe.
- e. Strainer provided with 3/4-inch drain valve.
12. Backflow preventer:
- a. Reduced-pressure type with two check valves and automatically operated pressure-differential relief valve located between two check valves.
  - b. Relief valve and discharge port to drain intermediate chamber to level below supply-line inlet.
  - c. Moving parts and trim constructed of corrosion-resistant material.
  - d. Equipped with test cocks.
  - e. Conform to applicable section of ASSE and AWWA Standards.
13. Butterfly valves:
- a. MSS SP-67, sizes as shown.
  - b. Provide extended necks or neck extenders to accommodate two inches of insulation.
  - c. Provide 10-position latch-lock handles.

- d. Provide enclosed work screw operators, sizes eight inches and larger.
- e. Provide chainwheels when above normal reaching area.
- f. Provide adjustable balance-return stops for balancing service.
- g. Meeting MSS SP-67.
- h. Test shell at 225 psi.
- i. Body:
  - 1) Wafer-type, cast iron, ASTM A126, Class B, or lug-type, ductile iron, ASTM A536 grade 60-40-18, or ASTM A395.
  - 2) To fit between ANSI/ASME B16.5 flanges.
  - 3) Bodies with integral flanges or full lugs drilled.
- j. Seat:
  - 1) Provide ethylene-propylene-terpolymer (EPT) bonded to rigid ring providing noncollapsible and replaceable seat.
  - 2) Provide bubble-tight shutoff of 150 psi at temperatures between 25F and 225F.
  - 3) Provide O-ring as secondary seal between seat and stem.
- k. Disc:
  - 1) Aluminum-bronze: ASTM B150.
- l. Stem:
- m. Stainless steel: AISI Type 304, 316, 410 or 416.
  - 1) Isolate from contact with piped material.

D. Portable Flow Meters:

- 1. Factory-fabricated case, carrying handle and fitted to hold meter securely to accommodate the following accessories:
  - a. Two 10-foot lengths of connecting hose with female connectors for venturi-tube pressure-tap nipples.
    - 1) Hose designed for minimum of 125 psi or 150 percent of system working pressure, whichever is greater.
    - 2) Completely assembled three-valve manifold with two block valves and vent and drain valves piped and mounted on base.
  - b. Set of curves showing flow versus pressure differential for each orifice or venturi tube.
  - c. Metal instruction plate, secured inside cover, illustrating use of meter.

E. Orifices and Venturis:

- 1. Stainless steel, square-edge type, mounted between pipe flanges with factory-made pressure taps.
- 2. Taps with shut-off valves and with quick-connection hose fittings for portable meters.
- 3. Orifice-throat diameter at specified flow and differential pressure in inches water gauge as follows:
  - a. Fall in 60 to 80 percent of full scale reading for square-root meters.
  - b. Twelve to 40 inches for linear-scale meters.
- 4. Venturi size selected with design flow rate between 10 and 40 inches of water-pressure differential.
  - a. Permanent pressure loss: 25-percent maximum of indicated flow-rate differential pressure.
- 5. Flow-metering equipment: Supplied by same manufacturer.

F. Thermometers:

- 1. Dial-type, chromium-plated case, remote or direct-type bulb with accuracy of plus-or-minus one degree.
  - a. Three-inch minimum dial with white face and black digits, graduated in two-degree increments.
- 2. Liquid-in-glass thermometers.

3. Thermometer ranges suitable for service at not less than 20 degrees above controlled temperature settings.
- G. Thermometer Wells:
1. Stainless steel with portions surrounding bulbs not over 1/16-inch thick, designed to hold engraved-stem thermometer.
  2. Six inches projecting two inches into pipe with dust-excluding caps with gaskets and chains.
  3. Pipe smaller than 2-1/2 inches enlarged where wells are located.
  4. Set vertical or at angle to retain oil.
- H. Gauges:
1. ASTM F709, Class 1, 2 or 3, Style A, Type I or III with metal case.
- I. Shock Absorbers:
1. Constructed of stainless steel, precharged with nitrogen, argon or pneumatic pure glycerine and permanently sealed.
  2. Provided on cold-water supply piping to flush-valve water closets and urinals.
  3. Provided on hot and cold supply piping to lavatories and mop service basins.
  4. Certified to meet requirements of PDI WH-201.
- J. Expansion Joints:
1. General:
    - a. Designed for 150 psi and 200F for systems operating at 100 psi or less.
    - b. Provide expansion joint traverse with 150 percent of pipe expansion resulting from temperature variation of 80F.
    - c. Provide corrugated-bellows expansion joints for pipe expansion of 1-1/2 inches or less, minimum of 200 percent of expansion.
    - d. 1-1/2 inches and smaller, threaded ends; two inches and larger, flanged ends.
  2. Flexible ball joints:
    - a. Carbon steel, providing 360 degrees rotation plus 15 degrees minimum angular-flexing movement, furnished with asbestos-composition gaskets, steam-molded in steam-heat presses.
  3. Corrugated-bellows expansion joints:
    - a. Bellows constructed of single-ply or multiple-ply, formed, corrugated stainless steel for pipe sizes smaller than three inches.
    - b. Self-equalizing type with equalizing or reinforcing rings, internal-telescoping stainless-steel or Monel sleeves, removable steel housing to protect bellows and support insulation.
    - c. Corrugated element: Seamless tubing or of single sheet of metal rolled into cylinder having one longitudinal seam for sizes up to 16 inches.
    - d. Joints 2-1/2 inches and smaller: Internal guides and limit stops.
    - e. Designed for a minimum life of 5,000 full-rated traverse cycles when tested at specified pressures and temperatures.
- K. Supporting Devices:
1. Pipe hangers and supports:
    - a. Provide adjustable steel pipe hangers and supports as follows:
      - 1) Clevis and clamp, cadmium-plated or zinc-plated: MSS SP-58, Type 1 and Type 8 for steel and cast-iron piping.
      - 2) With cast-iron roller and sockets: MSS SP-58, Type 41 for chilled-water piping.
      - 3) Space not greater than six feet for pipe sizes up to and including 1-1/2 inches; 10 feet for pipe sizes two inches through six inches; 16 feet for pipe sizes eight inches and larger

- b. Pipe hangers for copper tubing: Steel, copper-plated, clevis-type, spaced at maximum five feet for tubing sizes through 1-1/2 inches and maximum eight feet for sizes two inches and larger.
  - c. Hanger rods minimum diameter 3/8 inch, constructed of steel, cadmium-plated, threaded full-length and diameter required by pipe size and load imposed.
  - d. Hanger rod nuts and washers: Steel, cadmium-plated.
  - e. Supported from malleable-iron, hot-dip galvanized inserts in concrete slab: MSS SP-58, Type 18.
  - f. Pipe hangers and supports in tunnels and shafts: MSS-SP-58, stainless steel, ASTM A276, Type 304.
2. Pipe rolls, plates and stands:
- a. Cast iron: MSS SP-58, Types 44, 45, and 46.
    - 1) Adjustable types selected for piping require grading after setting in place.
  - b. Protection saddles for support piping: MSS SP-58, Type 39, welded to pipe.
3. Pipe anchors:
- a. Designed to withstand five times anchor load minimum.
  - b. Vertical pipes anchored by means of clamps welded around pipes and secured to wall or floor construction.
4. Pipe guides:
- a. Factory-made cast semi-steel or heavy fabricated galvanized steel, consisting of bolted two-section outer cylinder and base with two-section guiding spider bolted or welded tight to pipe.
  - b. Designed to clear pipe insulation and to prevent overtravel of spider and cylinder.
  - c. Guides not less than 12 inches long and spiders not less than the following:

Pipe size/ inches	Spider length/ inches
1-1/2 and smaller	2
2 to 3	2-1/2
4	3
5 and larger	3-1/2

- 5. Expansion bolt anchors:
  - a. Consisting of bolt, expander, star lock washer and nut.
  - b. Fabricated of stainless steel, Type 303, including expander and star lock washer.
  - c. Anchor assemblies: FS: A-A-1992, Group II, Type 4, Class 1.
- 6. Self-drilling anchors:

- a. Self-drilling expansion anchors, with self-cutting annular broaching grooves.
  - b. Anchor and expander plug: FS: A-A-1992, Group III, Type 1, double-plated.
7. Pipe sleeves:
- a. Through interior masonry-unit walls: As shown. Sleeve to be large enough to accommodate pipe and covering but not less than two sizes larger than pipe size.
  - b. Through poured-concrete interior walls, floors and ceiling: As shown.
    - 1) Sleeves minimum two sizes larger than pipe. At floors, sleeves to project four inches above finish floor.
  - c. Through exterior structural elements: Minimum two sizes larger than pipe and as shown.
  - d. Sleeves designed to allow expansion/contraction movement of pipe.
8. Escutcheon plates:
- a. Polished brass or stainless steel, screw-fastened to wall or ceiling.
  - b. Plate collars caulked watertight with mastic.
  - c. Mastic: FS SS-C-153C, Type I.
- L. Drains:
- 1. Area drains:
    - a. Cast iron with flashing flange and flat grate for entrance areas.
    - b. Outlets designed for connection to cast-iron soil pipe.
    - c. Drain sizes and types as shown.
    - d. Clamping devices: For securing membrane or flashing for drains installed in membrane-waterproofed floors and in floors not laid on ground.
  - 2. Floor drains:
    - a. Cast iron with flashing flanges and bottom or side outlet as required and designed for connection to cast-iron soil pipe.
    - b. Clamping devices: For securing membranes or flashing, for drains installed in membrane-waterproofed floors and in floors not laid on ground.
    - c. Reinforced-neoprene flashing: For drains installed in floors that are not membrane-waterproofed and are not laid on ground.
    - d. Flashing of reinforced sheet neoprene, secured to drain by clamping device and extending 12 inches minimum from drain to ensure watertight connection.
    - e. Area, yard and floor drains in public spaces having finished brass grates.
    - f. Floor-drain sizes and types as shown.
  - 3. Roof drains:
    - a. Cast iron having integral flange and a clamping device for securing the roof covering to make a watertight connection.
    - b. Drains for promenade roofs with removable, loose-set, round flat grate in square frame secured to nonpuncturing flashing clamp collar with weep holes and for two inch or more roof fill.
    - c. Other roof drains furnished with cast-iron beehive or dome-shaped strainer.
    - d. Openings in each strainer having a combined-area minimum twice the area of drain outlet.
    - e. Each drain outlet having same size as downspout and with parts to make watertight connection to threaded pipe or cast-iron pipe as required.
    - f. Meeting requirements shown.
  - 4. Canopy drains (Roof Drain - Type 5):
    - a. Ductile iron: ASTM A536, Grade 65-45-12.
    - b. 30 square inches minimum grate free area.
    - c. Removable gratings, contoured to match opening in concrete rib and as shown.
- M. Air Separators:
- 1. Provide in-the-pipeline air separators with tangential openings for water in and out.

2. Design to create low-velocity vortex for internal separation of free air from water stream.
  3. Size according to size of connecting pipeline as shown.
  4. Equip with two-inch blowdown connection located at bottom of separator.
  5. Equip with 1-1/4 inch minimum compression tank connection located at top of tank.
  6. Tank:
    - a. Size as shown and rated at 125-psi working pressure.
    - b. Construct of carbon steel and in accordance with ASME Code for Unfired Pressure Vessels and so certified and stamped.
  7. Strainer:
    - a. Stainless steel with perforations sized for water flow.
    - b. Install in location to assist in separation of air.
    - c. Removable from bottom of separator.
  8. Insulation: Section 15080.
- N. Coal-Tar Epoxy Coating: Section 02535.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION:**

- A. Welding Procedure:
1. Perform welding by manual metallic arc-process except for pipe sizes four inches and smaller where gas welding (oxyacetylene) may be used.
    - a. Use electrodes and rods of composition recommended for pipe by AWS.
    - b. Heat surface within three inches from point where weld will start to temperature warm to the hand before welding.
  2. Weld corrosion-resistant nickel-copper alloy steel pipe by arc-process utilizing low-hydrogen electrodes of AWS E8016 or E8018 types.
  3. Leave joint surfaces smooth, uniform, free from fins, tears and other defects which adversely affect proper welding.
  4. After each pass of weld on multiple-pass welding, clean weld free of slag and other deposits before applying next pass.
  5. Peen with light blows of blunt-nosed peening hammer.
    - a. Do not peen surface layers or first pass in groove welds.
  6. For groove welds, have surface pass substantially centered on the seam, smooth and free from depressions.
  7. Perform fillet-welds with minimum cutting back of outside pipe.
    - a. Leave throat of full fillet-weld not less than 0.707 of thickness of pipe.
    - b. Repair excess cutting back and undercutting of base metal in pipe adjoining weld.
    - c. Fill up craters to full cross section of weld.
  8. Align and position accurately joints to be welded, so that pipe will not project beyond its adjoining pipe by more than 20 percent of pipe wall thickness or 1/8-inch maximum.
  9. Install welded pipe in accordance with ANSI/ASME B31.1.
- B. Soil, Waste, Vent and Drainage-Piping Installation:
1. Grade piping to 1/4 inch per foot and not less than that of main drain to which it is connected.
  2. Use reducers to change pipe sizes on vent and drain lines.
  3. Use long-sweep bends, Y-fittings, 1/8 or 1/16-bends, or combination Y and 1/8-bends to make changes in direction.
  4. Join service-weight soil pipe and fittings with service-weight gaskets and extra-heavy soil pipe and fittings with extra-heavy gaskets.
    - a. Designate and clearly identify service-weight and extra-heavy gaskets.

- b. Use lubricant for making joints.
  - c. Make tight seal between external face of pipe and internal face of bell.
  - d. Use gaskets capable of making and maintaining tight seal with deflection not exceeding five degrees.
  - e. Assemble joints by use of tools recommended by pipe, fittings and gasket manufacturers.
  - f. Employ trained workmen experienced in installation of gasket system to install entire gasket system.
5. Install embedded cast-iron piping at angle of 90 degrees to contraction joints with end of pipe bell coinciding precisely with centerline of contraction joint.
  6. Cut ends of screw-jointed pipes squarely to seat in bottom of recess of fittings and ream after cutting so waterway is not reduced in size.
  7. Apply thread dope or compound to male thread only.
- C. Buried Ductile-Iron Pipe:
1. Install pipe with mechanical joints and neoprene gaskets and stabilize by use of thrust blocks.
  2. Thrust blocks: Section 02515.
- D. Potable-Water System Installation:
1. Connect and install service water piping, sizes as shown, to fixtures, equipment and outlets.
  2. Install water meter in accordance with requirements of local water authority and provide the following valves:
    - a. Main shut-off gate valve inside service room ahead of water meter.
    - b. Drain with globe valve and hose nipple for 3/4-inch hose installed on house side of meter.
  3. Pipe or tubing free from cuts, dents and other surface damage. Remove damaged pipe and replace with new pipe or tubing.
  4. Cut square and ream ends of copper tubing.
  5. Tubing ends to extend full depth of fitting recesses without binding.
  6. Use lead-free 95.5-percent tin, four-percent copper and 0.5-percent silver solder with non-corrosive flux; ASTM B32.
  7. Ream and clean ends of threaded pipes before assembling with fittings and apply approved joint compound to pipe thread only.
  8. Make connections to equipment and fixtures without undue strain.
  9. Run horizontal piping with minimum pitch of one inch in 40 feet and arrange for drains at low points.
    - a. Install drain valves and hose nipples not smaller than 3/4 inch at low points.
  10. Connect nonferrous piping to ferrous piping with dielectric couplings.
  11. Install pressure-reducing valves where main water pressure exceeds 60 psi to maintain pressure of 15 psi at most remote fixture.
- E. Control-Air Piping Installation:
1. Do not run piping concealed under duct insulation, inside of ducts or in direct contact with surfaces colder than normal room temperature.
- F. Steel-Pipe Installation:
1. Weld embedded pipe and install so that pipe will not penetrate construction joints or structural contraction joints.
  2. Install horizontal piping with minimum pitch of one inch in 40 feet and arrange for drains at low points.
    - a. Install drain valves and hose nipples not smaller than 3/4 inch at low points.
  3. Install high-capacity automatic air vents at high points, designed for 125 psi and suitable for operation on pressures under 125 psi.
    - a. Pipe air-vent outlet to floor drains.
  4. Pipe drip pan to discharge as shown; if not shown, discharge to nearest open drain.

5. Provide flexible connections to coils, pumps and other equipment so as to eliminate undue strains in piping and equipment.
  6. Install condensate-drain lines for each air-handling unit with pitch of 1/4 inch per foot in the direction of flow.
    - a. Run drain lines to nearest open drain.
    - b. Do not exceed 400 feet maximum length of pipe between anchor and expansion joint or 90-degree offset.
  7. Do not support embedded pipe from reinforcing bars with metallic means.
- G. Expansion-Joint Installation:
1. Field set expansion joints for position corresponding to ambient temperature at time of installation.
  2. Setting based on manufacturer's calibration data furnished with expansion joints.
  3. Do not use corrugated-bellows expansion joints where exposed in train tunnels.
  4. Install ball joints in accordance with approved published recommendations of manufacturer.
  5. Do not use shims or steel spacers.
- H. Pipe Anchors:
1. Securely anchor piping where shown and where necessary for proper installation to force pipe expansion in proper direction.
- I. Expansion-Bolt Anchors:
1. Drill holes and install expansion-bolt anchors as recommended by anchor-bolt manufacturer. Do not locate less than eight inches from concrete edge.
- J. Pipe Sleeves:
1. Exterior walls:
    - a. Install as shown.
    - b. For cathodically protected pipe, test in accordance with Section 13115.
  2. Interior walls:
    - a. Install as shown. Seal to maintain integrity of walls.
- K. Plumbing-Fixture and Equipment Connections:
1. Make connections to wall-hung water closets and urinals with adjustable flanged nipples secured to chair supports, wax rings and rubber or impregnated-felt gaskets.
  2. Face plate of carrier not more than six inches from back of finish wall.
- L. Drains:
1. Install floor drains with traps.
- M. Air-Separator Installation:
1. Install air separator on suction side of chilled-water pump and as near to pump as practicable.
  2. Install dead-level in both directions and support from structure so that pipe can be removed without moving air separator.
  3. Install two-inch drain line, equipped with gate valve and union, from blowdown connection to nearest drain.
- N. Attachments to Prestressed-Concrete Girders:
1. Attach pipes and similar items to prestressed girders by welding to embedded plates or bolting to embedded fittings. Drilling into prestressed girders is prohibited, except as shown.
- O. Refrigeration Copper Tubing Installation:
1. Before heating joints, force nitrogen or carbon dioxide into the system.

2. Sweat each copper tubing installation joint in accordance with standard accepted practice.
- P. Bonding: In accordance with Section 16060, and with the following additional requirements:
1. Bond mechanical joints and fittings , including valves, by exothermic-welding method.
  2. Make welds in accordance with recommendations of the manufacturer. Clean and coat with coal tar epoxy.
  3. Bond pipe using bonding strap welded to each side of joint not less than six inches from joint. Allow sufficient slack in conductor for expansion of pipe.
- Q. Firestopping: Section 07841.
1. Pipe penetration through fire rated partitions to be sealed with approved fireproof sealant.

### **3.02 PROTECTION OF PIPING AND EQUIPMENT:**

- A. Protect pipe, openings, valves and fixtures from dirt, foreign objects and damage during construction.
- B. Replace damaged piping, valves, fixtures and appurtenances.
- C. Prior to testing, flush piping with chemically treated water until systems are clean and free of scale, slag, dirt, oil, grease and other foreign material.
- D. Hand-clean expansion joints and strainers.
- E. Coal-Tar Epoxy Coating for Protection of Ferrous Piping: Apply as specified in Section 02535 and test as specified in Section 13115.

### **3.03 FIELD QUALITY CONTROL:**

- A. Water-Pressure Testing:
  1. Prior to burial or concealment, test affected piping in presence of the Engineer using specified procedures.
  2. Test entire piping systems and test until found leak-free in presence of and to satisfaction of the Engineer.
  3. Notify the Authority at least 36 hours in advance of making tests.
  4. Test piping at following pressures:
    - a. Soil, waste and vent piping: Requirements of local plumbing code but not less than equivalent to ten feet of water.
    - b. Chilled-water and condenser-water piping embedded or otherwise inaccessible: 400-psi minimum.
    - c. Ductile-iron pipe: 150 psi or 1-1/2 times maximum working pressure, whichever is greater, at lowest point in system.
    - d. Potable-water piping: 1-1/2 times operating pressure but not less than 100 psi at topmost outlet.
    - e. Chilled-water and condenser-water piping, exposed and accessible: 150 psi or 1-1/2 times maximum working pressure, whichever is greater, at lowest point in system.
- B. Test Procedures:
  1. Soil, waste and vent piping:
    - a. Water test to include entire system from lowest point to highest point.
    - b. After filling system, shut off water supply and allow it to stand two hours without loss or leakage.

- c. Conduct final test by smoke test or peppermint test as prescribed by jurisdictional authority.
  - 2. Chilled-water and condenser-water piping embedded or otherwise inaccessible:
    - a. Avoid excessive pressure on safety devices and mechanical seals.
    - b. Fill entire system with water and vent air from system at least 24 hours before test pressure is applied.
    - c. Apply test pressure when water and average ambient temperatures are approximately equal and constant.
    - d. Maintain test pressure for minimum of six hours without drop after force pump has been disconnected.
    - e. Visually inspect joints while pipe is under test pressure.
  - 3. Ductile-iron pipe and black-steel piping:
    - a. Use procedure specified for chilled-water and condenser-water piping embedded or otherwise inaccessible.
  - 4. Potable-water piping:
    - a. Use procedure specified for chilled-water and condenser-water piping embedded or otherwise inaccessible, except tests may be conducted in sections as long as no pipes or joints are left untested.
- C. Control-air piping:
  - 1. Test main air piping at minimum of 150 psi and maintain pressure for one hour without pumping.
    - a. Test low-pressure air piping at minimum of 30 psi and maintain pressure for one hour without pumping.
    - b. Correct leaks by remaking joints.
- D. Pressure Testing:
  - 1. Refrigerant piping: Test at 300 psi on high side and 150 psi on low side.
    - a. Maintain pressure for minimum of 12 hours.
    - b. Use electronic leak detector to check leaks, after soap-bubble test.
- E. Repair of Leaks:
  - 1. Do not repair by mechanical caulking leaks in threads or welds occurring while pipeline is under test or in service.
  - 2. Introduction into piping system of material intended to stop leakage is prohibited.
  - 3. Repair leaks in threaded piping by breaking joint, cutting new threads on pipe and installing new pipe fitting.
  - 4. Remove defective welds by chipping or gas gouging from one or both sides of joint.
    - a. Reweld chipped-out places.
    - b. When base metals of fillet-weld are cut back or throat of weld is less than specified, repair defect by adding additional weld metal.

### 3.04 DISINFECTION:

- A. Adjust and Clean:
  - 1. Flush entire hot and cold-water piping and other piping and equipment connected downstream from the domestic-water inlet main shutoff valve with water to remove sediment after completion of tests, replacements or repairs.
    - a. Use chlorine for disinfection in form of hypochlorite solution or in form of compressed gas applied through approved chlorinator.
    - b. Operate valves and equipment during chlorination to ensure that chlorine reaches entire system.
    - c. Feed water and chlorination agent into system at rate providing for 50 ppm of chlorine and allow to stand 24 hours before flushing.
    - d. Residual chlorine at end of 24-hour retention period: Two-ppm minimum.
  - 2. Flush treated water from system completely after disinfection.

3. Continue flushing until samples show that quality of water delivered is comparable with public water supply and satisfactory to jurisdictional public-health authority.
4. Do not take samples from hydrants or through unsterilized hose.

**3.05 FIELD PAINTING:**

- A. Paint exposed soil and waste pipe lines in accordance with Section 09920.

**END OF SECTION**

## SECTION 15410

### PLUMBING FIXTURES

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing plumbing fixtures, including emergency-eyewash and body-spray facilities.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. FS: WW-P-541/GEN, A-A-1154.
  - 3. ASMEA112.19.2M
  - 4. ADA.
  - 5. ANSI: Z358.1.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings
  - 2. Certification.

##### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Ship products securely packaged and labeled for safe handling in shipment and to avoid damage and distortion.
- B. Mark each item permanently and legibly with manufacturer's name, brand, reference specification, type, class and other pertinent information as applicable.
- C. Store products in a secure, dry storage facility.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. Plumbing Fixtures:
  - 1. General requirements:
    - a. Fixtures manufactured of twice-fired vitreous chinaware of best quality, nonabsorbent and burned so that whole mass is thoroughly fused and vitrified producing material white in color, which when fractured will show homogenous mass, close-grained and free from pores.
    - b. Brass fittings, faucets, traps and exposed piping, chrome-plated over nickel plate, with polished finish.
    - c. Brass pipe, chrome-plated over nickel plate and provided with heavy cast-brass escutcheons and set screw plated to match pipe at fixtures passing into floors, walls or partitions.
  - 2. Water closet:
    - a. Wall-hung, flush valve, siphon jet, vitreous china: ASMEA112.19.2M.
  - 3. Urinal:
    - a. Wall-hung, flush valve, washout-type, vitreous china: ASMEA112.19.2M

4. Lavatory:
  - a. Vitreous china: FS WW-P-541/GEN.
  
- B. Fixture Supports:
  1. Supports for wall-hung water closets, urinals and lavatories: FS WW-P-541/GEN.
  2. Supports of metal, concealed in building construction. Fixtures rigidly supported from floor by means of one or more heavy extensions or feet built into floor.
  
- C. Mop Service Basin:
  1. One-piece precast terrazzo, approximate size 36 inches by 24 inches by six inches high.
  2. Terrazzo made of marble chips, cast in grey portland cement to produce minimum seven-day compressive strength of 3,000 psi.
    - a. Terrazzo surfaces ground with holes and pits grouted.
    - b. Excess grout removed and surfaces polished
  3. Stainless-steel bumpers furnished for exposed sides of basin.
  4. Drain body of chrome-plated brass, cast integral with basin and provided for inside neoprene joint connection two inches minimum depth to three-inch pipe.
  5. Chrome-plated service faucet with vacuum breaker, integral stops, adjustable wall brace, pail hook and 3/4-inch hose thread on spout.
  
- D. Vacuum Breakers:
  1. Chrome-plated brass sized to provide minimum air area equal to piping served and approved by local jurisdictional authorities
  
- E. Traps:
  1. Plain-pattern type having seal minimum of 2-1/2 inches and maximum four inches.
  2. 1-1/2 inch and two-inch traps: Heavy cast brass.
  3. All other size traps: Same material as specified for piping system to which they are connected.
  4. Fixture traps: As specified under plumbing fixtures, and insulated in accordance with ADA guidelines..
  
- F. Emergency Eyewash Fountain and Body Spray:
  1. In accordance with ANSI Z358.1.
    - a. Permanent type:
      - 1) Equipped with automatic pressure and volume-control devices to ensure safe and steady water flow under varying pressures.
      - 2) Wall-mounted, with functional parts constructed of corrosion-resistant materials and as follows:
        - a) Eyewash fountain: Twin chrome-plated brass eyewash heads, angled to direct flow of water into eyes and ocular area of face and mounted in stainless-steel bowl.
        - b) Body spray: Chrome-plated brass spray head and wall bracket. Spray head mounted on heavy-duty rubber hose.
      - 3) Operated by valves of the following types:
        - a) Eyewash fountain: Push-flag operating handle on stay-open valve.
        - b) Body spray: Quick-opening, chrome-plated, hand-squeeze level valve.
      - 4) Eyewash fountain and body spray equipped with pedal-operated and self-draining freeze proof valve where shown.
      - 5) Water filter:
        - a) Made of FDA-approved polypropylene with disposable FDA-approved viscose-fiber filter media capable of removing particles larger than 20 microns.

- b) Capable of withstanding rate of flow of seven gpm and working pressure of 200 psi at 100F.
    - 6) Shield: Fabricated as specified for toilet partition: Section 10155.
  - b. Portable type
    - 1) ASME rated 5-gallon stainless steel pressure tank.
    - 2) Equipped with built-in carrying handles, resilient bottom, pressure relief valve, tire filler valve and air pressure gauge.
    - 3) Furnished with twin chrome plated brass eye wash heads with automatic flow control and stay-open valve, with eight foot hose with hand held squeeze type valve and full size spray nozzle.
    - 4) Flow: 7-1/2 minutes from eye wash and 2-1/2 minutes from hose spray.
    - 5) Size: 25 inches tall and 26 inches circumference.
    - 6) Weight: 12 pounds empty and 42 pounds full.
    - 7) Chrome plate all metal parts.
- G. Electric Water Cooler: FS A-A-1154, minimum capacity 4.75 gallons per hour, Type 1 or Type 2 dispenser, temperature not more than 60F at 15 minute period, bubbler-style, air cooled, wall-hung, System T, for operation on 120-volt ac, 60-Hertz power. Dispenser not exceeding 18 inches in depth, with up-front spouts and controls; and complying with the ADA.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION:**

- A. Protection of Fixtures:
  - 1. Protect plumbing fixtures from dirt, foreign objects and damage during construction period.
  - 2. Do not use warped or otherwise imperfect fixtures.
  - 3. Do not use installed fixtures for any purpose, except testing, prior to final acceptance by the Authority.
  - 4. Replace damaged and defective fixtures.
  - 5. Install vacuum breakers on water supply-piping connections to fixtures and equipment in accordance with requirements of jurisdictional authorities.
- B. Chair supports adjusted so that heights of fixtures above finished floor are as follows:
  - 1. Water closet: 18 inches to top of earthenware.
  - 2. Urinal: 17 inches to top surface of lowest part of lip.
  - 3. Lavatory: 31 inches to top of rim.
  - 4. Handicapped lavatory: 29-1/2 inches clear under apron.
- C. Emergency-Eyewash and Body-Spray Facilities:
  - 1. Install in locations shown and as follows:
    - a. Install water-supply line connecting facilities to water service.
    - b. Install filter on water-supply line at readily serviceable location.
    - c. Install drain line connecting facilities to drainage system as shown.
    - d. Install freeze-proof valve a minimum of 42 inches below grade.
    - e. Install portable type where shown.
- D. Electric Water Cooler:
  - 1. Install in locations shown and with top of spout 36 inches above floor.

**END OF SECTION**

## SECTION 15444

### DRAINAGE PUMPING SYSTEM

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing complete drainage pumping system consisting of factory-assembled submersible pumping facilities.
- B. Related Work Specified Elsewhere:
  - 1. Subway drainage system: Section 02625.
  - 2. Piping systems: Section 15205.
  - 3. Control equipment: Section 15900.
  - 4. Raceways, boxes and cabinets Section 16130.
  - 5. Wire, cable and busways: Section 16120.
  - 6. Motors: Section 16225.
  - 7. Motor starters and control centers: Section 16425.
  - 8. Wiring and control devices: Section 16145.
  - 9. Grounding and bonding: Section 16060.
  - 10. Circuit breakers panelboards and load centers: Section 16440.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ASTM: A276, A312.
  - 3. NEMA: 250.
  - 4. P-MSHA: Permissible - Mining Safety and Health Association.
- B. Source Quality Control:
  - 1. Submersible: Perform the following in the order given:
    - a. Check impeller, motor rating and electrical connections.
    - b. Perform motor and cable-insulation tests.
    - c. Run dry to establish rotation and mechanical integrity.
    - d. Run for 30 minutes, a minimum of six feet underwater. Test head and capacity.
    - e. Repeat motor and cable-insulation tests.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Submit complete catalog information and shop drawings for material and equipment including wiring and control diagrams.
  - 2. Certification:
    - a. Manufacturer's certified test reports.
  - 3. Operation and Maintenance Manuals:
    - a. Submit for each drainage pumping system.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. General Requirements:
  - 1. In design and purchase of equipment, provide for interchangeability of subassemblies, parts, motors, starters and relays.
  
- B. Submersible Pumping System:
  - 1. Pumps:
    - a. Heavy-duty, non-clog, fully submersible drainage-water pumps and motors as shown on pump schedule.
    - b. Casings and impeller fabricated of gray cast iron with stainless-steel wear rings and external nuts and bolts.
    - c. Impeller: Fully enclosed, vane-type, non-clog design capable of passing minimum two-inch diameter solids.
    - d. Seals: Tandem double mechanical seals running in oil reservoir; lower seal composed of two separate carbon or ceramic lapped face rings. Protect lower compression spring against exposure to pumped liquid.
    - e. Pump units capable of automatic connection to discharge piping by single linear downward motion of pump pressing tightly against discharge connection.
    - f. Discharge connection: Automatic discharge connection permanently bolted level to bottom slab with four 3/4-inch heavy-duty, stainless-steel threaded anchor bolts ASTM A276, Type 304, and at exact location required relative to respective access cover.
    - g. Guide bars, permanently attached to discharge connection or sole plate and to the access cover, for automatic hookup and dismount of pump units.
      - 1) Guide bars for pumps: Stainless-steel pipe, ASTM A312, Grade TP 304.
    - h. Pump units with integral sliding guide bracket easily removable from upper room equipment hatches, without requiring personnel to enter pump well to remove bolts, nuts or other fastenings.
    - i. Lifting handle and chain provided for service work. Lifting chain permanently attached to lifting handle and to safety hook on access cover. Galvanized steel design using safety factor of four.
  - 2. Pump motors: Section 16225, with the following additional requirements:
    - a. 1,750 rpm maximum; 460-volt; tolerance, plus 10 percent, minus 10-percent nameplate-value voltage; nonoverloading at all points of pump curve with cooling characteristics for continuous operation and with thermal-overload protection.
    - b. Air-filled, watertight, Class B insulation system with Class F materials, insulated windings and watertight terminal board. Dry, shell-type, squirrel-cage induction-type design. Provide watertight cable entry with power-cable strain-relief mechanism.
      - 1) Cable entry: Designed to preclude specific torque requirements to ensure watertight submersible seal.
      - 2) Cable entry, junction chamber and motor separated by terminal board isolating motor interior from foreign matter entering through pump top.
  - 3. Controls: Control-system components to be supplied by pump manufacturer.
    - a. Liquid-level controllers of direct-acting float, mercury switch sensors for pump control and HIGH/LOW level indicators. Pump control-point elevations and fully automatic operational sequence for each pump as shown. HIGH/LOW level alarm-indication system to be independent from pump control.
    - b. Panel: Duplex pump-control panel, in NEMA 250, Type 4 wall-mounted enclosure as shown. Provide surveillance for malfunction. Provide space for each pump motor starter.

- c. Motor starter: In accordance with Section 16425, with HAND/OFF/AUTO selector switch.
  - d. Provide automatic electric alternator with duplex pump-control panel.
    - 1) Solid state, plug-in type.
    - 2) Independent ON, common OFF operation.
    - 3) Relay rating: Heavy-duty, 10 amperes, 250 volts.
  - e. HIGH/LOW level-indication relays.
  - f. Float switches: Direct automatic float switches with Type 316 stainless-steel, 5-1/2 inch diameter housings; mounting clamps and attached cables. Capable of detecting level changes of one inch from rest position and suitable for mounting to one-inch, stainless-steel vertical pipe.
  - g. Provide local high-motor-temperature indicator light.
4. Wiring:
- a. Wiring and conduit: Sections 16130 and 16120. Cable racking in upper room and below floor slab.
  - b. Wiring for controls and motors by pump-system equipment manufacturer.
  - c. Autotransformer, pump-starter control panel wired from transfer switch as shown.
  - d. Pump-motor cables: Suitable for submersible-pump application with P-MSHA (Permissible-Mining Safety and Health Association) approval demonstrated by code or legend permanently embossed on cable, 25 feet per pump, strain-relieved within pump junction chamber.
  - e. Float switches: Flexible three-conductor, 14AWG cable, stranded conductor with synthetic-rubber submersible jacket and attached mercury switch. Each float furnished with 25 feet of cable grounded internally to float housing.
5. Piping, valves and fittings: Section 15205.
6. Thrust restraints: Provide on discharge lines as shown in accordance with Section 02515.
7. Pump hatches: Lightweight modularized design, fabricated of structural aluminum, stainless-steel hardware, recessed tilt-up access handle and hasp, torsion bar, changeable hinge side, lateral sliding nuts for station-hardware attachment. Each pump cover furnished with stainless-steel upper guide-bar brackets and lifting-chain hook.
8. Trolley and hoist: Single-chain hoist and trolley, 3,000-pound capacity, with 3.33-inch operating flange track, traversing centerline of pumps and installed as shown to permit installation and removal of units with station's internal equipment.
- a. Wheels: Special alloy iron with chilled and ground tread. Double row, prelubricated and permanently sealed precision bearings, with the following additional requirements:
    - 1) Overall diameter: Five inches.
    - 2) Tread diameter: Four inches.
    - 3) Axle diameter: 3/4 inch.
  - b. Yokes and load bar: Formed steel.
  - c. Fitting: Two-piece malleable-iron swivel clevis.
- C. Flowmeter: As approved by WASA, Controlotron, including the following components or approved equivalent system:
- 1. Flow Computers:
    - a. Model 1010 ANI,-JBLV Single Ultrasonic Transit Time Clamp On Flow Computer System with Full Graphical Digital Display, incorporating phase based detection, phase marker correlation, multipulse transmission and 4~20 mA outputs. Flow Computers having amplitude based detection are not acceptable due to EMI/RFI potentially generated by electric driven trains.
- D. Miscellaneous Equipment: Provide the following:

1. 120-volt, duplex, polarized convenience outlet furnished in side of control panel.
  2. 120-volt accessory controls provided with 15-ampere single-phase circuit breaker for each item.
  3. Ground-fault protection in each combination starter to trip breaker. Field-adjustable device with range to 50 amperes and factory-set at five amperes pick-up fault current.
  4. Automatic transfer switch in accordance with Section 16145.
  5. Ground bus bar in accordance with Section 16060.
  6. Circuit breaker in accordance with Section 16440.
  7. Surveillance in accordance with Section 15900:
    - a. Indicating malfunction when water level falls below or rises above predetermined range.
    - b. Indicating loss of power.
  8. DTS cabinet in accordance with Section 16130.
- E. Nameplates:
1. Securely attached to each major item of equipment showing manufacturer's name, model number and serial number.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION:**

- A. Install complete pumping system including provision for hoisting in accordance with manufacturer's recommendations and place into operation. Prior to such operation, maintain drainage system specified in Section 02625 and as shown.
- B. Fit equipment and appurtenances within space provided and make readily serviceable
- C. Install remote totalizer where shown.
- D. Where shown, install flowmeter in accordance with manufacturer's instructions. Engage services of manufacturer of flowmeter for start-up services and instruction of personnel with a minimum of four hours on site.

#### **3.02 FIELD QUALITY CONTROL:**

- A. Tests and Inspections:
  1. Verify performance of drainage pumping station in accordance with items indicated on Exhibit 15444-1.
  2. Make arrangements for water needed for testing.

#### **3.03 TEMPORARY PUMPING SYSTEM:**

- A. The Contractor may at his option elect one of the following courses of action:
  1. Install a temporary drainage pump for his use during construction and replace it prior to final acceptance with the specified permanent system.
  2. Install specified permanent drainage pump for use during construction and prior to final acceptance have it rehabilitated by the manufacturer as necessary to restore it to a new condition.

**EXHIBIT 15444-1**

**CONTRACTOR VERIFICATION OF DRAINAGE PUMPING**

**STATION PERFORMANCE**

I. Instruments Required:

	<u>Instrument</u>	<u>Date of Calibration</u>
A.	Amprobe	_____
B.	Tachometer or Strobe	_____
C.	Stop Watch	_____ N/A _____
D.	Measuring Stick	_____ N/A _____
E.	Pressure Gauge	_____

II. Hand Operation: The purpose of this test is to establish operating characteristics of pumps and motors.

- A. Fill wet well with enough water to start pump.
- B. Pump No. 1 selected as lead pump:
  - 1. Set for hand operation with HAND/OFF/AUTOMATIC (HOA) switch on H.
  - 2. Start pump.
  - 3. Record:
    - Motor voltage \_\_\_\_\_ volts.
    - Motor current \_\_\_\_\_ amperes.
    - Pump speed \_\_\_\_\_ rpm.
    - Discharge pressure \_\_\_\_\_ psi.
  - 4. Stop pump.
- C. Fill wet well with enough water to start pump.
- D. Pump No. 2 selected as lead pump:

**EXHIBIT 15444-1 (CONT.)**

1. Set for hand operation (HOA on H).
2. Start pump.
3. Record:
  - Motor voltage \_\_\_\_\_ volt.
  - Motor current \_\_\_\_\_ amperes.
  - Pump speed \_\_\_\_\_ rpm.
  - Discharge pressure \_\_\_\_\_ psi.
4. Stop pump.

E. Record size of wet well: \_\_\_\_\_

III. Automatic Operation: The purpose of this test is to check alternator and automatic pump operation.

A. Set both pumps for automatic operation (HOA on A).

B. Add water to wet well. As soon as water reaches invert of influent pipe level (datum), one pump should start. Record data for four continuous cycles.

Cycle	Pump Running #1 or #2	Water level from datum $\pm$ at start	Time of Start	Water level from datum $\pm$ at stop	Time of stop	Calc. Flow Rate
1.						
2.						
3.						
4.						

IV. Alarm Operation: The purpose of this test is to check operation of lag-pump starting and high-level alarm.

A. Set both pumps for automatic operation (HOA on A).

B. Add water to wet well. As soon as water reaches the invert of influent pipe level (datum), one pump should start.

**EXHIBIT 15444-1 (CONT.)**

C. When lead pump starts, shut it off (HOA on O).

D. When lag pump starts, record water level and return lead-pump control to automatic (HOA on A) and record water level when pumps stop. Repeat for a total of four cycles with each pump being lead pump twice.

Cycle	Alarm Yes/No	Lead pump #1 or #2	Water level when lag pump starts, datum $\pm$	Water level when pumps stop, datum $\pm$
1.				
2.				
3.				
4.				

E. Repeat steps A, B, and C above.

F. When lag pump starts, shut it off (HOA on O). Allow water to continue to rise in wet well until high alarm sounds. Then record level and turn both pumps on automatic (HOA on A). Repeat for two cycles.

Cycle	Alarm for Lag Pump Yes/No	Alarm for high- water level Yes/No	Water level, datum $\pm$ when high- water level alarm sounds
1.			
2.			

**EXHIBIT 15444-1 (CONT.)**

V. Performance Calculations:

Pump(s) Operating	Pumping Rate Contract Requirements	Pumping Rate Test Results
Pump #1		
Pump #2		
Pump #1 & #2		

**END OF SECTION**

**SECTION 15445**  
**SEWAGE EJECTORS**

**PART 1 - GENERAL**

**1.01 DESCRIPTION:**

- A. This section specifies providing complete triplex dry pit submersible vertical electric sewage ejector.
  
- B. Related Work Specified Elsewhere:
  - 1. Piping systems: Section 15205.
  - 2. Control equipment: Section 15900.
  - 3. Miscellaneous pumps: Section 15135.
  - 4. Grounding and bonding: Section 16060.
  - 5. Wire, cable and busways: Section 16120.
  - 6. Conduit, raceway and boxes: Section 16130.
  - 7. Wiring and control devices : Section 16145.
  - 8. Motors: Section 16225.
  - 9. Motor starters and control centers: Section 16425.
  - 10. Circuit breakers panelboards and load centers. Section 16440.

**1.02 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications.
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ASME code.
  - 3. ASTM: A48, E527.
  - 4. NEMA.
  - 5. P-MSHA.
  - 6. UL.

**1.03 SUBMITTALS:**

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Submit complete catalog information and shop drawings for material and equipment including wiring and control diagrams.
  - 2. Certification.
    - a. Manufacturer's certified test reports.
  - 3. Operation and Maintenance Manuals.
    - a. Submit for each drainage pumping system.

**PART 2 - PRODUCTS**

**2.01 PRODUCTS AND MATERIALS:**

- A. General Requirements:
  - 1. In design and purchase of equipment, provide for interchangeability of piping subassemblies, parts, motors, starters and relays.
  
- B. Dry Pit Pumping System:
  - 1. Pumps:

- a. Vertical dry-pit, non-clog sewage water pumps and motors as shown on pump schedule.
  - b. Castings fabricated of gray cast iron with stainless steel wear rings and external nuts and bolts, conforming to ASTM A48 Class 30.
  - c. Impeller: One piece, single suction, fully enclosed, vane-type, conforming to an ASTM A48 Class 30, non-clog design capable of passing minimum three-inch diameter solids statically, balanced and secured directly and straight motor shaft.
  - d. Seals: Tandem double mechanical seals running in oil reservoir; lower seal composed of two separate carbon or ceramic lapped face rings. Protect lower compression spring against exposure to pumped liquid.
  - e. Provide a pump which rotates on a minimum of two bearings permanently lubricated but capable of being regreased, suitable for a minimum L10 bearing life of 40,000 hours.
  - f. Provide a heavy duty fabricated steel base with openings for access to the suction elbow and cleanout bolted directly to the volute. Provide a base which supports the assembled weight of the pump and driver. Furnish a cast iron elbow with 1/4-inch gauge connection, contoured hand hole clean out, and a 125-pound flat faced flange conforming to ANSI drilling.
  - g. Provide a volute of one piece circular design with smooth fluid passages large enough to pass any solid that can pass through the impeller, made of close-grained cast iron conforming to ASTM A48 Class 30. The volute is to be side flagged tangential discharge, and capable of rotation in 45 increments to accommodate piping orientation. The volute is to have large cleanout openings located at the impeller centerline. Provide volute priming drain and 1/4-inch minimum gauge connections. Provide 125-pound flat faced flanges in accordance with ANSI drilling. Provide for removal of the rotating assembly without disturbing the suction or discharge piping. Hydrostatically test the casing to 1.5 times the design head or 1.25 times the shutoff head, whichever is greater.
2. Pump Motors: Section 16225, with the following additional requirements:
- a. 1,750 rpm maximum; 460-volt tolerance; plus or minus 10 percent nameplate-value voltage; non-overloading at all points of pump curve with cooling characteristics for continuous operation and with thermal-overload protection.
  - b. Submersible as defined by the air-filled cast iron watertight enclosure.
  - c. Shaft: Alloy S41600 stainless steel in accordance with ASTM E527; the rotor dynamically balanced to meet NEMA vibration limits; hardware stainless steel.
3. Controls: Control system components to be supplied by the pump manufacturer.
- a. Liquid-level controllers of direct acting float, mercury switch sensors for pump control and HIGH level indicators. Pump controls pint elevations and fully automatic operational sequence to reach pump as shown. HIGH level alarm indication system to be independent from pump control.
  - b. Panel: Triplex pump control panel, in NEMA I, wall-mounted enclosure as shown. Provide surveillance for malfunction. Provide space for each pump motor starter.
  - c. Motor starter: In accordance with Section 16425, with HAND/OFF/AUTO selector switch.
  - d. Provide automatic electric alternator with triplex pump control panel.
    - 1) Solid state, plug-in type.
    - 2) Independent ON, common OFF operation.
    - 3) Relay rating: Heavy-duty, 10 amperes, 250 volts.
  - e. HIGH level indication relays.
  - f. Float switches: Direct automatic float switches with Alloy S31600 stainless steel in accordance with ASTM E527, 5-1/2-inch diameter housing;

mounting clamps and attached cables. Capable of detecting level changes of one inch from reset position, and suitable for mounting to one-inch stainless steel vertical pipe.

- g. Provide local high-motor-temperature indicator light.
  - 4. Sequence of operation:
    - a. As the liquid level rises in the wet well have SE-1 energize as the lead pump float switch rises, and deenergize at the off level/lowering of the float switch.
    - b. On the next cycle, have SE-2 energize and proceed as described for SE-1.
    - c. On the following cycle, have SE-3 proceed the same as described above.
    - d. Program SE-1, SE-2 and SE-3 to alternate each cycle and program the other pumps to be first lag pump on and second lag pump on. The sequence is as follows:
      - 1st Cycle SE-1, SE-2, SE-3
      - 2nd Cycle SE-2, SE-3, SE-1
      - 3rd Cycle SE-3, SE-1, SE-2Normal operation = one pump per load only.
    - e. If the water level continues to rise after the first pump has energized and due to clog or mechanical failure, have SE-2 energize and trigger alarm at the first lag pump input; and if the water continues to rise due to second pump failure, then have SE-3 energize and activate alarm at the second lag pump input.
    - f. Program two more alarm inputs for indication functions.
    - g. Make low-level and high-level alarms independent of pump control and activated as required.
  - 5. Wiring:
    - a. Wiring and conduit: Sections 16130 and 16120. Cable racking in upper room and below floor slab.
    - b. Wiring for controls and motors by pump system equipment manufacturer.
    - c. Auto transformer, pump starter control panel wired from transfer switch, as shown.
    - d. Pump-motor cables: Suitable for submersible-pump application with P-MSHA approval demonstrated by code or legend permanently embossed on cable, 25 feet per pump, strain-relieved within pump junction chamber.
  - 6. Piping, valves and fittings: Section 15205, except check valves to be swing type with outside lever and spring or outside lever and weight; steel or iron body and cap and flanged end connection.
  - 7. Thrust restraints and anchors: Provide on discharge lines as shown or in accordance with Section 02515 for buried pipe or Section 15205 for exposed pipe.
  - 8. Pump access gratings and ladders: In accordance with Section 05500, and as shown.
- C. Miscellaneous Equipment: Provide the following:
- 1. Furnish 120-volt, duplex, polarized convenience outlet inside of control panel.
  - 2. Provide 120-volt accessory controls with 15-ampere single-phase circuit breaker for each item.
  - 3. Provide ground-fault protection in each combination starter or trip breaker. Field adjustable device with range to 50-amperes and factory set at 5-amperes pickup fault current.
  - 4. Automatic transfer switch in accordance with Section 16145.
  - 5. Ground bus bar in accordance with Section 16060.
  - 6. Circuit breaker in accordance with Section 16440.
  - 7. Surveillance in accordance with Section 15900.
  - 8. Indication loss of power.
- D. Hand propelled carrier: Provide monorail and hand propelled carrier as shown.

- E. Sump pump: Provide sump pump as specified in Section 15135 and as shown.
- F. Nameplates: Securely attach to each major item of equipment showing manufacturer's name, model number and serial number.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION:**

- A. Install complete pumping system including provision for hoisting in accordance with manufacturer's recommendation and place into operation. Follow manufacturer's recommendation for minimum separation between sensor and maximum expected material level.
- B. Fit equipment and appurtenances within space provided and make readily serviceable.

#### **3.02 FIELD QUALITY CONTROL:**

- A. Tests and inspections:
  - 1. Pump chamber: Test shop and field joints for water tightness by pressurizing with compressed air to a minimum of five inches of water gauge and applying water and soap solution to the joints. Seal leaks and retest joints until leak free.
  - 2. Make arrangements for water needed for testing.

#### **3.03 MANUFACTURER'S ASSISTANCE AND WARRANTY:**

- A. Have the manufacturer guarantee equipment and controllers for two years of operation or 30 months from date of shipment, whichever comes first, so that the equipment is free from defects in design, workmanship or materials.
- B. In the event that a component fails to perform as specified or is proven defective in service during the guarantee period, have the manufacturer promptly replace the defective part at no additional cost to the Authority.
- C. Provide support beams, concrete pads, platforms, hangars and anchor bolts necessary for proper installation of equipment as recommended by manufacturer.

**END OF SECTION**

## SECTION 15480

### DOMESTIC WATER HEATERS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing domestic electric water heaters.
- B. Related Work Specified Elsewhere:
  - 1. Concrete Pads: Sections 03100 and 03300.
  - 2. Miscellaneous Pumps : Section 15135.
  - 3. Piping Systems: Section 15205.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ASME Boiler and Pressure Vessel Code.
  - 3. UL listed.
  - 4. ASHRAE: 90.1b, Standard for Energy Efficiency.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings.
  - 2. Certification.
  - 3. Operations and Maintenance Manuals.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. General Requirements:
  - 1. In design and purchase of equipment, provide for interchangeability of items of equipment, subassemblies, parts, relays and other items
- B. Water-Heater Equipment; UL listed and as follows:
  - 1. Capacity of storage-type water heaters and accessories: As shown.
  - 2. Water heaters fabricated of steel in accordance with the following additional requirements:
    - a. 120-gallon capacity or more: ASME Boiler and Pressure Vessel Code and applicable local plumbing code.
    - b. Less than 120-gallon capacity: Applicable local plumbing code.
  - 3. Minimum storage capacity: As shown.
  - 4. Water heaters designed for heat-recovery capacity as shown.
  - 5. Glass-lined tanks insulated with minimum 1-1/2 inch fibrous-glass blanket, or manufacturer's standard insulation with metal jacket over insulation.
  - 6. ASME rated temperature-pressure relief valve on tank, piped to indirect waste.
  - 7. Heating elements of double Incoloy rod-type for operation at voltage shown.
    - a. Water heaters with capacity of 20 gallons or less equipped with single heating element.

- b. Water heaters with capacity of more than 20 gallons equipped with two or more heating elements.
  - 8. Furnished with complete automatic controls including temperature protector designed to shut-off power supply if water temperature in tank rises to 205F.
  - 9. Low-water cutoff to protect system from operating when water level drops below electrical probe.
  - 10. Immersion-type thermostats and dial-indicating temperature gauge.
  - 11. In-line hot-water recirculating pump: Section 15135.
  - 12. Meets ASHRAE 90.1b, Standard for Energy Efficiency.
- C. Nameplates:
- 1. Securely attached plate on each water heater showing manufacturer's name, model number and serial number.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION:**

- A. Fit equipment and appurtenances within space provided and make readily serviceable.
- B. Provide supports, concrete pads, hangers and anchor bolts necessary for proper installation of equipment as recommended by manufacturer.
- C. Install complete potable make-up water system as shown and in accordance with Section 15205.

**END OF SECTION**

## SECTION 15625

### CHILLERS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing complete factory-assembled packaged water-chilling units.
- B. Related Work Specified Elsewhere:
  - 1. Concrete pads: Sections 03100 and 03300.
  - 2. Water Treatment System: Section 15186.
  - 3. Piping systems: Section 15205.
  - 4. Insulation: Section 15080.
  - 5. Vibration isolation: Section 15070.
  - 6. Control equipment: Section 15900.
  - 7. Conduit, raceways and cabinets: Section 16130.
  - 8. Wire, cable and busways: Section 16120.
  - 9. Motors: Section 16225.
  - 10. Motor starters and control center: Section 16425.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ASME Code.
  - 3. ARI: 550.
  - 4. ANSI: B9.1.
  - 5. ASHRAE Standards.
- B. Design Criteria:
  - 1. For single-chiller chiller plant: Select each water-chilling unit in accordance with the following criteria:
    - a. Water on evaporator: 55F.
    - b. Water off evaporator: 42F.
    - c. Water on condenser: 85F.
    - d. Water off condenser: 95F.
    - e. Net refrigeration effect, chilled-water flow rate and condenser water-flow rate: as shown on the Contract Drawings.
    - f. Control system compatible with AEMS system.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Capacity curves for evaporator/compressor and compressor/condenser plotted on charts to ensure properly balanced refrigeration equipment under design conditions.
  - 2. Certification:
    - a. Record of packaged water chillers in field operation for minimum of 12,000 operating hours for not less than ten individual units prior to shipment. Types that have already shown satisfactory operation for this period may

- have modifications , provided modifications will not increase maintenance and operating costs or decrease life of machine and complies with ARI 550.
- b. Verification of successful use of material used for impeller wheel for centrifugal compressors, if other than aluminum alloy.
- 3. Operation and Maintenance Manuals.

#### **1.04 JOB CONDITIONS:**

- A. Safety Requirements:
  - 1. Properly guard belts, pulleys, chains, gears, couplings, projecting set screws, key and other rotating parts to prevent danger to personnel.

#### **1.05 OPERATION AND MAINTENANCE TRAINING:**

- A. In accordance with the General Requirements.

### **PART 2 – PRODUCTS**

#### **2.01 PRODUCTS AND MATERIALS:**

- A. General Requirements:
  - 1. Supply chiller with full operating charge of HFC-134a Refrigerant and oil. In design and purchase of equipment, provide for interchangeability of items of piping equipment, subassemblies, parts, motors, starters and relays.
- B. Centrifugal Compressors:
  - 1. Single-stage, statically and dynamically balanced impeller.
  - 2. Driven by drive motor directly or by means of gears.
  - 3. Casing fabricated of cast iron, aluminum or steel plate with split sections gasketed and bolted.
  - 4. Impeller wheel constructed of aluminum alloy or other material that has been demonstrably successful in use.
  - 5. Impeller shaft fabricated of heat-treated alloy steel with sufficient rigidity for proposed operation at specified operating speeds.
  - 6. Shaft main bearings: Journal with bronze or babbitted liners or one-piece aluminum alloy inset.
  - 7. Lubrication: Forced feed to lubrication points.
  - 8. Differential oil-pressure cutout interlocked with compressor starter to allow compressor to operate only when recommended oil pressure is provided to bearings.
  - 9. Capacity reduction designed to provide automatic capacity modulation from 100 percent capacity to 10-percent capacity without cycling.
  - 10. Capacity-control system actuated by temperature of water leaving evaporator.
  - 11. Transducers for remote surveillance and control by AEMS system as shown and in accordance with Section 15900.
- C. Water Cooler:
  - 1. Removable bundle-type copper tube, constructed of seamless copper tubing minimum 0.035-inch wall thickness, plain or with integral fins individually replaceable and rolled or brazed into copper or steel-tube sheets, with baffles and tube supports of copper or steel.
  - 2. Complete refrigerant-feed control, designed to control feed to evaporator at each level of load range from 100 percent to 10 percent of package water-chilling capacity without use of hot-gas bypass.
  - 3. Performance based on water velocity of minimum three fps and maximum ten fps throughout full length of tubes and fouling factor of 0.00025 for individual machine.

4. Water spaces in coolers designed for minimum 150-psi working pressure; tested in accordance with ASME Code.
  5. Water spaces not subject to the ASME Code due to size or other limitations, tested at pressure of not less than 1-1/2 times working pressure.
- D. Insulation:
1. Each water-chilling unit provided with insulation as specified in Section 15080.
- E. Condenser:
1. Shell-and-tube type permitting tubes to be cleaned from each end by removing water-box cover plates or head.
  2. Tubes fabricated of seamless copper tubing, minimum 0.035-inch wall thickness, with integral fins individually replaceable and rolled or brazed into copper or steel-tubed sheets.
  3. Performance based on rate of water flow specified and water velocity of 3-fps minimum and 10-fps maximum throughout full length of tubes and fouling factor of 0.0075.
  4. Water spaces in condenser designed for minimum 150-psi working pressure; tested in accordance with requirements of ASME Code.
  5. Refrigerant side of shell tested at 1-1/2 times refrigerant saturation pressure.
- F. Compressor Drive Motor, Hermetic Units:
1. Squirrel-cage induction, refrigerant gas-cooled, rated at 460 volts, three-phase and 60 Hertz and in accordance with Section 16225.
  2. Bearings: Sleeve-type.
  3. Pressure lubrication with pump and cooler.
  4. Gear cases oiltight.
  5. Motor starter conforming to recommendations of water-chiller manufacturer and as specified in Section 16425.
  6. Wiring as recommended by compressor manufacturer to provide complete automatic operation of centrifugal refrigeration system.
  7. Each centrifugal machine, driven through speed-increasing gears designed to ensure self-alignment, lubrication and minimum of unbalanced forces.
- G. Compressor Drive Motor, Open-Drive Units:
1. Drip-proof, fully guarded, squirrel-cage induction and as specified in Section 16225.
- H. Controls, Control Panel and Gauges: Provide refrigerant monitors suitable for refrigerant R-134a per ASHRAE Standards.
1. Provide a microprocessor control panel which can monitor and display various chiller parameters and alarms. As a minimum, monitor the following points:
    - a. Analog points:
 

1)	Chilled water enter temperature	DEG F
2)	Chilled water return temperature	DEG F
3)	Condenser water enter temperature	DEG F
4)	Condenser water return temperature	DEG F
5)	Condenser water pressure	PSI
6)	Chilled water pressure	PSI
7)	Condenser refrigerant pressure	PSI
8)	Evaporator refrigerant pressure	PSI
9)	Chiller oil pressure	PSI
10)	Chiller KW demand	KW
11)	Chiller efficiency	KW/TON
    - b. Alarm points:
      - 1) Chiller oil temperature
      - 2) Chiller bearing temperature

- c. In addition, for future interface with an Energy Management System, provide a 4-20 mA signal output for each analog point and a dry contact closure for each alarm point.
  2. Each water-chilling unit provided with electronic or pneumatic controls as specified in Section 15900.
  3. Capacity-control mechanism to be integral part of packaged water chiller maintaining leaving water temperature within 0.75 degrees F of setting temperature from 100 percent to 10 percent of chiller capacity.
  4. Control mechanism: Compressor stopped when chiller output drops below 10 percent and automatically restarted when leaving water rises to preset temperature.
  5. Timing device: Restarting unit limited to four starts per hour, minimum 15 minutes apart.
  6. Modulating chilled-water operating control having adjustable throttling range, with means of calibration by adjusting chilled-water temperature control point. Pneumatic or solid-state electronic control.
  7. Control panel provided on each unit with compressor-operating control, START/STOP switch and the following gauges and protective devices:
    - a. Suction-pressure gauge.
    - b. Condensing-pressure gauge.
    - c. Oil-pressure gauge.
    - d. Low-refrigerant-pressure cutout.
    - e. High-pressure cutout, manual reset only.
    - f. Low-oil-pressure cutout, manual reset only.
    - g. Low-water-temperature cutout, manual or automatic reset.
    - h. Motor-winding high-temperature cutout, manual reset only.
    - i. Running-time meter.
  8. Signal lights for protective devices.
  9. Alarm-circuit terminals in basic chiller-package control panel designed to actuate alarm device in event of machine cutout of protective devices.
- I. Evacuation System:
  1. Manually started and stopped evacuation system when positive-pressure refrigerant is used and chiller package is not designed to permit pumpdown storage and isolation of entire charge in condenser.
  2. Motor-driven, air-cooled or water-cooled reciprocating condensing unit and receiver of sufficient capacity to store entire refrigerant charge of largest water-chilling system.
  3. Receiver in accordance with ASME Code, mounted on floor brackets and provided with rupture members and dual relief valves in series.
  4. Entire system completed with valves, piping and controls so that evacuation system may be utilized for pumpout, without temporary piping or wiring.
- J. Receiver, Refrigerant:
  1. Horizontal liquid receiver designed, fitted and rated in accordance with ASME Code.
  2. Each receiver having storage capacity 25 percent minimum in excess of that required for fully charged system.
  3. Inner surfaces thoroughly cleaned by sandblasting.
  4. Each receiver equipped with inlet, outlet drip pipe, drain plug, purging valve, relief valves of capacity and setting in accordance with ANSI B9.1 and two bulls-eye liquid sight glasses.
  5. Sight glasses installed in same vertical plane, 90 degrees apart, perpendicular to the axis of the receiver and not over 3-inches horizontally from drip pipe measured along axis of receiver.
  6. Receiver constructed and tested in accordance with ASME Code.
- K. Starter:

1. Motor starters: Section 16425.
- L. Tools:
  1. One complete set of special tools as recommended by manufacturer for field maintenance of system.
- M. Factory Wiring:
  1. In accordance with manufacturer's standard practice.
- N. Nameplates:
- O. Securely attached to each chiller showing manufacturer's name, model number and serial number.

### **PART 3 – EXECUTION**

#### **3.01 INSTALLATION:**

- A. Fit equipment and appurtenances within space provided and make readily serviceable.
- B. Provide concrete pads, platforms and hangars necessary for proper installation of equipment.
- C. Install chillers on concrete pads 4-inches minimum height in accordance with Sections 03100 and 03300.
- D. Install chillers on vibration Isolators in accordance with Section 15070.
- E. Coordinate work with other trades.
- F. Mount tools on tool board in equipment room, as directed.
- G. For piping system installation, see Section 15205.
- H. For water treatment installation, see Section 15186.
- I. For conduit, raceways and cabinets installation, see Section 16130.
- J. For wire cable, and busways, installation, see Section 16120.

#### **3.02 FIELD SERVICES:**

- A. Hermetic Units: Obtain on-site services for two man-days of manufacturer's engineering representative to advise on the following:
  1. Pressure test on hermetic water-chilling unit for leaks.
  2. Evacuation and dehydration of machine to minus 12F wet bulb or to absolute pressure of not over 0.204-inch of mercury for 24 hours minimum.
  3. Charging machine with refrigerant.
  4. Starting machine and instructing representative of the Authority as to its proper care and operation.
- B. Open Units: Obtain on-site services for two man-days of manufacturer's engineering representative to advise on the following:
  1. Erection, alignment, testing and dehydrating.
  2. Charging machine with refrigerant.

3. Starting machine and instructing Authority personnel in proper care and operation of machine.

**END OF SECTION**

**SECTION 15640**

**COOLING TOWERS**

**PART 1 - GENERAL**

**1.01 DESCRIPTION:**

- A. This section specifies providing factory-assembled, counterflow, vertical-discharge, blow-through, cooling towers.
- B. Related Work Specified Elsewhere:
  - 1. Piping systems: Section 15205.
  - 2. Vibration isolation: Section 15070.
  - 3. Sound attenuators: Section 15825.
  - 4. Control equipment: Section 15900.
  - 5. Motors: Section 16225.

**1.02 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. NFPA: 214.
  - 3. CTI: Bulletin ATP-105.
  - 4. ASME: Performance Test Code PTC-23.
  - 5. ASTM: A653, B117.

**1.03 SUBMITTALS:**

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings.
  - 2. Certification:
    - a. Certificates stating that the sound power level of cooling tower based on 10<sup>12</sup> watts does not exceed following decibel ratings, without attenuators:

Octave Band Center Frequency/Hertz	Sound Power Level/dB
63	97
125	95
250	92
500	90
1000	86
2000	85
4000	82
8000	78

- b. Certified field test reports as specified and as directed.

3. Operation and Maintenance Manuals.

#### **1.04 JOB CONDITIONS:**

- A. Safety Requirements:
  1. Properly guard belts, pulleys, chains, gears, couplings, projecting set screws, keys and other rotating parts to prevent danger to personnel.

#### **1.05 OPERATION AND MAINTENANCE TRAINING:**

- A. Upon completion of installation, furnish on-site services of manufacturer's engineering representative with specialized experience in components of system for minimum of 1/2 man-day to instruct Authority personnel in proper operation and maintenance of each system.

### **PART 2 - PRODUCTS**

#### **2.01 PRODUCTS AND MATERIALS:**

- A. General Requirements:
  1. In design and purchase of equipment, provide for interchangeability of items of piping equipment, subassemblies, parts, motor starters and relays.
  2. Galvanized-steel sheets: ASTM A653; coating designation G90 with raw edges coated with a zinc-rich compound.
  3. Galvanized surfaces finished with zinc-chromate primer and aluminum-paint finish coat or finished with manufacturer's standard coating, with the following additional requirements:
    - a. Coating permitting no corrosion on steel when exposed to 20-percent salt spray at 95F for a minimum of 400 consecutive hours.
    - b. Coating tested in accordance with ASTM B117.
- B. Cooling Towers:
  1. Each cooling tower designed to meet the following performance criteria:
    - a. Water-flow rate: As shown.
    - b. Cooling: From 95F to 85F minimum.
    - c. Ambient temperature: 78F wet bulb.
    - d. Water-pressure drop: Not exceeding value shown.
  2. Sump sections:
    - a. Galvanized steel, heavy-gauge.
    - b. Provided with outlet connection, overflow, valved drain and electric water-level control consisting of magnetic-type electric float switch in moisture proof housing and control solenoid valve in makeup water line.
    - c. Outlet connections with large-area lift-out strainer with perforated openings sized smaller than spray-nozzle orifices, mounted in assembly and baffled to prevent cavitation.
    - d. Pipe drain and overflow connections as shown or to nearest drain leading to sewer.
  3. Fan sections:
    - a. Hot-dip galvanized steel.
    - b. Fans forward-curved, centrifugal, with one or more wheels, statically and dynamically balanced.
    - c. Designed to overcome resistance of tower, its enclosure, connecting ductwork and sound attenuators, if any, and quiet in operation.
    - d. Air inlets designed for smooth air entry.
    - e. Hot-dip galvanized bird screen at fan air inlets.
  4. Fan bearings:

- a. Heavy-duty ball bearings, precision-grade, incorporating cast-iron pillow blocks and self-aligning with wide inner rings for greater load capacity.
  - b. Slip-fit bearings equipped with eccentric locking collars to provide for positive means of securing bearings to shaft.
  - c. Prelubricated bearings, ready for immediate service.
  - d. Grease-fitting for relubrication.
  - e. Lithium-base grease, waterproof, containing inhibitor and effective for temperature range of minus 65F to plus 250F.
5. Fan drives:
- a. Fan driven by electric motors through V-belt drives.
  - b. Belt guard of expanded metal, wire mesh or solid side panels.
  - c. Adjustable motor brackets.
  - d. Entire fan drive, including sheaves, belts, keys and other items manufacturer-rated for minimum of 1.5 times maximum horsepower required to drive fan.
  - e. Rating taken from manufacturer's standard catalog data.
  - f. Fan-shaft sheave-pitch diameter minimum 35 percent of fan wheel outside diameter.
6. Fan motors: Section 16225, with the following additional requirements:
- a. Four-pole, totally enclosed, fan-cooled and guarded.
7. Casings:
- a. Fabricated of heavy-gauge hot-dip galvanized steel using channel-type sheets.
  - b. Gasketed access doors for strainer.
  - c. Towers designed for live load of 40 pounds per square foot on horizontal deck surfaces and wind load of minimum 100 miles per hour for vertical surfaces.
  - d. Ladder: Aluminum or hot-dip galvanized steel for towers having water-distribution section more than eight feet above roof or grade.
8. Tower fill and drift eliminators:
- a. Tower fill (wet deck) fabricated in modular layers consisting of hot-dip galvanized, wave-formed, 26-gauge surface sheets or manufacturer's equivalent standard product.
  - b. Drift eliminators fabricated of materials specified for fill but located at top of tower and assembled in easily handled removable sections to provide access to spray tree and nozzles.
9. Water distribution:
- a. Water evenly distributed over tower fill area through spray tree consisting of hot-dip galvanized steel header and removable hot-dip galvanized steel branches.
  - b. Branches and spray nozzles retained in place by means of snap-in rubber grommets to provide for ease of removal for cleaning and replacement of spray nozzles.
  - c. Plastic nozzles provided.
  - d. Spray tree and spray nozzles designed for total flow rate for each tower as specified.
  - e. Spray header with plugged tap for measurement of pressure.
  - f. Separate regulating and stop valves for complete balancing and complete shutoff for each tower.
10. Makeup-water solenoid valve:
- a. 120-volt, 60-Hertz solenoid valve installed in makeup-water line.
  - b. Maximum operating pressure-drop across valve: 10 psi.
  - c. Solenoid valve controlled by electric float switch.

C. Nameplates:

1. Securely attached plate on each cooling tower showing manufacturer's name, model number and serial number.
- D. Sound Attenuators: Section 15825.
- E. Controls: Section 15900.
- F. Vibration Isolators: Section 15070.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION:**

- A. Start ladders at roof or grade level.
- B. Provide support beams, concrete pads, platforms, hangers and anchor bolts for proper installation of equipment as recommended by the manufacturer.
- C. Install complete potable makeup-water system as shown and as specified in Section 15205.
- D. Mount units on vibration isolators in accordance with Section 15070.
- E. Provide sound attenuators where shown.

#### **3.02 FIELD QUALITY CONTROL:**

- A. Field Tests:
  1. Test cooling towers in accordance with ASME Performance Test Code PTC-23 or CTI Bulletin ATP-105, using services of independent testing agency.
  2. Prior to commencing tests, submit name of testing agency for approval.
  3. Tests will be observed by the Authority and calculations performed immediately following tests. Have tests and calculations signed by observers.
  4. Submit computations to the Engineer together with six complete sets of test results.
  5. Compute and test in accordance with particular test procedure employed by testing agency.
  6. When the Engineer considers the performance of cooling towers unsatisfactory, the Engineer will direct that cooling towers be retested.
  7. Should tests show that cooling towers are deficient, modify or replace towers to provide specified capacities.
  8. If cooling tower performance is proven satisfactory, cost of tests will be borne by the Authority. If cooling tower performance is proven unsatisfactory, cost of tests will be borne by the Contractor.

**END OF SECTION**

**SECTION 15725**  
**VENTILATING UNITS**

**PART 1 - GENERAL**

**1.01 DESCRIPTION:**

- A. This section specifies providing ventilating units.
- B. Related Work Specified Elsewhere:
  - 1. Concrete pads: Sections 03100, 03200 and 03300.
  - 2. Vibration isolation: Section 15070.
  - 3. Air conditioning units: 15733.
  - 4. Heating equipment: Section 15765.
  - 5. Control equipment: Section 15900.
  - 6. Electrical connections: Sections 16120 and 16130.

**1.02 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.

**1.03 SUBMITTALS:**

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings.
  - 2. Operation and Maintenance Manuals.

**PART 2 - PRODUCTS**

**2.01 PRODUCTS AND MATERIALS:**

- A. General Requirements:
  - 1. In design and purchase of equipment, provide for interchangeability of items of equipment, subassemblies, parts, motors, starters and relays.
- B. Ventilating Units:
  - 1. Ventilating units furnished in accordance with Section 15733, but without cooling-coil section in ventilating units.
  - 2. Provide heating when required as per Section 15765.

**PART 3 - EXECUTION**

**3.01 INSTALLATION:**

- A. Fit equipment and appurtenances to space provided and make readily serviceable.
- B. Mount ventilating units on concrete pads and vibration isolators in accordance with Sections 03100, 03200, 03300, and 15070.
- C. Provide supports, hangers and anchor bolts necessary for proper installation of equipment as recommended by manufacturer.

D. Wire, cable and boxes: Sections 16120 and 16130.

**END OF SECTION**

## SECTION 15733

### AIR CONDITIONING UNITS - CHILLED WATER COOLED

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing factory-built air-conditioning units with cabinet-type fan sections and coil sections.
- B. Related Work Specified Elsewhere:
  - 1. Equipment foundations: Sections 03100, 03200 and 03300.
  - 2. Water coils: Section 15734.
  - 3. Filters: Section 15865.
  - 4. Ductwork: Section 15810.
  - 5. Piping systems: Section 15205.
  - 6. Vibration isolation: Section 15070.
  - 7. Control equipment: Section 15900.
  - 8. Raceways, boxes and cabinets: Section 16130.
  - 9. Wire, cable and busways: Section 16120.
  - 10. Motors: Section 16225.
  - 11. Motor starters and control centers: Section 16425.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. NFPA: 90A.
  - 3. ARI: 430.
- B. Qualifications of Manufacturer:
  - 1. Furnish air-conditioning units which are the products of a manufacturer who is a member of AMCA.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings.
  - 2. Certification:
    - a. Each air-conditioning unit fan.
  - 3. Operation and Maintenance Manuals.

##### 1.04 JOB CONDITIONS:

- A. Safety Requirements:
  - 1. Properly guard belts, pulleys, chains, gears, couplings, projecting set screws, keys and other rotating parts to prevent danger to personnel.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. General Requirements:

1. In design and purchase of equipment, provide for interchangeability of items of piping equipment, subassemblies, parts, motors, starters and relays.
- B. Fans:
1. Class I or II: Double width, double inlet, centrifugal, meeting ARI 430 and bearing ARI seal.
  2. Blades backward inclined airfoil sections, with the following additional requirements:
    - a. Forward curved blades may be furnished for fan wheel diameter 24 inches or less.
  3. Inlets with smooth, rounded edges.
  4. Fan housing fabricated of zinc-coated steel sheets, heavy-gauge consistent with size and use of unit.
  5. Fan wheels having heavy-gauge rims, blades of heavy-gauge steel consistent with blade size and for capacity, with matching heavy-gauge backplates. Steel, painted with zinc-oxide primer or corrosion-proof plastic coating.
  6. Fan wheels and sheaves: Splined or keyed, fastened to shafts with set screws.
  7. Shafts of steel, solid or hollow, ground to tolerance on working surfaces.
  8. Nonworking surfaces of shafts coated with factory-applied corrosion proof plastic coating.
- C. Fan Bearings:
1. Self-aligning, antifriction type, designed to prevent leakage of lubricant and entrance of dirt.
  2. Design life: 200,000 hours minimum.
  3. Extended grease fittings when bearings are located internally.
- D. Fan Operating Characteristics:
1. Brake horsepower necessary to drive fan at air volume and static pressure shown.
  2. Fans which do not approach 25 percent of first critical speed of shaft during normal operation or while attaining speed.
  3. Prior to shipment, statically and dynamically balance fans on their own shafts in their own units at design speed.
- E. Fan Drives:
1. Fan driven by electric motor through high-capacity, V-belt drive.
  2. Drives protected with belt guard of expanded-metal wire mesh or solid-metal side panels with tachometer opening.
  3. Adjustable motor brackets and sheaves with nominal rating at midpoint.
  4. Gasketed, hinged access doors with quick-opening latches or removable access panels.
  5. Entire fan drive, including sheaves, belts, keys and other items rated by manufacturer at minimum 1.5 times maximum horsepower required to drive fan.
  6. Ratings in accordance with manufacturer's standard catalog data.
  7. Fan-shaft sheave-pitch diameter: 30-percent minimum outside diameter of fan wheel.
  8. Metal label riveted to unit stating size of replacement belt .
- F. Fan Motors: Section 16225, with the following additional requirements:
1. Four-pole, dripproof, fully guarded.
- G. Motor Starters and Control Centers: Section 16425.
- H. Unit Casings:
1. In sections to facilitate handling.
  2. Fabricated of steel sheets, manufacturer's standard heavy-gauge.

3. Steel sheets, angles and other structural shapes used in construction of casings: Zinc-coated steel or chemically pretreated and painted with enamel primer and exterior surface finished with factory-applied enamel coating.
  4. Panels removable for access.
  5. Cadmium-plated steel bolts, screws and washers.
  6. Structural frame fabricated with members rigidly braced to hold parts in line and to prevent distortion when operating.
  7. Structural frame of welded construction; slag and splatter removed after welding.
  8. Welds painted with two coats of approved primer and one finish coat of aluminum epoxy paint.
  9. Fan sections and coil sections factory-insulated.
    - a. Insulation: Minimum one-inch thick neoprene-coated fibrous glass, 1-1/2 pounds per cubic foot density, securely adhered to panel inner surface with adhesive and weld pins on minimum two-foot centers.
    - b. Exposed edges coated with adhesive.
    - c. Insulation and adhesive: NFPA 90A.
  10. Fan section or fan-coil section connected by flexible connections as specified in Section 15810.
  11. Filters: Section 15865.
  12. Drain pan:
    - a. Drain pan under fan and coil section where cooling coil used.
    - b. Drainage connection: As shown.
    - c. Insulate entire drain pan with 1/2-inch cellular foam.
  13. Coil: Section 15734.
- I. Nameplates:
1. Securely attached plate to each air-conditioning unit showing manufacturer's name, model number and serial number.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION:**

- A. Fit equipment and appurtenances within space provided and make readily serviceable.
- B. Provide foundations, platforms and hangers necessary for proper installation of equipment.
- C. Construct equipment foundations four inches minimum height in accordance with Sections 03100, 03200 and 03300.
- D. Install units on vibration isolators where shown as specified in Section 15070.
- E. Electrical connections: Sections 16130 and 16120.
- F. Condensate piping: Section 15205.
- G. After installation, adjust fans to operate without noticeable vibration.
- H. Arrange belt guards to permit oiling, testing and using tachometer with guards in place.

**END OF SECTION**

## SECTION 15734

### WATER COILS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing chilled water-coils in factory-built air-conditioning units.
- B. Related Work Specified Elsewhere:
  - 1. Air Conditioning Units: Section 15733.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. ARI: 410.
- B. Qualifications of Manufacturer:
  - 1. Furnish water coils which are the products of a manufacturer who is a member of ARI.
- C. Source Quality Control:
  - 1. Factory test water coils at 350-psi air pressure underwater.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings.
  - 2. Certification.
  - 3. Operation and Maintenance Manuals.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. General Requirements:
  - 1. In design and purchase of equipment, provide for interchangeability of items of piping equipment, subassemblies and parts.
  - 2. Coil section to interface directly with sections on sides without use of transition sections.
  - 3. Meet ARI 410.
- B. Water Coil:
  - 1. Seamless deoxidized-copper tubes, minimum 0.025-inch thick wall with aluminum fins.
  - 2. Coil casings of zinc-coated, rust-resistant steel.
  - 3. End panels: Heavy-gauge steel.
  - 4. Side panels: 16 gauge for tube lengths up to 90 inches; 14 gauge for tube lengths of 91 to 120 inches.
  - 5. Top and bottom casing flanges formed into box shape for strength and durability with flat surface for coil stacking.
  - 6. Coils with 48 to 84-inch tube lengths provided with one center tube support; for longer coils, up to 120-inch tube lengths, provided with two intermediate supports.

7. Maximum fin spacing: 12 per inch of tube.
  8. Water velocity: Minimum two fps and maximum six fps throughout tube length.
  9. Maximum water-pressure drop through coils: 35 feet water gauge.
  10. Maximum air velocity through coil face: 550 fpm.
  11. Designed with continuous circuits from inlet header to outlet header.
  12. Drainable, pitched 3/16 inch per foot toward return header for complete drainage.
  13. Self-venting with supply connection at bottom of supply header and return connection at top of return header.
  14. Vent connection provided in supply header and drain connection in return header.
- C. Nameplates:
1. Securely attached to each coil showing manufacturer's name, model number and serial number.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION:**

- A. Support coils on rails and make readily removable.
- B. Make supply connection to header giving counter flow as shown.
- C. Use of coils to support piping is prohibited.

**END OF SECTION**

## SECTION 15735

### AIR CONDITIONING UNITS - PACKAGED

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing factory-packaged self-contained air-conditioning units with direct expansion coil, electric heating coils, air-cooled condensers and automatic controls.
- B. Related Work Specified Elsewhere:
  - 1. Filters: Section 15865.
  - 2. Conduit, raceways and cabinets: Section 16130.
  - 3. Wire, cable and busways: Section 16120.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ARI: 210.
  - 3. UL listed.
- B. Design Criteria:
  - 1. Select units in accordance with requirements shown.
- C. Factory wiring:
  - 1. In accordance with manufacturer's standard practice.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings.
  - 2. Certification.
  - 3. Operation and Maintenance Manuals.

##### 1.04 JOB CONDITIONS:

- A. Safety Requirements:
  - 1. Properly guard belts, pulleys, chains, gears and other rotating parts to prevent danger to personnel.

#### PART 2- PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. General Requirements:
  - 1. In design and purchase of equipment, provide for the interchangeability of items of piping equipment, subassemblies, parts, motors, starters and relays.
  - 2. Each unit completely piped, wired, charged and factory-tested as a package and designed for through-wall installation.
  - 3. Meet ARI 210.
  - 4. UL listed

- B. Cabinet:
1. Welded cabinet constructed of heavy-gauge steel, zinc-coated or chemically pretreated, painted with enamel primer and exterior surface finished with factory-applied enamel coating.
  2. Containing junction boxes, polarized sockets and plugs for chassis electrical connection.
  3. Discharge grilles, front panels and return air grilles assembled to be removable for cleaning and access.
  4. Interior casing lined with sound-absorbing insulation material resistant to moisture, vermin and rot.
  5. Discharge grille with adjustable louver blades, fabricated of extruded aluminum.
- C. Compressor:
1. Hermetically and semi-hermetically sealed, refrigerant-cooled, suitable for operation with refrigerant R-22.
  2. High-pressure cutout with manual reset and low-pressure cutout with automatic reset.
  3. Compressor motor protected by means of overload relays and internal-winding thermostat.
  4. Mounted on rubber-isolated spring mountings.
- D. Evaporator Coil:
1. Direct expansion, fabricated of seamless copper tubing with aluminum fins, tightly bonded to tubing.
  2. Cooling-capacity selection based on space conditions and the following as shown:
    - a. Entering wet-bulb temperature at evaporator.
    - b. Entering ambient temperature at condenser coil.
  3. Single thermal-expansion valve for refrigerant control or capillary tube.
  4. Tested at minimum 300 psig.
- E. Condenser Coil:
1. Air-cooled type, fabricated of seamless copper tubing with aluminum fins, tightly bonded to tubing.
  2. Capable of a total heat rejection based on condensing and ambient temperatures as shown.
  3. Tested at minimum 425 psig.
- F. Electric Heating Coil:
1. Consisting of finned, metal-sheathed elements, anchored to ensure noiseless expansion and contraction.
  2. Fins furnace-brazed to steel sheath.
  3. Sheath and fins coated with heavily-fired ceramic capable of resisting spalling under operating conditions.
  4. Automatic-reset, snap-action, thermal-overheat switch.
  5. Voltage: As shown.
- G. Evaporator Fan and Motor:
1. Centrifugal fan of corrosion-resistant construction.
  2. Fan wheels dynamically and statically balanced.
  3. Motors: Air-conditioning unit manufacturer's standard for intended use and location.
  4. Brake horsepower selected to drive fan at air volume and static pressure shown.
- H. Condenser Fan and Motor:
1. Propeller fan of corrosion-resistant construction.
  2. Fan dynamically and statically balanced.

3. Motors: Air-conditioning unit manufacturer's standard for intended use and location.
  4. Brake horsepower selected to drive fan at air volume and static pressure as shown.
- I. Filters:
1. Replaceable (throwaway)-type: Section 15865.
- J. Ventilation-Control Damper:
1. Ventilation-control damper furnished in one piece, rotating on oilless bearings and capable of air-tight closure.
  2. Damper fabricated from heavy-gauge galvanized steel.
- K. Chassis:
1. Complete factory-wired, packaged heating and cooling-unit chassis consisting of the following:
    - a. Electric heating bank.
    - b. Hermetically sealed compressor.
    - c. Condenser coil and fan.
    - d. Evaporator coil and fan.
    - e. Self-contained temperature controls.
    - f. Protective devices.
- L. Condensate Pan:
1. Condensate pan provided with opening for drain connection or provision for condensate drains into condenser-coil pans to be evaporated by condenser heat.
- M. Wall Sleeves:
1. Watertight, connection provided between cabinet and wall louver.
  2. Constructed from corrosion-resistant material.
  3. Baffles provided to separate flow paths of ventilating and condenser inlet and outlet air.
- N. Wall Louver:
1. Wall louver fabricated from extruded aluminum with 16-gauge enclosing frame.
  2. Louver blades fabricated from heavy-gauge aluminum.
  3. Removable louver for access.
- O. Automatic-Control Kit:
1. Automatic-control package for both cooling and heating consisting of the following:
    - a. Manual changeover-selector switch for cooling or heating.
    - b. Multiple-position thermostat for desired temperature setting.
    - c. Fresh-air control for filtered outside air.
    - d. Heating control relays for staging heating elements.
    - e. Head-pressure control to maintain proper condensing pressure at low outdoor temperature.
    - f. Compressor motor to start after evaporator fan motor starts operating.
- P. Self-Contained Unit Controls:
1. Controls capable of maintaining mechanical cooling and heating operation, factory-mounted and wired to terminal blocks in unit-control compartment.
  2. Room-air thermostat.
  3. Thermostat-setting dial.
  4. Damper operators.
  5. Heating and compressor contacts.
  6. Condenser and evaporator fan contactors.
  7. Interlock switch to de-energize entire unit when front panel is removed.
  8. Push-button selector switch for OFF/FAN/COOLING/HEATING operations.

9. Control sequence: Room-air thermostat cycles condenser fan and compressor or heater to maintain room at thermostat setting.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION:**

- A. Interlock heating coil with evaporator fan motor, so that heating coil will not operate when evaporator fan motor is operating.
- B. Fit equipment and appurtenances within space provided and make readily serviceable.
- C. Provide supports and hangers required for proper installation of equipment.
- D. Ensure that fans operate without noticeable vibration after installation
- E. Electrical connections: Sections 16120 and 16130.

**END OF SECTION**

## SECTION 15736

### KIOSK MECHANICAL WORK

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing air-cooled split-system air-conditioning unit and wall heater for Station kiosks.
- B. Related Work Specified Elsewhere:
  - 1. Vibration isolators: 15070.
  - 2. Insulation: Section 15080.
  - 3. Piping systems: Section 15205.
  - 4. Ductwork: Section 15810.
  - 5. Filters: Section 15865.
  - 6. Wire, cable and busways: Section 16120.
  - 7. Conduit, raceways and cabinets: Section 16130.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. UL 181.
  - 3. FS: 595 B, F-F 310.
  - 4. SMACNA:
    - a. HVAC Duct Construction Standard: Metal and Flexible.
    - b. HVAC System: Testing, Adjusting and Balancing.
  - 5. ASTM: A36, B280, B 486 C534, C1071, E84.
  - 6. NFPA: 90A, 90B.
  - 7. AWS: A5.8.
- B. Design Criteria:
  - 1. Select units in accordance with requirements shown.
  - 2. Provide completely matched combination between evaporator unit and condensing unit.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings.
  - 2. Certification.
  - 3. Operation and Maintenance Manuals.

##### 1.04 JOB CONDITIONS:

- A. Safety Requirements:
  - 1. Properly guard belts, pulleys, chains, gears and other rotating parts to prevent danger to personnel.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. General Requirements:
  - 1. In design and purchase of equipment, provide for the interchangeability of items of piping equipment, subassemblies, parts, motors, starters and relays.
- B. Air-Conditioning Unit:
  - 1. Fan coil unit:
    - a. Horizontal unit with front discharge and back return connections.
    - b. Unit casing galvanized steel with ½-inch fiberglass insulation, bonderized and finished with baked enamel. Access to the entire unit provided through bottom swing down panel attached to casing with removable locking lugs.
    - c. Fan forwardly curved, centrifugal type, direct drive, and quiet in operation. Fan wheel statically and dynamically balanced at the factory.
    - d. Motor: Standard with the manufacturer, two speed, frequency 60 Hertz, voltage RPM and HP as shown. Make provisions for grounding motor.
    - e. Drain pan fabricated of continuous galvanized steel, insulated with closed-cell insulation, sealed with mastic and pitched toward the drain connection.
    - f. Coil: Direct-expansion type, seamless non-ferrous tubing with aluminum fins mechanically bonded to the tubing. Tested at 300 psi.
    - g. Unit-mounted controls, out of air stream and accessible from the inside of the kiosk.
    - h. Filters: Two-inch glass fiber throwaway type, replaceable from inside of kiosk.
    - i. Vibration isolators: Rubber-in-shear type isolation hangers.
  - 2. Condensing unit:
    - a. Unit casing galvanized steel, heavy gauge, bonderized and finished with baked-on enamel paint.
    - b. Brass service valves with refrigerant line fittings to permit mechanical connections.
    - c. Compressor:
      - 1) Hermetic or semi-hermetic, refrigerant-cooled, designed for operation with refrigerant 134a. If 134a is unavailable for this application, submit an alternate to the Engineer for approval.
      - 2) Mounted on internal spring isolator with rubber-in-shear mounting pad.
      - 3) Crankcase heater.
    - d. Fan, forwardly curved centrifugal type, direct drive, quiet in operation. Fan wheel statically and dynamically balanced at the factory.
    - e. Motor: Standard with the manufacturer, frequency 60 Hertz, phase, voltage and RPM as shown.
    - f. Coils: Seamless, non-ferrous tubing with aluminum plate fins, mechanically bonded to the tubes. Tested at 425 psi.
    - g. Unit- mounted controls, out of the air stream.
    - h. Unit-mounted on vibration isolator pads
    - i. Noise level ratings as shown.
  - 3. Controls for fan coil unit and condensing unit:
    - a. Thermostat and manual two-speed fan controller labeled LOW/HIGH. Provide 24-volt control circuit with control transformer 208/24 volts, 60 Hertz and VA ratings as required.
    - b. Thermostat equipped with switch for manual and automatic operation fan.
    - c. Interlocked compressor and evaporator fan. Differential pressure switch on evaporator fan to keep compressor from energizing if evaporator fan is not running.
    - d. Time delay provided on compressor to prevent short cycling of compressor
  - 4. Other components
    - a. Liquid line refrigerant drier.
    - b. Moisture- ndicating sight glass on the liquid line.
    - c. Relief valve.

- d. Charging valve.
  - e. Pre-charged refrigerant aluminum tubing and fittings acceptable in lieu of specified field-fabricated copper tubing, if system is provided by manufacturer of unit.
- C. Wall Heater:
- 1. Heater cabinet: Designed for surface mounting, minimum 20-gauge sheet metal, finished with baked-on enamel. Front panel 16-gauge, ribbed, with downflow louver.
  - 2. Heating element: Cast-aluminum grid with nickel-chromium resistance wire, metal-sheathed, with automatically resetting thermal cutouts.
  - 3. Fan: Precision balanced, and fan and motor assembly mounted for vibration-free performance.
  - 4. Motor: Standard with the manufacturer, frequency, phase and voltage as shown.
  - 5. Built-in fan delay switch.
  - 6. UL-listed.
- D. Filter: Section 15865.
- E. Outlets and Grilles: Section 15850 with the following additional requirements:
- 1. Exhaust and return grilles:
    - a. Fan coil unit return grille: Surface mounted, extruded aluminum, Anemostat RC3HD-81 or approved equal.
    - b. Condensing unit return and exhaust grille: Penn Ventilator, Airstream Model D1 or approved equal. Finish: Spatter surface texture FS 595B, Color No. 20040. Deflection as shown.
  - 2. Linear air diffusers:
    - a. Finish: Baked enamel FS 595B, Color No. 36586.
- F. Ductwork: Section 15810, with the following additional requirements
- 1. Flexible Ductwork:
    - a. Factory-fabricated, insulated flexible round air duct with reinforced metalized mylar outer jacket enclosing a 1-1/2-inch thick fiberglass insulation wrapped around a continuous inner air barrier of double-layer polyester reinforced with encapsulated steel wire helix. UL-181, Class 1, meeting NFPA standards 90A and 90B. Certaflex 25, Certainteed Corporation, or approved equal.
- G. Piping: Section 15205.
- H. Insulation: Section 15080, with the following additional requirements:
- 1. Condensate drain line insulation:
  - 2. 3/8-inch thick closed-cell, foamed plastic, tubular pipe insulation complying with ASTM C1071, Type 1 and NFPA 90A.
- I. Vibration Isolation: Section 15070, with the following additional requirements:
- 1. Isolation materials/isolation pads:
    - a. Non-adhesive neoprene type provided in accordance with manufacturer's recommendations and selected to eliminate transmission of vibration to kiosk structure. Minimum one-inch thick.
- J. Hanger Rods and Angles: ASTM A36, hot-dip galvanized or shop painted, with sufficient rigidity to prevent visible deflection.

### **PART 3 - EXECUTION:**

### **3.01 INSTALLATION:**

- A. Install equipment and appurtenances where shown, securely anchored.
- B. Adjust all items to function as shown and specified.
- C. Install air conditioning unit and wall heater as shown, to be easily removable.
- D. Install remote control for air conditioning unit at location shown.
- E. Install thermostat and speed controller for fan coil unit and condensing unit as shown.
- F. Ductwork Installation:
  - 1. Install dampers so as to permit adjustment after completion of the work.
  - 2. Install dampers without strain or distortion of any part of dampers.
  - 3. Adjust moving parts to move freely without binding.
  - 4. Caulk dampers airtight around frames.
  - 5. Adjust damper to operate freely between open and closed positions.
  - 6. Secure flexible ducts with metal clamps and sealer tape for air tightness, using short and straight segments, and stretched to smooth out internal corrugations with long radius bends. Install flexible ducts in accordance with UL-181.
  - 7. Line ductwork where shown with internal duct insulation as specified.
- G. Install vibration isolators where shown as recommended by the manufacturer.
- H. Mount mechanical equipment on vibration isolators to isolate equipment from structure.
- I. Electrical Connections: Sections 16120 and 16130.

### **3.02 FIELD QUALITY CONTROL:**

- A. Operational Test:
  - 1. Test unit after installation to demonstrate that all components are functioning properly, that noise level meets criteria as shown, and that the required heating and cooling capacities are achieved.
- B. Furnish necessary equipment, perform required tests and submit certified reports. Test the following:
  - 1. Air conditioning unit and wall heater
    - a. Circuit for connections in accordance with wiring diagrams.
    - b. Equipment enclosures for continuity to the grounding system.
    - c. Insulation resistance of motor windings using a 500-volt dc megohmmeter to ensure that the ground is not less than two megohms.
    - d. Insulation resistance of each ungrounded conductor with respect to ground and adjacent conductors and of each grounded conductors with respect to adjacent ungrounded conductors to ensure that resistance is not less than one megohm when test is performed using a 500-volt megometer.
    - e. Operations of circuits, operating each control ten times minimum.

2. Air leak test for accessible ductwork..
  - a. Perform air leak tests in accordance with SMACNA Manual for the Balancing and Adjustment of Air Distribution System.
3. Pressure testing:
  - a. Refrigerant piping: Test at 300 psi on high side and 150 psi on low side.
    - 1) Maintain pressure for minimum of 12 hours.
    - 2) Use electronic leak detector to check leaks after soap-bubble test.

**3.03 CLEANING OF AIR SYSTEM:**

- A. Before fan or filter is operated, clean inside of air system, including casing, plenums, and ductwork used for air supply or return.
- B. Clean by means of industrial vacuum cleaners which will effectively remove dust and foreign material from surfaces swept by air stream.
- C. Clean exposed ductwork and leave in satisfactory condition, free from grease, oil, and finish painting.

**END OF SECTION**

## SECTION 15737

### AIR CONDITIONING UNITS - AIR-COOLED SPLIT SYSTEM

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing air-cooled split-system air-conditioning units.
- B. Related Work Specified Elsewhere:
  - 1. Concrete pads: Sections 03100, 03200 and 03300.
  - 2. Insulation: Section 15080.
  - 3. Piping systems: Section 15205.
  - 4. Filters: Section 15865.
  - 5. Wire, cable and busways: Section 16120.
  - 6. Conduit, raceways and cabinets: Section 16130.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ARI: 210.
  - 3. UL listed.
- B. Design Criteria:
  - 1. Select units in accordance with requirements shown.
  - 2. Provide completely matched combination between evaporator unit and condensing unit.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings.
  - 2. Certification.
  - 3. Operation and Maintenance Manuals.

##### 1.04 JOB CONDITIONS:

- A. Safety Requirements:
  - 1. Properly guard belts, pulleys, chains, gears and other rotating parts to prevent danger to personnel.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. General Requirements:
  - 1. In design and purchase of equipment, provide for the interchangeability of items of piping equipment, subassemblies, parts, motors, starters and relays.
  - 2. UL listed.
  - 3. Meet ARI 210.
- B. Evaporator Unit:
  - 1. Cabinet:

- a. Welded, constructed of heavy-gauge steel, zinc-coated or chemically pretreated, painted with enamel primer and exterior surface finished with factory-applied enamel coating.
  - b. Interior of cabinet completely lined with sound-absorbing thermal insulation resistant to moisture, vermin and rot.
  - c. Casing provided with insulated condensate-drain pan.
  - 2. Evaporator coil:
    - a. Direct expansion, fabricated of seamless copper tubing with aluminum fins tightly bonded to tubing.
    - b. Selection of cooling capacity of coils based on space conditions and the following as shown:
      - 1) Entering wet-bulb temperature at evaporator coil.
      - 2) Entering ambient temperatures at condenser coil.
    - c. Factory-mounted thermal-expansion valve:
      - 1) For units of 10 tons or more: Coils double-circuited and provided with two expansion valves.
    - d. Tested at minimum 300 psig.
  - 3. Evaporator fan and motor:
    - a. Centrifugal fans of corrosion-resistant construction.
    - b. Fan wheels dynamically and statically balanced.
    - c. Fan belt drives designed for 150 percent of required fan-motor brake horsepower.
    - d. Motor mounted on adjustable base.
    - e. Brake horsepower selected to drive fan at air volume and static pressure shown.
    - f. Fan motors: Air-conditioning unit manufacturer's standard for intended use and location.
  - 4. Filters:
    - a. Replaceable (throwaway)-type: Section 15865.
- C. Air-Cooled Condensing Unit:
- 1. Casing:
    - a. Weatherproof suitable for outdoor installation.
    - b. Fabricated of heavy-gauge steel, zinc-coated or chemically pretreated, painted with enamel primer and exterior surface finished with factory-applied enamel coating.
    - c. Removable panels provided for access to accessories
  - 2. Condenser coils:
    - a. Air-cooled, fabricated of seamless copper tubing with aluminum fins tightly bonded to tubing.
    - b. Condenser coil capable of total heat rejection based on condensing and ambient temperature shown.
    - c. Tested at minimum 425 psig.
  - 3. Condenser fan and motor:
    - a. Fan of corrosion-resistant construction.
    - b. Fans dynamically and statically balanced.
    - c. Fans protected with heavy-gauge welded-wire fan guards.
    - d. Motors: Air-conditioning unit manufacturer's standard for intended use and location.
  - 4. Compressor:
    - a. Hermetically semi-hermetic sealed, refrigerant-cooled, suitable for operation with refrigerant R-22.
    - b. Capacity control provided for compressor of 10 tons and more to permit partial operation at low-load conditions.
    - c. High and low-pressure cutouts.
    - d. Compressor motor protected by means of overload relays and internal-winding thermostat.

- e. Compressor mounted on internal spring isolator or on rubber-in-shear mounting pads.
- f. Number of compressors:
  - 1) For units rated up to and including 7-1/2 tons: One compressor.
  - 2) For units rated at 10 or more tons: Two compressors with two separate refrigerant circuits.
- 5. Refrigerant piping: Section 15205.
- 6. Refrigerant-piping insulation: Section 15080.
- 7. Refrigeration circuits:
  - a. Provide the following components in refrigeration circuits:
    - 1) Back-seating service valves in liquid and hot-gas lines.
    - 2) Filter drier on liquid line.
    - 3) Moisture-indicating sight glass on liquid line.
    - 4) Charging valves on suction side.
    - 5) Hot-gas muffler on discharge side.
- D. Air-Cooled Split-System Air-Conditioning Unit Controls:
  - 1. Factory-wired in separate control cabinet mounted on exterior of condenser casing.
  - 2. Heating and compressor contactors.
  - 3. Condenser and evaporator-fan contactors.
  - 4. High-pressure cutout with automatic reset.
  - 5. Low-pressure cutout with manual reset.
  - 6. Reset relay to prevent unit from cycling on automatic resetting of safety controls.
  - 7. Noncycling pumpdown control.
  - 8. Controls provided near evaporator unit:
    - a. Room-air thermostat heating/cooling control for systems incorporating electric-duct heaters.
    - b. Damper operators.
  - 9. Pushbutton selector switch for OFF/FAN/COOLING/HEATING operations, mounted on evaporator unit.
  - 10. Control sequence:
    - a. Room-air thermostat cycles condenser fan and compressor heater to maintain room temperature at thermostat setting.
    - b. Low-ambient control to permit condensing-unit operation down to ambient temperature of 30F.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION:**

- A. Fit equipment and appurtenances within space provided and make readily serviceable.
- B. Provide foundation, platforms and hangers necessary for proper installation of equipment.
- C. Install equipment on concrete pads minimum of four inches in height in accordance with Section 03100, 03200 and 03300.
- D. Ensure that fans operate without noticeable vibration after installation.
- E. Arrange belt guards to permit use of tachometer, oiling and testing with guards in place.
- F. Charge refrigerant in accordance with manufacturer's recommendations.
- G. Electrical connections: Sections 16120 and 16130.

**END OF SECTION**

## SECTION 15765

### HEATING EQUIPMENT

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing heating equipment and electric heat tracing for piping.
- B. Related Work Specified Elsewhere:
  - 1. Vibration isolators: Section 15070.
  - 2. Ventilating Units: Section 15725.
  - 3. Control equipment: Section 15900.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. UL: 1025.
- B. Source Quality Control:
  - 1. Test electric heating coils dielectrically at 2,000 volts before shipment.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings.
  - 2. Certification:
    - a. Successful dielectric testing of electric heating coil at 2,000 volts.
  - 3. Operation and Maintenance Manuals.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. General Requirements:
  - 1. In design and purchase of equipment, provide for interchangeability of items of equipment, subassemblies, parts, motors, starters and relays.
- B. Electric Heating Coils:
  - 1. Casings:
    - a. Frame members, casings, terminal box, terminal-box cover and similar sheet metal parts fabricated of minimum 18-gauge, die-formed steel with integral corrosion-resistant coating.
    - b. Casing assembled into rigid structure by means of welding or threaded fastenings.
    - c. Flanged in-line heater for inclusion in duct or ventilating unit.
    - d. Coil-section panels factory-insulated.
  - 2. Heating element:
    - a. Heating elements composed of individual flange-mounted, finned-tube heating elements with highest grade nickel-chromium alloy resistor wire centered within tubes and embedded in compacted insulating material.
    - b. Flanges and fins permanently furnace-brazed to elements for rigid support and rapid heat transfer.
    - c. Finned tubes of copper-plated or ceramic-coated steel.

- 1) Ceramic coating fired at minimum of 1,500F and capable of continuous resistance to corrosion without cracking, checking or spalling under operating conditions.
3. Controls:
- a. In accordance with Section 15900, with the following additional requirements:
    - 1) Heaters provided with built-in step controllers.
    - 2) Heaters of 30 kw or less with manufacturer's standard steps.
    - 3) Heaters larger than 30 kw having six equal steps.
    - 4) An automatic-reset, snap-action, thermal-overheat switch provided to instantly de-energize heating coil when safe operating temperatures are exceeded.
    - 5) Heating coil interlocked with fan to prevent energization of heating coil while fan is not running.
- C. Electric Unit Heaters:
1. Factory-assembled unit heaters consisting of heating element, fan, fan motor, housing and outlet diffuser.
    - a. Casings:
      - 1) Fabricated of galvanized steel or bonderized steel, factory-primed and finished with baked enamel.
      - 2) Parts rigidly stiffened to prevent vibration and to hold working parts in line.
      - 3) Casings for suspended-type units designed for direct attachment to hangers.
      - 4) Ceiling or wall-mounted, spring-type brackets furnished as necessary to support unit.
      - 5) Casings readily removable for access to interior parts.
      - 6) Adjustable horizontal vanes, arranged to give uniform air distribution without objectionable drafts.
    - b. Fan and fan motor:
      - 1) Propeller fan directly connected to fan motor.
      - 2) Fan air throw: As shown.
      - 3) Fan factory-balanced dynamically and designed for quiet operation.
      - 4) Unit heater/fan motor: As standard with manufacturer.
      - 5) Each unit equipped with combination fan guard/motor support resiliently mounted to absorb motor vibration.
      - 6) Motor speed: 1,750-rpm maximum.
      - 7) Integral transformer where fan-motor voltage differs from line voltage.
    - c. Heating element:
      - 1) Resistance wire of corrosion-resistant metal surrounded by finned metal sheath, interspace filled with ceramic material or magnesium oxide.
      - 2) Each heating element wired to built-in, line-voltage, automatic-reset, thermal-overheat protection.
      - 3) Complete controls, contactors, control-circuit transformers factory-assembled and factory-wired.
      - 4) Unit heaters tested and listed under UL 1025.
      - 5) Thermostats: Built-in, unless otherwise shown.
      - 6) Disconnect switch near unit heater.
    - d. Unit heaters with capacities of 10 kW or higher equipped with H.O.A. switches.
- D. Electric Wall Convectors:
1. Factory-assembled consisting of heating element, connection boxes, controls, surface-mounted steel cabinet and wall-mounted thermostat.
  2. Convector cabinet: Fabricated of heavy-gauge reinforced steel with inlet and outlet grilles.

3. Surface-mounted cabinet, chemically treated to resist corrosion and finished in baked prime coat.
  4. Cabinets equipped with disconnect switch and automatic-reset thermal-overload protection.
  5. Heating elements of steel-sheath or aluminum-sheath enclosed construction, nonhumming, with fins permanently brazed to tube for quick and efficient heat transfer.
  6. Heating elements having a nonoxidizing heat-resistant finish.
  7. Completely factory-wired, tested and UL-listed.
  8. Capacity and operating characteristics: As shown.
- E. Electric Heat Tracing for Piping:
1. Heat-traced pipe insulated after installation of heating tape in accordance with Section 15080.
  2. Heating tape with single or twin heating elements embedded in impact-resistant, high-dielectric refractory material, UL-listed and with stainless-steel exterior protective sheath acting as electrical ground in case heating element touches sheath.
  3. Heating tape rated for voltage shown and capable of producing wattage shown.
  4. Heating tape flexible with minimum bending radius of not more than six times diameter of tape.
  5. Heating tape compatible with pipe temperature-sensing thermostat: Section 15900.
  6. Heating tape connected to power source and controls through nonheating leads minimum seven feet in length.
- F. Nameplates:
1. Securely attached to each major item of equipment showing manufacturer's name, model number and serial number.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION:**

- A. Fit equipment and appurtenances to space provided and make readily serviceable.
- B. Mount electric unit heaters on vibration isolators in accordance with Section 15070.
- C. Provide supports, hangers and anchor bolts necessary for proper installation of equipment as recommended by manufacturer
- D. Provide heat tracing on piping where shown.
- E. Install electric heating coil where shown.
- F. Apply insulation on heat-traced piping in accordance with manufacturer's recommendations.
  1. Where heating tape is spiralled, ensure that adjacent turns do not touch so as to avoid overheating and damaging sheath material.
  2. Allow minimum of one inch between spirals.
  3. Do not flex wire when ambient temperature is less than 32F, unless tape is warmed.
  4. Connect unheated cold end to power source.
  5. Secure heating tape in contact with pipe with banding or strapping.
  6. Provide automatic temperature control by thermostat designed and set to energize at 40F.
  7. Upon completion of installation and testing of pipe, install and test heating tape in accordance with manufacturer's recommendations.

**END OF SECTION**

## SECTION 15806

### AIR CONDITIONING PYLONS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing air-conditioning pylons.
- B. Related Work Specified Elsewhere:
  - 1. Ductwork: Section 15810.
  - 2. Insulation: Section 15080.
  - 3. System balancing and testing: Section 15950.
  - 4. Raceways, boxes and cabinets: Section 16130.
  - 5. Lighting fixtures: Section 16525.
- C. Work by Others:
  - 1. Graphic panels.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. ANSI: C80.3.
  - 2. FED STD: 595.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings.
  - 2. Certification.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. Air Control Damper:
  - 1. Each pylon body equipped with air control damper containing low leakage opposed blades of aluminum airfoil shape and 16-gauge galvanized steel frame.
  - 2. Single-shaft damper control provided with air control damper. Damper shaft end which projects to pylon exterior fitted with high-pressure damper regulator with neoprene gaskets and acorn nut.
- B. Supply Grille:
  - 1. Each pylon furnished with square supply grille. Frames, vanes and fins fabricated of steel (Tuttle and Bailey/Hart and Cooley G-series, GOS Core with Style A, or approved equal).
  - 2. Diffusion grille fabricated of 22-gauge galvanized steel, perforated with 3/32-inch diameter holes on 3/16-inch centers, 33-percent free area. Fixed horizontal vanes (square grille) fabricated of steel oriented to deflect supply air at 15-degree angle from horizontal plane. Vanes spaced maximum 1/4-inch apart. Grille finished in flat black, FED STD 595, Color No. 37038..
  - 3. Fixed vertical fins (masking plates), spaced as shown, welded to top and bottom finish plates, finished in baked enamel.

- C. Electrical Items:
  - 1. Zinc-coated, thin-wall steel conduit in accordance with ANSI C80.3.
  - 2. Junction box and flexible conduit: As specified in Section 16130.
  - 3. Lighting fixture as shown. Steel-cone housing for lamp and reflector insert: Black baked-enamel finish.
  - 4. Aluminum-reflector insert: Seamless aluminum with clear specular alzak finish on interior of cylindrical surface and clear semi-specular alzak finish on interior of conical surface.
  - 5. Lampholder and lamp: As specified in Section 16525 and as shown on Dwg ST-A-PY.-2.
    - a. Lamp for Type L-1 Fixture: 1000-watt, BT-56 mercury-vapor lamp, ANSI Code H36GW-1000/WDX; General Electric warm deluxe white No. H1000 WDX 36-15 or equal.
    - b. Lamp for Type L-1a Fixture: 400-watt, E-37 mercury-vapor lamp, ANSI Code H33GL-400/WDX; General Electric warm deluxe white, H400WDX 33-1 or equal.
- D. Pylon Body: Constructed as shown.
- E. Pylon-body insulation and innerliner: As specified in Section 15080.
- F. Wire Pylon Cover: Stainless-steel mesh wire cloth with steel frame as shown.
- G. Louver Pylon Cover: Steel louvers and frame as shown.
- H. Finish: Unless otherwise shown, factory-finish, FED STD 595, Color No. 20040, provided on items exposed to public view.

### **PART 3 - EXECUTION:**

#### **3.01 INSTALLATION:**

- A. Fit equipment and appurtenances into space provided. No portion of pylon to extend into space in which graphics panels will be installed by others.
- B. Mercury-vapor lamp ballast as specified in Section 16525 and installed in space between reflector cone and square grille.

#### **3.02 FIELD QUALITY CONTROL:**

- A. Pressure Test:
  - 1. Include pylon in ductwork pressure test as specified in Section 15810.
- B. Balancing and Testing:
  - 1. Include balancing of pylons in balancing and testing of system specified in Section 15950.

**END OF SECTION**

## SECTION 15810

### DUCTWORK

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing ductwork and accessories.
- B. Related Work Specified Elsewhere:
  - 1. Firestopping; Section 07841.
  - 2. Insulation: Section 15080.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. SMACNA:
    - a. HVAC Duct Construction Standards - Metal and Flexible.
    - b. Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems.
    - c. HVAC Systems - Testing, Adjusting and Balancing.
    - d. HVAC Air Duct Leakage Test Manual.
  - 3. ASTM: A36, A53, A653.
  - 4. NFPA: 90A
  - 5. AASHTO: M81.
  - 6. UL: Building Materials Directory, 181, 555.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Scale: 1/4-inch minimum
  - 2. Certification.

#### PART 2 - PRODUCTS

##### 2.01 MATERIALS:

- A. Galvanized Sheet Steel: ASTM A653.
- B. Steel Plate: ASTM A36, Grade A.
- C. Steel Pipe: ASTM A53, Grade A.
- D. Flexible Material:
  - 1. Fibrous-glass cloth, 32 ounces per square yard, UL-listed.
  - 2. Tensile strength: 450-psi minimum.
  - 3. Coated on both sides with fire-resistant neoprene.
  - 4. Suitable for operating temperature of 200F and meeting requirements of NFPA 90A.
- E. Paint:
  - 1. Zinc-rich gray, No. 721, Detroit Graphite or equal.
  - 2. Bituminous, AASHTO M81, Grade RC-250.

## 2.02 FABRICATION:

- A. Duct Construction:
  - 1. Fabrication in accordance with HVAC Duct Construction Standards-Metal and Flexible.
- B. Access Doors in Ducts:
  - 1. Provide access doors as shown to gain access to resistance heaters, fans, fan motors, dampers, filters, coils and controls.
  - 2. Doors: Of same metal thickness as ducts.
  - 3. Gasketed doors: Secured to duct.
- C. Plenums:
  - 1. Field-fabricated and reinforced consistent with class of ductwork in which used.
  - 2. Outward-opening access doors to plenums provided where necessary for equipment access and as shown.
- D. Embedded Ductwork:
  - 1. Fabricated of welded steel plate or round steel pipe. Minimum thickness for steel plate 1/4 inch. Minimum wall thickness for pipe 1/4 inch. For galvanizing, mask joint areas at ends of sections after fabrication.
  - 2. Hot-dip galvanized after fabrication, with minimum coating weight of two ounces per square foot. Where shown, inside of sections insulated as specified in Section 15080. Apply one coat of specified paint to exterior surfaces.
- E. Expansion Joints in Embedded Ducts:
  - 1. Where ductwork crosses structural contraction joints at 90 degrees to plane of joint, provided slip-type expansion joints in ductwork at structural contraction-joint crossings.
  - 2. Provide expansion joints designed to accommodate linear movement at contraction joint.
  - 3. Provide slip-type expansion joint in perforated-metal duct liner
- F. Dampers:
  - 1. Splitter or butterfly damper provided in duct leading to air terminal as shown.
  - 2. Butterfly dampers:
    - a. Balanced-type with flat blades.
    - b. Rigid blades fabricated with close-fitting hemmed edges.
    - c. Damper rods minimum 3/8-inch square at one end passing directly through ducts.
    - d. Square end of each rod held in self-locking lever device.
    - e. Where installed in furred ceilings, damper-locking device may be provided with short lever and concealed in box with flush cover in lieu of access panel.
  - 3. Opposed-blade dampers:
    - a. Gang-operated multiple blades provided in ducts over 12 inches in dimension.
    - b. Multiple blades fabricated maximum six inches wide.
    - c. Fabricated with nonmetallic edges or coating in low-pressure, medium-pressure or high-pressure ducts.
    - d. Ends of damper rods sealed to prevent leakage of air.
  - 4. Splitter dampers:
    - a. Single blade with hemmed edges, provided at branch duct connections.
    - b. Each blade hinged at one end with sheet metal straps.

- c. Free end of each blade connected to 1/4-inch adjusting rod secured to side of duct in flanged bushing with set screws.
    - d. Rods adjusted to operate freely between open and closed positions.
  - 5. Damper material:
    - a. Splitter and damper blades fabricated of same metal and two gauges heavier than ductwork and casings.
    - b. Fastening details and other items fabricated of metal specified for ductwork and casing bracing.
  - 6. Damper regulators:
    - a. Self-locking, damper and splitter regulators furnished, labeled SHUT and OPEN.
    - b. Factory-fabricated damper and splitter hardware furnished with zinc or cadmium protective coating.
  - 7. Fire dampers:
    - a. Fabricated to meet requirements of codes and regulations of jurisdictional authorities.
    - b. Constructed so that, during normal operation, folded blade assembly does not interrupt air stream.
    - c. Access provided for replacement of links.
    - d. Sleeve provided for fire damper, 14-gauge hot-rolled steel.
    - e. Fire dampers remote from fire partitions; connecting ductwork provided between fire damper and fire partition, fabricated of 11-gauge, zinc-coated sheet steel and supported by 1/2-inch diameter rods.
    - f. Fire dampers constructed to meet requirements of NFPA 90A and UL 555.
- G. Flexible-Duct Connections:
  - 1. Flexible-duct connections provided between air-handling unit fan and related ductwork and wherever necessary to prevent transmission of vibration to adjacent elements.
  - 2. Factory-assembled flexible material bordered each side with three-inch wide galvanized-steel edging mechanically attached.
  - 3. Width of flexible portion: Three to nine inches as necessary for installation conditions and to allow freedom of movement without unnecessary slack.
  - 4. Fabric parts of flexible connections: Unpainted.
- H. Instrument Test Holes:
  - 1. Factory-fabricated, airtight, non-corrosive instrument test hole with screw cap and gasket.
  - 2. Instrument test holes provided where required by balancing and testing agency.
  - 3. Cap extended up through insulation.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION:**

- A. Ductwork Installation:
  - 1. Install dampers and splitters so as to permit adjustment after completion of the work.
  - 2. Install dampers without strain or distortion of any part of dampers.
  - 3. Adjust moving parts to move freely without binding.
  - 4. Caulk dampers airtight around frames.
  - 5. Adjust damper and splitter adjusting rods to operate freely between open and closed positions.
    - a. Cut off projecting ends of rods after adjustment and bend over two inches from bushings.
    - b. Leave cut ends smooth and free from burrs.

6. Where diffuser is located at end of rectangular duct, extend duct minimum of one-neck diameter beyond center line of neck.
  7. Fire dampers:
    - a. Install fire dampers in ducts which penetrate walls or floors separating areas normally used by the public from ancillary areas. Patron-used areas include, but are not limited to, the following:
      - 1) Station train rooms.
      - 2) Train tunnels.
      - 3) Passageways ordinarily used by patrons.
    - b. Install fire dampers in ducts which penetrate walls and floors of elevator machinery rooms.
    - c. Install fire dampers to conform with fire, smoke and radiation damper installation guide for HVAC system
  8. Embedded Ductwork:
    - a. Join sections by continuous weld to achieve watertightness.
  9. Duct penetration through fire-rated partitions to be sealed with approved fireproof sealant in accordance with Section 07841.
  10. At in-line fans, provide flanged removable transition to permit access to and removal of fan motor
- B. Flexible Connections:
1. Install flexible connections in accordance with HVAC Duct Construction Standards – Metal and Flexible.
- C. Protection of Ductwork:
1. Protect ductwork, appurtenances and openings from dirt, foreign objects and damage during construction.
  2. Replace damaged ductwork and appurtenances.
  3. Provide sheet metal caps on duct ends that are to be connected to future ductwork.
- D. Painting of Embedded Ductwork:
1. After pressure test, clean joint areas.
  2. Coat outside of duct joints with zinc-rich paint measuring not less than five mils dry-film thickness or with two coats of bituminous paint over compatible primer.

### **3.02 FIELD QUALITY CONTROL:**

- A. Air-Leak Tests for Accessible Ductwork: Perform air-leak tests in accordance with SMACNA HVAC Air Duct Leakage Test Manual.
- B. Air-Leak Test for Embedded Ductwork: Test ductwork with internal air pressure of six inches wg. In accordance with SMACNA.

### **3.03 CLEANING OF AIR SYSTEM:**

- A. Before fans or filters are operated, clean inside of air system, including casing, plenums, ductwork and concrete tunnels used for air supply or return.
- B. Accomplish cleaning by means of industrial vacuum cleaners which will effectively remove dust and foreign material from surfaces swept by air stream.
- C. Clean exposed ductwork and leave in satisfactory condition, free from grease, oil and foreign material prior to application of insulation or finish painting.
- D. Clean ducts after the system has been used for adjusting, testing or temporary ventilation.

**END OF SECTION**

**SECTION 15825**

**SOUND ATTENUATORS**

**PART 1 - GENERAL**

**1.01 DESCRIPTION:**

- A. This section specifies providing factory-fabricated sound attenuators.

**1.02 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. AMCA Standards.
  - 3. SMACNA HVAC Duct Construction Standards.
  - 4. UL: 723.
  - 5. NFPA: 130, 255.
  - 6. ASTM: E84.
- B. Source Quality Control:
  - 1. Run tests for subway ventilation-fan attenuators on dynamic insertion-loss performance by duct-to-reverberation-room method with air flowing through sound attenuator at rated capacity.
  - 2. Test methods to eliminate effects due to end reflection, vibration, flanking transmission and standing waves in reverberant room.
  - 3. Take air flow and pressure loss data in accordance with AMCA Standards.

**1.03 SUBMITTALS:**

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings.
  - 2. Certification.
    - a. Certify that values for sound-pressure levels, i.e., decibels, Re 0.0002 microbar, of cooling tower with attenuators do not exceed those scheduled below measured at 50 feet in free field in any direction

Octave Band Center Frequency/Hertz	Sound Pressure Level/dB at 50 Feet with Inlet and Outlet Attenuators
63	66
125	61
250	54
500	45
1000	42
2000	41
4000	39
8000	39

## PART 2 - PRODUCTS

### 2.01 PRODUCTS AND MATERIALS:

- A. General Requirements:
  - 1. In design and purchase of equipment, provide for interchangeability of items of equipment, subassemblies and parts.
  
- B. Subway Ventilation-Fan and Jet-Fan Attenuators:
  - 1. Factory-fabricated with nominal rectangular cross section and length as shown.
  - 2. Outer casing constructed of minimum 22-USSG, galvanized sheet steel in accordance with SMACNA HVAC Duct Construction Standards.
  - 3. Interior partitions minimum 24-USSG, galvanized, perforated steel sheet.
  - 4. Factory-banded with 1-1/2 inch square by 1/8-inch steel angle flanges and two-inch bar straps.
  - 5. Airtight when operated at two inches water-gauge static pressure and rated capacity.
  - 6. Acoustic filler material:
    - a. Inorganic fibrous glass, permanently odorless.
    - b. Minimum five-percent compression to eliminate voids and setting.
    - c. Combustion rating when tested in accordance with ASTM E84, NFPA 255, or UL 723, maximum 20 for flame spread, 20 for smoke developed and 15 for fuel contributed.
  - 7. Designed for maximum pressure drop as specified for 100-percent forward flow and 70-percent reverse flow for air flow volume as shown.
  - 8. Minimum dynamic insertion loss (dB) under operating conditions shown in accordance with Table 15825-1.
  - 9. Comply with high temperature requirements given in NFPA 130.
  
- C. Cooling-Tower Sound Attenuators:
  - 1. Factory-fabricated, packaged-type, furnished by tower manufacturer.
  - 2. Outer casing constructed of minimum 22-USSG, hot-dip galvanized sheet steel in accordance with SMACNA HVAC Duct Construction Standards.
  - 3. Panels lines:
    - a. With weatherproof, inorganic, permanently odorless, fibrous-glass acoustic material.
    - b. Combination rating when tested in accordance with ASTM E84, NFPA 255, or UL 723, maximum 25 for flame spread, 20 for smoke developed and 20 for fuel contributed.
  - 4. Lining secured in place with galvanized-steel screening.
  - 5. Removable panels: For access to the eliminator sections and upper interior of tower.
  - 6. Exposed metal surfaces finished with zinc-chromate aluminum paint or manufacturer's standard finish providing equal or greater corrosion protection.
  - 7. Intake attenuators designed to bolt directly to the cooling tower, having removable access doors at ends for entry to moving parts of unit.
  - 8. Discharge attenuators designed to mount directly to top of tower and requiring no additional structural support.
  - 9. Galvanized-sheet-metal hooded inlet provided for protection from weather.
  
- D. Nameplates:
  - 1. Securely attached to each attenuator showing manufacturer's name, model number and serial number.

## PART 3 - EXECUTION

### 3.01 INSTALLATION:

- A. Fit sound attenuators within space available without restricting air flow.
- B. Install attenuators in accordance with manufacturer's recommendations and printed instructions.
- C. Provide sheet metal transitions, supports and concrete pads for fan attenuators.
- D. Provide self-supported cooling tower attenuators which can be readily attached.

**TABLE 15825-1 MINIMUM DYNAMIC INSERTION LOSS**

Std. 8000 Type Hz	Max. Press. Length Ft.	Drop In.- -wg. -wg.	Dynamic Insertion Loss/Hertz					
			125 Hz	250 Hz	500 Hz	100 Hz	2000 Hz	4000 Hz
3A	3 8	.31	5	8	15	16	14	10
5A	5 10	.31	8	13	25	28	21	14
7A	7 12	.31	9	18	31	38	28	18
3B	3 11	.31	7	12	19	24	23	18
5B	5 14	.37	10	18	30	42	33	23
7B	7 18	.40	14	24	36	48	44	31

**END OF SECTION**

## SECTION 15830

### FANS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing fans.
- B. Related Work Specified Elsewhere:
  - 1. Vibration isolation: Section 15070.
  - 2. Ductwork: 15810.
  - 3. Control equipment: Section 15900.
  - 4. Motors: Section 16225.
  - 5. Motor starters and control centers: Section 16425.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. AISI Standards.
  - 3. AMCA: 210, 99-2408.
  - 4. NFPA: 130.
  - 5. SAE: 1035,1040.
- B. Factory Wiring:
  - 1. In accordance with manufacturer's standard practice.
- C. Source Quality Control:
  - 1. Notify the Engineer 14 days prior to each test.
  - 2. Tunnel ventilation-fan testing:
    - a. Whirl tests:
      - 1) Perform tests on each fan at factory prior to shipment.
      - 2) Three tests total, each two minutes in duration, each performed at 125 percent of the operating rpm minimum.
    - b. Fan-reversal tests:
      - 1) Operate fan in primary direction at rated rpm for five minutes minimum.
      - 2) Disconnect power for 20 seconds; start fan in reverse direction.
      - 3) Operate fan in reverse direction for five minutes minimum, disconnect power for 20 seconds and restart fan in primary direction.
      - 4) Operate fan in primary direction for five minutes minimum, disconnect power and allow fan to stop gradually.
      - 5) Record following data and submit with shop drawings:
        - a) Motor-winding temperature and motor current, recorded continuously during test.
        - b) Motor-winding electrical resistance, recorded immediately prior to and following test.
      - 6) After completion of testing, inspect hub and blades for surface defects with approved penetrant dye. Submit certification of visual acceptability of fan hub and blades.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Performance tests certified by AMCA or performed either in accordance with AMCA 210 or in a laboratory approved by AMCA, for capacities shown.
    - b. Performance curves for each fan showing brake horsepower, static pressure and static efficiency plotted against air volume and noise level. For reversible fans, submit curves for both forward and reverse modes.
  - 2. Certification:
    - a. For under-platform-exhaust fans, dome-exhaust fans and subway-ventilation fans, certify that fans are rated and tested in accordance with AMCA 210.
    - b. For subway-ventilation fans, certify that sound power level based on  $10^{-12}$  watts does not exceed decibel ratings, without attenuators as specified.
  - 3. Operation and Maintenance Manuals.

#### 1.04 JOB CONDITIONS:

- A. Safety Requirements:
  - 1. Properly guard belts, pulleys, chains, gears, couplings, projecting set screws, keys and other rotating parts to prevent danger to personnel.

## PART 2 - PRODUCTS

### 2.01 PRODUCTS AND MATERIALS:

- A. General Requirements:
  - 1. In design and purchase of equipment, provide for interchangeability of items of equipment, subassemblies, parts, motors starters and relays.
  - 2. Requirements of this section apply to fans which are not a component part of air-handling units designed as complete units by the manufacturer.
  - 3. Fan rating based on tests performed in accordance with AMCA 210.
  - 4. Fans statically and dynamically balanced and quiet in operation.
  - 5. Fans designed to ensure that resonance frequency of blade assembly is not within 15 percent of harmonics of rotational frequency.
  - 6. Finished parts of fans, such as shafts and bearings, protected from rust prior to operation by means of wrappings or protective grease or plastic coatings.
  - 7. Exhaust fans, except subway-ventilation fans, under-platform-exhaust fans and dome-exhaust fans, provided with firestats to stop fan when temperature of air being handled reaches 125F.
    - a. Firestat having adjustable range from 100F to 200F and manual reset.
  - 8. Fans with wheels less than 12 inches in diameter, and utility fans operating at less than 0.75 inches WG may have forward-curved blades.
  - 9. Fan construction suitable for operating conditions defined in AMCA 99-2408.
- B. Centrifugal Fans:
  - 1. Class I or II, nonoverloading.
  - 2. Fan blades:
    - a. Fan wheels larger than 30 inches: Backward-inclined air-foil section.
    - b. Fan wheels 30 inches or less: Backward-inclined plate-type blades.
  - 3. Air entering fan uniformly over inlet area.
  - 4. Fan housing: Fabricated of steel sheets, manufacturer's standard heavy-gauge construction, except for those of low-pressure fans of less than 5,000-cfm capacity which may be fabricated of aluminum, 0.080-inch thick or heavier.

5. Fan wheel rims and blades: Fabricated of steel, manufacturer's standard heavy-gauge construction, with back plates of steel, 3/16 inch, except for those of low-pressure fans of less than 5,000 cfm which maybe fabricated of aluminum, 0.080-inch thick or heavier.
  6. Fan wheels: Aluminum or steel provided with manufacturer's standard corrosion-resistant coating.
  7. Fan scroll attached to the side plates by means of continuous lock-seam or welded-seam construction.
  8. Fan wheels and sheaves splined or keyed and fastened to the shafts with set screws.
  9. Shaft constructed solid or hollow of SAE 1035 or SAE 1040 ground and polished steel.
  10. One layer of corrosion-resistant coating on nonworking surfaces of shafts, factory-applied.
  11. Inspection openings provided for fan housing having wheels larger than 22 inches in diameter.
    - a. Cover plate having pressure latches on fan housing on scroll sheets located opposite outlets.
  12. Large fan housings provided in sections to permit installation or removal through openings available in structure.
  13. Field joints: Flanged and bolted.
  14. Fans designed to provide self-limiting, nonoverloading power characteristics.
  15. Two bearings for double-inlet and single-inlet fans having wheels larger than 36 inches in diameter, one on each side of wheel, with overhung sheaves.
  16. Inside and outside of fan housings factory-painted with baked-enamel primer; exterior surfaces given additional factory finish-coat of enamel.
  17. Fan driven by V-belt rated at 150 percent of driving-motor brake horsepower.
    - a. Adjustable sheaves furnished on motor, capable of 20-percent adjustment in fan speed, with design fan-capacity setting at approximately midpoint of adjustment.
    - b. Drives provided with belt guard of expanded-metal wire mesh or belt guards with solid-metal side panels with tachometer opening.
  18. Motors:
    - a. One-half horse power and above: Totally enclosed, fan-cooled and guarded in accordance with Section 16225.
    - b. Less than 1/2 horsepower: Manufacturer's standard for intended use.
  19. Vibration isolators: In accordance with Section 15070.
- C. Tubular Centrifugal Fans:
1. Class I or II, belt-driven, nonoverloading, designed for straight through airflow.
  2. Housing: Manufacturer's standard heavy-gauge steel construction.
    - a. Flanged inlet and outlet for connection to ductwork, with inlet and outlet identical in size.
    - b. Welded, cylindrical construction, braced to prevent vibration.
    - c. Fan bearings and drive enclosed and isolated from air stream.
  3. Fan wheels:
    - a. Welded construction, centrifugal wheel, with backward-inclined blades.
    - b. Fan wheels 27 inches in diameter or larger supplied with double thickness, air-foil blades.
    - c. Fan wheels less than 27 inches in diameter supplied with plate-type blades.
    - d. Fan wheels statically and dynamically balanced.
  4. Fans supplied with stationary conversion vanes on discharge side of wheel designed to reduce turbulence.
  5. Fan bearings:
    - a. Heavy-duty, self-aligning ball bearings.

- b. Lubrication fittings extended to fan casing and provided with covers to effectively exclude water and dirt.
  - 6. Fan shaft accurately machined and ground for proper fit to wheel hub and bearing and designed to operate well below first critical speed.
  - 7. Inside and outside of fan housing factory-painted with baked-enamel primer. Exterior surfaces given an additional factory-coat of corrosion-resistant finish enamel.
  - 8. One coat of corrosion-resistant coating on nonworking surfaces of shafts, factory-applied.
  - 9. Fan driven by V-belt rated at 150 percent of driving-motor brake horsepower.
    - a. Adjustable sheaves furnished on motor allowing 20-percent adjustment in fan speed, with design-capacity setting at approximately midpoint of adjustment.
  - 10. Fan wheels and sheaves splined or keyed and fastened to the shaft with set screws.
  - 11. Internal and external belt guards as necessary for complete protection.
  - 12. Motors:
    - a. One-half horsepower and above: Totally enclosed, fan-cooled and guarded in accordance with Section 16225.
    - b. Less than 1/2 horsepower: Manufacturer's standard for intended use.
- D. Axial Fans:
  - 1. Direct-driven or belt-driven as shown.
  - 2. Welded tubular-steel casings, except for low-pressure fans of less than 5,000-cfm capacity, which may have aluminum casings.
  - 3. Equipped with stationary discharge conversion blades and adjustable motor mounts.
  - 4. Air-foil blades: High-strength cast aluminum or steel.
  - 5. Blade pitch:
    - a. Fans with wheels 18 inches or larger: Blades field-adjustable without removing wheel from casing.
    - b. Fans with wheels less than 18 inches in diameter: May be equipped with stationary blades.
  - 6. Flanged-type for fan-casing connections to ductwork.
  - 7. Internal and external belt guards, as appropriate.
  - 8. Inlets with smooth, rounded edges.
  - 9. Air entering and leaving fan axially.
  - 10. Belt-driven fans:
    - a. Provide with high-grade, open-hearth steel fan shaft accurately machined and ground for proper fit to wheel hub and bearings.
    - b. Fan bearings and drive shafts enclosed and isolated from the air stream.
    - c. Bearings sealed mechanically against dust and dirt, self-aligning and grease-lubricated.
    - d. Fan driven by V-belt rated at 150 percent of driving-motor brake horsepower.
  - 11. Motors:
    - a. 1/2 horsepower and above:
      - 1) Belt-driven fans: Totally enclosed, fan-cooled and guarded in accordance with Section 16225.
      - 2) Direct-driven fans: Totally enclosed, air-over, fully guarded in accordance with Section 16225.
    - b. Less than 1/2 horsepower: Manufacturer's standard for intended use.
- E. Power Roof Ventilators:
  - 1. Direct-driven or belt-driven as shown.
  - 2. Consisting of fan with housing and weatherproof hood mounted on factory-supplied acoustical-thermal curb.

3. Fan housing constructed of spun aluminum and arranged to facilitate access for servicing from roof.
    - a. Discharge openings with 1/2-inch wire-mesh bird screen of aluminum or provided with corrosion-resistant coating.
    - b. Acoustical-thermal curb: Product of power roof-ventilator manufacturer.
    - c. Aluminum-blade back-draft dampers sized to fit curb opening.
    - d. Power roof-ventilator housing secured to curb to resist winds of 100 MPH.
  4. Motor: Totally enclosed weatherproof housing located outside of air stream and as specified in Section 16225.
    - a. Motor having unfused power-disconnect switch, mounted under fan housing adjacent to motor.
    - b. Permanently sealed, grease-lubricated, ball bearings or roller bearings.
  5. Belt-driven unit and belt drivers rated for 150 percent of motor-nameplate horsepower.
    - a. Adjustable sheaves to permit 20-percent adjustment in fan speed, with design fan capacity at approximately midpoint of adjustment.
  6. Wheel and drive assembly isolated from base section by means of rubber-in-shear isolators.
- F. Propeller Fans:
1. Direct-connected or belt-connected, motor-driven.
  2. Wheels having steel or aluminum blades; statically and dynamically balanced at the factory.
  3. Cast or die-formed mounting rings or plates.
    - a. Mounting plates designed to prevent distortion.
    - b. Mounting plates turned up at edges or braced with steel angles.
  4. Wire-mesh guard completely surrounding fan blades.
  5. Steel shafts for fans which are not mounted directly on motor shafts.
    - a. Shafts accurately finished on working surfaces.
  6. Self-aligning sleeve bearings or ball bearings:
    - a. Sleeve bearings:
      - 1) Ring oiled sleeve bearings or wool-packed and provided with oil reservoirs.
      - 2) Oiling device arranged in manner so that oil can be added while fan is running without danger of over-oiling.
    - b. Ball bearings:
      - 1) Prelubricated sealed bearings.
      - 2) Factory-installed grease fittings to permit external bearing relubrication.
  7. Motors:
    - a. Up to and including 1/2 HP: Manufacturer's standard.
    - b. Above 1/2 HP: Section 16225.
- G. Under-Platform-Exhaust Fans and Dome-Exhaust Fans:
1. Tube axial, direct-driven, reversible.
  2. Air volume in reverse: Minimum of 70 percent of that in forward direction.
  3. Minimum efficiency: 75 percent at specified forward direction and operating conditions.
  4. Brake horsepower: Not exceeding 100 percent of associated motor-nameplate rating at any point on fan power curve.
  5. Construction:
    - a. Fan housing constructed of minimum 1/4-inch welded steel plate, reinforced as necessary and flanged for connection to system ductwork or for mounting as otherwise shown.
    - b. Wheel and motor entirely enclosed within fan housing.

- c. Stationary curved guide vanes integrally welded with housing and located on discharge side of wheel to straighten motion of air leaving blades.
  - d. Fan wheels: Fabricated of high-strength cast aluminum or steel with air-foil shaped, adjustable blades.
  - e. Blades adjustable without removing wheel. Index and stops at hub to prevent overload of motor.
  - f. Positive-locking device installed for attaching rotor to motor shaft.
  - g. Drain fittings located in low parts of fan housing.
  - h. Fan fabricated of corrosion-resistant materials.
6. Fan motors: Section 16225, with the following additional requirements:
- a. Totally enclosed, air-over, squirrel cage, induction, reversible, fully guarded.
  - b. Adequate cooling in both directions at 50 percent of flow.
  - c. Motor bearings precision-grade anti-friction type, packed at the factory with special lubricant designed for maximum radial and thrust loads to be encountered in both directions of air flow.
  - d. Double-shielded bearings, minimum 200,000-hour life, regreasable with readily accessible inlet grease fittings and outlet grease plug to allow for in-service greasing, and metering the amount of grease which actually enters the bearings to protect against over-lubrication.
  - e. Grease fittings brought to outside of fan housing and provided with covers which effectively exclude water and dirt between lubrications.
  - f. Each motor with a drain plug at bottom of shell.
  - g. Motor speed not to exceed 1,200 rpm.
7. High temperature: Fans and motors capable of meeting high temperature requirements specified in NFPA 130.
- H. Subway-Ventilation Fans:
- 1. Tube axial, direct-driven, reversible, corrosion-resistant, designed for mounting in any position without modification.
  - 2. Capacity:
    - a. Each subway-ventilation fan having forward direction and reverse direction capacity as shown when operating at total pressures shown.
    - b. Minimum efficiency: 75 percent at specified forward direction and operating conditions.
    - c. Brake horsepower: Not exceeding 100 percent of associated motor-nameplate rating at any point on fan power curve.
  - 3. Construction:
    - a. Fan housing constructed of minimum 1/4-inch welded steel plate, reinforced as required and flanged for connection to inlet bells, outlet cones and outlet transitions provided by fan manufacturer.
    - b. Inside diameter of housing: 60 inches.
    - c. Wheel and motor totally enclosed within fan housing and not protruding at either end of housing exclusive of attached bells and cones.
    - d. Stationary curved guide vanes, integrally welded with housing and located on discharge side of wheel to straighten motion of air leaving blades.
    - e. Drain fittings located in low part of fan housing.
    - f. Inlet bell, outlet cone and outlet transition constructed of heavy-gauge, welded steel, flanged for connection to fan housing.
      - 1) Outlet transition having not more than ten degrees divergence all around.
    - g. Fan wheels fabricated of high-strength cast aluminum or steel with air-foil shaped, adjustable blades.
    - h. Blades adjustable without removing wheel.
    - i. Positive-locking device installed in attaching rotor to motor shaft.
    - j. 3/4-inch square woven-mesh, galvanized-steel screen on inlet side of each fan.

4. Fan motors: Section 16225, with the following additional requirements:
  - a. Totally enclosed, air-over.
  - b. 900-rpm maximum.
  - c. Motor bearings precision-grade, anti-friction bearings, factory-packed with special lubricant designed for maximum radial and thrust loads encountered in both directions of air flow.
  - d. Double-shielded bearings, regreasable with readily accessible inlet grease fittings and outlet grease plug to allow for in-service greasing and metering amount of grease which actually enters bearings to protect against over-lubrication. In normal ambient conditions the bearings shall be designed for 200,000 hours operation services (L-50 life rating).
  - e. Grease fittings brought to outside of fan housing and provided with covers to effectively exclude water and dirt.
  - f. Each motor with drain plug at bottom of shell.
  - g. Factory-installed resistance heater within motor enclosure.
    - 1) Resistance heater: Single-phase, 460 volt, 60 Hertz.
    - 2) Heater energized by means of NC auxiliary contact located in magnetic motor starter.
    - 3) Control sequence: Section 15900.

5. Sound ratings:
  - a. Maximum permissible sound levels, based on 10-12 watts:

Octave Band Center Frequency/Hertz	Sound Power Level/dB
63	87
125	96
250	98
500	99
1000	99
2000	94
4000	91
8000	90

- b. If sound exceeds permissible levels, provide sound attenuators as specified in Section 15825.
6. High temperature: Fans and motors capable of meeting high temperature requirements specified in NFPA 130.

- I. Jet Fans:
  1. Constructed of corrosion-resistant materials and finishes.
  2. Fan components and assemblies supplied by a single manufacturer. Parts interchangeable to the extent possible.
  3. Capable of delivering same volume of air in both forward and reverse directions of airflow. Capable of reversing airflow a minimum of three times during any one-hour period.
  4. Maximum vibrations are not to exceed a peak-to-peak amplitude of 2.0 mm for a normal operating speed of 1800 rpm or less.

5. Blade pitch manually adjustable without removing impeller. The maximum blade setting is to permit a minimum 15-percent increase in capacity above the design operating blade setting without motor overload or use of motor service factor.
  6. Conforming to NFPA 130 and applicable ANSI, AISI, AMCA and ASHRAE standards.
  7. Provided with fan support and suspension system designed per AISI Allowable Stress Design Method and which permits removal or replacement or both within a two-hour maintenance period.
  8. Housing, motor mounts and supports fabricated of hot-rolled steel and of continuous-welded construction; minimum eight-gauge USSG thickness and capable of withstanding penetration forces from blade failure and rotating forces due to loss-of-blade imbalance.
  9. Equipped with serviceable assemblies, including access doors of adequate size in the fan housing for inspection of blade locking devices and vibration devices and vibration test instrumentation. Doors of steel construction with AISI Type 316 stainless steel hardware and gasket material for the operating conditions as required.
  10. Capable of starting and continuously operating at full capacity in ambient air temperature range of zero to 40 degrees Celsius.
  11. Fan assemblies capable of operating at elevated temperatures as defined in NFPA 130.
  12. Impeller designed to withstand the stresses and loads created by overspeed testing of 125-percent of the nominal operating speed.
  13. Provided with adequate clearance between blade tips and housing at all points to allow for expansion and contraction over the operating and emergency temperature ranges.
  14. Motors and motor assemblies are to conform to the following:
    - a. NEMA Design B.
    - b. Capable of accelerating the fan impeller from stand still to the rated rotational speed in less than 15 seconds when connected to the terminal voltage of 75-percent of the nominal supply voltage.
    - c. Applicable ANSI, IEEE and NEMA or approved equivalent ISO standards.
    - d. Minimum Class H insulation and Class F rating for temperature rise when tested at the service factor load.
    - e. Totally enclosed, high efficiency, air-over, all cast iron or high grade silicone steel frame, induction type, wound for 480-volt, three-phase, 60-hertz alternating current.
    - f. Bearings designed and constructed for maximum radial thrust loads anticipated during starting, operating and reversing conditions. Bearings are to have a minimum L-10 life rating equal to 40,000 hours as defined by the AFBMA.
    - g. Equipped with 120-volt, single-phase heaters to prevent condensation in the motor windings.
    - h. Bearing lubrication lines extending to the exterior of the fan housing and terminating in straight lubrication fittings; fittings provided with covers to exclude water and dust
- J. Nameplates:
1. Fans: Securely attached on each fan showing manufacturer's name, model number and serial number.
  2. Motors: As specified in Section 16225.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION:**

- A. Fit fans and appurtenances within space provided and make readily serviceable.
- B. Provide support beams, concrete pads, support legs, platforms, hangers and anchor bolts required for proper installation of equipment as recommended by manufacturer.
- C. Vibration isolation for fans: As specified in Section 15070.
- D. Concrete pads: As specified in Section 15070.
- E. Axial and tubular centrifugal fans: Provide service access in accordance with Section 15810
- F. Motor starters and control centers: As specified in Section 16425.

**END OF SECTION**

## SECTION 15850

### OUTLETS AND GRILLES

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing outlets and grilles.
- B. Related Work Specified Elsewhere:
  - 1. Air conditioning pylons: Section 15806.
  - 2. System balancing and testing: Section 15950.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings.
  - 2. Samples:
    - a. One full-size sample of each outlet and grille in each finish specified.
  - 3. Certification.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. Supply Grilles:
  - 1. Type: Removable core, adjustable, two-way directional.
  - 2. Horizontal adjustment: By means of individually adjustable vertical bars or vanes spaced one-inch apart maximum.
  - 3. Vertical adjustment: By means of individually adjustable horizontal bars or vanes placed in front of vertical bars or by means of fixed fins which can be removed as a unit from frame and inserted in four positions.
  - 4. Horizontal bars or vanes spaced one-inch apart maximum.
  - 5. Fixed fins spaced 1/4-inch apart maximum.
  - 6. Frames constructed of stamped-steel or rolled-steel sections.
    - a. Prior to priming and finishing, steel parts of grilles treated with zinc-phosphate or zinc-chromate, dipped after fabrication.
  - 7. Supply grilles provided with airtight felt, neoprene or plastic sealing strips at edges, designed to prevent leakage.
  - 8. Corner joints finished to provide neat, trim appearance.
  - 9. Each grille provided with factory-fabricated volume-control damper furnished by grille manufacturer.
    - a. Volume dampers: Group-operated, opposed-blade, key adjustable.
    - b. Volume adjustment: By inserting key through face of grille.
    - c. Operating mechanism not projecting through grille face.
  - 10. Factory-fabricated multiple-blade extractors, furnished by grille manufacturer where shown.

- a. Multiple-blade extractors: Air-deflecting and air-straightening type with blades spaced two inches apart maximum.
- B. Exhaust and Return Grilles:
1. Exhaust and return grilles constructed as specified for supply grilles except with single set of nonadjustable face bars or vanes having same appearance as supply grilles.
  2. Volume-control dampers where shown.
- C. Ceiling Diffusers:
1. Types: Circular, square, rectangular or linear as shown.
  2. Diffuser ring or frame: Compatible with ceiling construction in which they are installed.
  3. Diffusers fabricated to meet sizes and capacities shown.
  4. Transitions provided where necessary to connect ducts to diffusers.
  5. Diffusers equipped with baffles or other devices necessary to achieve air-distribution pattern shown.
  6. Turning vanes factory-fabricated, furnished by diffuser manufacturer, at each diffuser or takeoff except where flexible ductwork is used.
  7. Single-key, opposed-blade volume damper factory-fabricated for each diffuser, furnished by diffuser manufacturer.
  8. Diffuser constructed of steel or aluminum with edges exposed to view rolled or otherwise stiffened and rounded:
    - a. Internal parts removable as unit to permit cleaning of diffuser and provide access to ducts.
    - b. Removable parts constructed to prevent reassembly so as to produce incorrect air-distribution pattern.
    - c. Internal assembly fastened to permit removal and reassembly without special tools.
  9. Air-pattern control omitted from diffusers used for return air or exhaust air.
  10. Air-duct or plenum connections secured to diffusers in accordance with manufacturer's recommendations.
  11. Circular ceiling diffusers provided with two or more concentric circular elements designed to deliver air radially, in a generally horizontal direction.
  12. Square and rectangular ceiling diffusers provided similar to circular diffusers, except that outer elements to be square or rectangular.
  13. Where diffuser is located at end of rectangular duct, duct extended minimum one-neck diameter beyond centerline of neck.
- D. Linear Air Diffusers:
1. Size and capacity: As shown.
  2. Diffusers and components parts constructed of extruded aluminum and finished as specified.
  3. Where diffuser length necessitates sectional installation, alignment slots provided for insertion of key strips or with other concealed means to align exposed butt edges of diffuser:
    - a. Joints between diffuser sections to appear as hairline.
    - b. Corner joints of frames and flanges exposed below ceiling or side wall to appear as hairline cracks with unexposed sides or corner joints welded or secured with alignment keys.
  4. Air-delivery patterns: Manually adjustable from face of diffuser after installation.
    - a. Full 180-degree air pattern, from horizontal left or right, vertical or intermediate pattern from each slot independent of other slots.
  5. Damper blades:
    - a. Independent of pattern blades.
    - b. Damper designed for manual adjustment from face of diffuser.

6. Screws or bolts prohibited in exposed face of diffuser frames or flanges.

**2.02 FINISHES:**

- A. Items exposed to public view in stations: Unless otherwise shown, factory-finished in baked enamel, colors as directed.
- B. Items not exposed to public view: Factory-finished in light-gray baked enamel.

**PART 3 - EXECUTION**

**3.01 INSTALLATION:**

- A. Install grilles and diffusers to permit key adjustment from face without other special tools.
- B. Install vanes and volume-control dampers to permit removal through diffuser for access to duct.

**END OF SECTION**

## SECTION 15865

### FILTERS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing air filters.
- B. Related Work Specified Elsewhere:
  - 1. Remote-surveillance devices: Sections 13810 and 15900.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. UL 900 Class 1.
  - 2. ASHRAE: 52.1.
- B. Source Quality Control:
  - 1. Factory-tested or tested by an independent laboratory experienced in testing filters; certify compliance with requirements of ASHRAE Standard 52 for arrestance, efficiency, dust-holding capacity and pressure drop.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings.
  - 2. Certification.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. General Requirements:
  - 1. In design of equipment, provide for interchangeability of items of equipment, subassemblies, and parts.
- B. Throwaway (Replaceable) Prefilters:
  - 1. Flat-panel filter units designed and fabricated for disposal when dust-load limit is reached.
  - 2. Dry or adhesive-coated filter media, as standard with the manufacturer.
  - 3. Maximum air flow through filters: Not exceeding manufacturer's published rated capacity but not exceeding 500 feet per minute at 0.10-inch w.g.
  - 4. Designed to fit within space available and constructed so as to prevent passage of unfiltered air.
  - 5. Filter frames constructed of 18-gauge galvanized steel with air-tight access panels for filter inspection, cleaning and replacement.
  - 6. Filters are UL 900 Class I listed.
- C. Bag Filters:
  - 1. Horizontal air-flow filters of the high-density glass microfibers-type.
  - 2. Capacity based on air-handling capacity of unit to which it is applied with velocity limited to maximum of 500 feet per minute through filter based on net filter area.
  - 3. Provide high-density glass-microfiber filter media, reinforced with a backing to form a lofted filter blanket. Provide filter media with an average efficiency of 80 to 85

percent when tested by ASHRAE 52.1, and with an average arrestance of not less than 98 percent on that standard. Provide UL 900 Class 1 listed filters.

- a. Remote-surveillance devices: In accordance with Section 13810 and Section 15900.
4. Pocket construction: Pockets to consist of glass microfibers chemically bonded to a reinforced UL Class 1 backing. Sew pockets with a tapered stitch which forms a V or wedge-shaped pocket resulting in uniform velocity in the passages of the air-entering and air-exiting sides of the filter. Equip the pockets with a minimum of 40 support points per square foot of filter media:
  - a. Completely seal all stitching points with foam-seal or equivalent. Chemically adhere the pockets around the periphery of the galvanized-steel retainers. Provide retainers with rolled edges to reduce possible cuts to media, or lacerations to installers.
5. Enclosing frame: Construct enclosing frame of a J return channel of 16-gauge galvanized steel. The channel may be 7/8 inch or 1-1/8 inch.
6. Glide/Packs - for side-access applications: Factory fabricate and assemble filter housings. Construct the units of not less than 16-gauge galvanized steel, incorporating two access doors, extruded-aluminum tracks and individual universal holding frames designed to accommodate a wide range of standard size filters in varying efficiency ranges.
7. Leakage at rated airflow, upstream to downstream of filter, holding frame and slide mechanism to be less than one percent at 3-inch w.g. differential.
8. Leakage into housing from ambient atmosphere at rated airflow to be less than 0.5 percent at 3-inch w.g. negative. Manufacturer to submit substantiating test reports.
9. Construct access doors of 16-gauge galvanized steel and position them to facilitate removal and replacement of filters from either side of the housing. Equip each door with adjustable and replaceable post.
10. Provide factory installed 16-gauge galvanized steel transition plates on air-inlet and/or air-exit side to match air-handling unit.

D. Controls:

1. Control panels factory wired.
  - a. Adjustable pressure-differential sensing device and wiring for remote surveillance.
  - b. Pressure range of 0.02-inch w.g. to 1.0-inch w.g. Accuracy of plus-or-minus 0.03-inch w.g.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION:**

- A. Fit equipment and appurtenances within the space provided and make readily serviceable.
- B. Install bag filters with capacities as shown.
- C. Examine each bag filter's media before installation for seepage and adhesive to surface of container.
- D. Replace bag filters showing evidence of seepage.
- E. After final testing and cleaning of fans and ductwork, replace prefilters and final filter media with new, clean media.

**END OF SECTION**

## SECTION 15900

### CONTROL EQUIPMENT

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing automatic temperature controls, remote surveillance and control and local control systems.

##### 1.02 QUALITY ASSURANCE:

- A. Qualifications of Manufacturer:
1. Select manufacturer who maintains full-time organization for installation and service in the Washington, D.C. metropolitan area.
  2. Have instruments, piping and wiring installed by representative of temperature control-equipment manufacturer.
- B. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
  2. ASTM: A153.
  3. ASME: Boiler and Pressure Vessel Codes.
  4. NEMA: 250, ICS 2-1993
  5. UL: Electrical Construction Materials Directory.
- C. Design Criteria:
1. Automatic temperature-control systems:
    - a. Design systems to perform functions and operate in sequence as shown or specified for air conditioning and ventilation of station platforms, mezzanines, station ancillary rooms, tie-breaker stations, traction-power substations and chilled-water plants.
    - b. Maintain conditions shown or specified.
    - c. Operate and control motor-operated dampers.
    - d. Design duplex air compressor to have sufficient capacity to supply entire system, under normal conditions, while running less than 50 percent of the time.
    - e. Design dessicant dryer system to maintain maximum pressure dew point of -10F at main air pressure and delivery volume necessary.
    - f. Design control system to interface with fire and smoke-detection system by others to shut off the following fans on activation of fire and smoke-detection system.
      - 1) Battery-room fans:
      - 2) Air-conditioning and ancillary area fans in excess of 2,000 cfm, except the following:
        - a) Underplatform-exhaust fans.
        - b) Subway-ventilation fans.
        - c) Dome-exhaust fans.
        - d) Jet fans.
  2. Remote surveillance and control systems:
    - a. Continuously measure parameters as shown including pressure, temperature and flow. Convert analog values of sensing transducer into seven-bit binary code and transfer to designated interface DTS terminals by relays.
    - b. Monitor abnormal operations, such as high and low limits on pressure, temperature, water level, water flow, damper position, mode-selector switch

position and air flow as shown; provide contact closure to designated DTS terminals.

- c. Design system to compensate for electrical losses in wiring. Design dc-power supplies and signal amplifiers, as necessary

D. Source Quality Control:

- 1. Test and stamp air storage tank in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Div. I.
- 2. Identify each transducer according to type, sensitivity, accuracy and operating range.
- 3. Each remote-indication system installed to have accuracy shown.

### 1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- 1. Shop Drawings:
  - a. Complete catalog information and shop drawings for material and equipment including wiring and control diagrams.
  - b. Submittals include, but are not limited, to the following:
    - 1) Air compressors, with motors and controls.
    - 2) Compressed-air storage tanks.
    - 3) Dessicant air drier system including prefilters, after each if provided, after filter.
    - 4) Thermostats.
    - 5) Controllers.
    - 6) Damper operators, electric or pneumatic as applicable.
    - 7) Automatic valves and operators.
    - 8) Dampers.
    - 9) Control panels and cabinets.
    - 10) Gauges and indicators.
    - 11) Transducers.
    - 12) Data-transmission system-interface relays.
    - 13) Sensing devices.
    - 14) Wiring diagrams, control diagrams and layouts for each system.
    - 15) Pneumatic controls.
    - 16) Control, indication and time-delay relays.
    - 17) Damper limit switches.
  - c. Complete set of floor plans of rooms showing by means of graphic coding actual location and mounting heights of thermostats and zone served by each thermostat.
- 2. Operation and Maintenance Manuals:
  - a. Complete electrical schematic of each system showing and identifying each internal and external component and internal and external wiring.
  - b. Detailed piping and wiring diagrams showing graphic coding.
  - c. Terminal numbers for wire or pipe connections.
  - d. Complete parts list of internal and external components.

### 1.04 OPERATION AND MAINTENANCE TRAINING:

A. Upon completion of installation, furnish services of competent field engineer with specialized experience in temperature control and remote surveillance and control system to train Authority personnel in accordance with the General Requirements and as follows:

- 1. Instructional period: Three consecutive man-days minimum. A minimum of one day to be devoted to hands-on demonstration of the equipment operation, trouble analysis, repair, adjustment and maintenance.

2. Train operators in preventive maintenance of systems and to recognize malfunctions.
3. Provide complete printed operating instructions in manual or handbook form, completely and clearly indexed for ready reference during actual operation and for use as text during instruction of operating personnel.
  - a. Include descriptions of systems, background information and complete procedures for adjustment, calibration, replacement and repair of components in system.

## **PART 2 - PRODUCTS**

### **2.01 PRODUCTS AND MATERIALS:**

- A. General Requirements:
  1. In design and purchase of equipment, provide for interchangeability of items of piping equipment, subassemblies, parts, motors, starters, relays and transducers.
- B. Automatic Temperature-Control System:
  1. Air compressors:
    - a. Duplex-type, with intake air cleaners of cleanable, impingement type, designed for heavy-duty service.
    - b. Relief valve located between compressor and discharge shutoff valve, set for pressure 10-psi greater than that of control-switch cutout.
    - c. Cast-iron or steel base for each compressor and motor for mounting on air tank or on separate concrete foundation.
    - d. Controls:
      - 1) Enclosed, adjustable, pressure-operated pilot switches connected to motor starter and mounted on unloading device.
      - 2) To start lead compressor when air storage-tank pressure falls to 85 psig and stop it when pressure rises to 100 psig.
      - 3) To start lag compressor when air storage-tank pressure falls to 75 psig and stop it when pressure rises to 90 psig.
      - 4) Automatic alternator to change sequence of operation of compressors on completion of each cycle.
    - e. Motors: Four-pole, dripproof and fully guarded: Section 16225.
  2. Air storage tank:
    - a. Construction: Welded steel plate designed for minimum of 125 psi in accordance with ASME Boiler and Pressure Vessel Codes.
    - b. Finish: Zinc-coated after fabrication.
    - c. Relief valve and automatic drain with drain piping extended to nearest drain.
    - d. Tanks mounted with compressors: Horizontal or vertical.
      - 1) Tanks mounted separately: Vertical.
    - e. Capacity: Such that idle time between compressor running periods is 10 minutes minimum.
  3. Aftercooler:
    - a. Air-cooled.
    - b. Designed to reduce compressed-air temperature to a maximum of 100F.
    - c. Operating pressure and temperature compatible with air compressor.
    - d. Fabricated in accordance with ASME Boiler and Pressure Vessel Codes.
    - e. Equipped with ASME PTC 25-3 safety valve.
    - f. Built-in moisture separator with automatic drain valve.
  4. Air dryer:
    - a. Heatless/heaterless regenerative desiccant-type.
    - b. Designed to supply air with a maximum pressure dew point of -10F at 80 psi and in sufficient quantity to operate controls as determined by controls contractor.

- c. Two-tower design constructed in accordance with ASME Boiler and Pressure Vessel Codes.
  - d. Designed for a working pressure of 150-psi minimum.
  - e. Towers equipped with safety relief valves and pressure gauges.
  - f. Supplied as a complete package unit, operable on 115V, single-phase, 60-Hz power.
  - g. Rated in accordance with Compressed Air and Gas Institute (CAGI) Standard for Rating and Testing Compressed Air Dryers and National Fluid Power Association Recommended Standards.
  - h. Muffler on purge air discharge.
  - i. Fully automatic operation with cycle controlled by timer.
  - j. Electrical components including:
    - 1) ON/OFF switch.
    - 2) POWER ON light.
5. Prefilter:
- a. Compatible with air dryer.
  - b. Automatic drain.
  - c. Coalescent-type.
6. Afterfilter:
- a. Compatible with air dryer and designed to prevent desiccant carryover into compressed-air supply line.
7. Automatic valves:
- a. Bodies, discs, stems and stuffing boxes designed for minimum working pressure of 125 psi.
  - b. Provide valves of type specified for each of the following body sizes:
    - 1) 1-1/2 inches or smaller: Brass or bronze with screwed or union ends.
    - 2) Four inches and larger: Iron bodies with brass or bronze trimmings and flanged ends.
    - 3) Two inches to three inches: Brass or bronze with screwed or union ends or iron bodies with brass or bronze trimmings and flanged ends.
  - c. Visible position indicators and renewable discs.
8. Automatic dampers, except fan shaft, vent shaft and dome relief dampers:
- a. Provided by automatic temperature-control manufacturer.
  - b. Factory-fabricated, opposed blade, balanced-type with factory-assembled linkages, mounted in galvanized-steel frames.
  - c. Blades: Flat or formed galvanized steel with interlocking edges or with compressible seals at point of contact.
    - 1) Air-temperature range of seals: Suitable for operation from minus 20F to plus 200F.
    - 2) Supported by thrust bearings for vertically mounted blades.
    - 3) Length of blades between bearings: 48 inches maximum.
    - 4) Width of blades: Eight inches maximum.
  - d. Leakage when closed: Maximum 20 cfm per square foot at static pressure of four inches water gauge.
  - e. Frames: Bar or channel, with corner bracing for rectangular dampers larger than four square feet in area.
  - f. Damper-operating linkage:
    - 1) Adjustable-length galvanized-steel rods capable of withstanding load of at least twice maximum operating force of damper operator without deflection.
    - 2) Joints: Brass pins and clevises or brass ball-and-socket joints.
  - g. Steel parts: Hot-dip galvanized after fabrication.
9. Automatic dampers for subway-ventilation fan discharge and bypass, vent shaft, underplatform-exhaust fan and dome-exhaust fan:

- a. Automatic dampers factory-fabricated, constructed of galvanized sheet metal or extruded aluminum. Frames constructed of minimum 13-gauge galvanized sheet steel or extruded aluminum.
  - b. Dampers designed for control by pneumatic or electric motor operators. Mounting provisions for motor operators included in damper assembly.
  - c. Damper blades designed for air velocities to be encountered in system.
  - d. Blades: Maximum width eight inches and 24 inches maximum between bearings, fabricated of galvanized sheet steel, 16-gauge or double 22-gauge minimum.
  - e. Seals designed to withstand air temperatures ranging from minus 20F to plus 200F.
  - f. Damper-operating linkage:
    - 1) Adjustable-length galvanized-steel rods capable of withstanding without deflection load of at least twice maximum operating force of damper operator.
    - 2) Joints: Brass pins and clevises or brass ball-and-socket joints.
    - 3) Damper operators attached to operating linkage so as to ensure positive operation without lost motion.
  - g. Motor mounting supported so that operator will not deflect from its normal path when operating under load.
  - h. Steel parts: Hot-dip galvanized after fabrication. Galvanizing: 1.25 ounces, in accordance with ASTM A153.
  - i. Conforming to NFPA 130 high temperature requirements.
10. Pneumatic valve and damper operators:
- a. Spring-return type with nonferrous-metal bellows or reinforced-neoprene diaphragms.
  - b. Bellows or diaphragm: Sized for operating pressure necessary to start valve or damper operator.
  - c. Spring to return valve or damper to fail-safe position in event of power failure, in normally open or normally closed position as shown.
  - d. Adjustment provisions: Adjustable stops to control open and closed positions of damper operators.
  - e. Damper operators for vent-shaft dampers and fan-shaft dampers to include pilot or positive positioners.
11. Space thermostats:
- a. Supplied with subbase for mounting and guards as shown.
  - b. Adjustment devices on controllers locked or concealed.
  - c. Operating points: Minimum range 10 degrees above and 10-percent below operating points shown.
  - d. Provide external thermometer with knob or lever-adjusting devices where shown.
  - e. Thermostat throttling range: 2F maximum.
  - f. Controllers, submaster controllers, lagged sensing elements and space thermostats provided with means for field adjustment of throttling range.
12. Duct thermostats:
- a. Remote sensing-element type, with controller mounted on apparatus control panel.
  - b. Enclosure for operating and adjusting mechanism: Metal or phenolic-resin case.
  - c. Thermostats used for freeze protection: Sensing element 20 feet minimum in length.
    - 1) Thermostat capable of operating when freezing condition exists at one-foot increments anywhere along sensing element.
  - d. Remote transmitter provided when distance from bulb to panel exceeds manufacturer's recommended capillary length.
13. Pipe thermostats:

- a. Immersion-type with liquid-filled separable sockets.
  - b. Remote sensing-element type, used where socket is located minimum five feet above floor.
  - c. Remote transmitter provided when distance from bulb to panel exceeds manufacturer's recommended capillary length.
  - d. Separable sockets: Stainless steel, heavy enough to withstand pulsations and turbulences in fluid controlled.
  - e. Pipe-sensing thermostat for electric heat tracing:
    - 1) Remote bulb suitable for attachment to outside of pipe as shown.
    - 2) Thermostat with DPST contacts, range of zero degree F to 100F and control differential of not more than 8F.
    - 3) Thermostat in NEMA 250, Type 4 enclosure, except NEMA 250, Type 12 enclosure for train tunnels, vent shafts or track-drainage pumping station.
    - 4) Contactor, as necessary, when total amperes of heating tape exceeds rated capacity of thermostat.
14. Pressure gauges:
- a. For individual-mounted controllers: Stem-mounted, two inches diameter minimum.
  - b. For panel-mounted controllers, individual gauges: Two inches minimum diameter.
  - c. For panel-mounted controllers, multiple-indication gauges: 3-1/2 inches minimum diameter.
15. Apparatus control panels, except for subway-ventilation fans and dome-exhaust fans:
- a. Separate apparatus control panel or metal cabinet for each air-handling and air-conditioning unit.
  - b. Control instruments located on panel, except fire and freeze-protection instruments.
  - c. Panel constructed of fire-resistant material with nonglare surfaces.
16. Electric damper operators:
- a. Spring-return type.
  - b. Two-position motor operation.
  - c. Spring returns damper to fail-safe position as shown in event of power failure or termination.
  - d. Opening time: 60 seconds maximum.
  - e. Adjustable stops to control open and closed positions.
17. Time clock:
- a. Suitable for automatic weekly switching operations of electrical equipment.
  - b. Seven-day cycle with ten-hour spring reserve to maintain programmed switching in event of power failure.
  - c. Capable of being programmed as desired.
  - d. Manual trip mechanism for overriding timer.
  - e. Mechanism powered by single-phase synchronous motor from available internal control power of 120 volts, 60 Hertz.
  - f. Motor capable of operating at temperatures ranging from zero degrees F to 120F.
  - g. Contacts of cadmium alloy, rated for 40-ampere, noninductive service at 120, 208/240, or 277 volts.
  - h. Enclosure: NEMA 250, Type 1, surface-mounted.
18. Selector switch, except for subway-ventilation fan, underplatform-exhaust fan and dome-exhaust fan:
- a. Positions labeled HAND/OFF/AUTOMATIC.
  - b. Maintained contact.
  - c. Oil-tight.

- d. Contact-rating designation: NEMA ICS 2-1993, with the following additional requirements:
  - 1) Continuous current rating: 10 amperes.
  - 2) Voltage rating: 120 volts, 60 Hertz
- 19. Damper limit switch:
  - a. Contacts: Single-pole; one NO, one NC; snap-action.
  - b. Enclosure: NEMA 250, Type 1.
  - c. Actuator: Level-operated, rotary-type, adjustable, with spring return.
  - d. Mounting: Plug-in type with receptacle tapped for conduit size as shown.
  - e. Contact-rating designation: NEMA A600, with the following additional requirements:
    - 1) Continuous-current rating: 10 amperes.
    - 2) Voltage rating: 120 volts, 60 Hertz.
- 20. Automatic alternator:
  - a. Equipped with ratchet mechanism to alternate opening and closing of two contacts after each ventilating-unit cycle.
  - b. Electrical requirements:
    - 1) Continuous-current rating: 10 amperes.
    - 2) Voltage rating: 120 volts, 60 Hertz.
    - 3) Enclosure: NEMA 250, Type 1.
- C. Remote Surveillance and Control:
  - 1. DTS Relays:
    - a. Energized from command-center control via DTS.
    - b. Momentary-pulse type requiring no sustained power consumption.
    - c. Maximum coil load: 15 volt-amperes, resistive or suppressed inductive.
    - d. Coil voltage: 28 volts dc.
    - e. Contacts: Compatible with equipment controlled.
  - 2. General relays:
    - a. Control and indication relays:
      - 1) Functional designations and schematic connections as shown.
      - 2) Number and configuration of contacts as shown.
      - 3) Contact ratings:
        - a) Maximum switched voltage: 600 volts ac
        - b) Maximum continuous current: 10 amperes.
        - c) Capable of making load of 720 volt-amperes ac.
        - d) Capable of breaking load of 720 volt-amperes ac.
        - e) Minimum open-contact resistance: 50 megohms, 400 volts dc.
        - f) Maximum duration of bounce: 50 milliseconds.
      - 4) Modular convertible contacts enclosed in plastic.
    - b. Time-delay relays:
      - 1) Functional designations and schematic connections as shown.
      - 2) Number and configuration of contacts as shown.
      - 3) Capable of operating from minus 20F to plus 165F.
      - 4) Externally adjustable time delay.
      - 5) Contact rating:
        - a) Current capacity of 20 amperes resistive at 120 volts ac for 100,000 operations.
      - 6) Insulation resistance: 50 megohms at 500 volts dc.
      - 7) Auxiliary contacts for instantaneous transfer or two-step timing as scheduled.
  - 3. Transducers:
    - a. Rise time: One-second maximum.
    - b. Sensitivity: Constant over operating range shown.

- c. Adjustment for high and low operating ranges: Manual, calibrated and clearly identified.
  - d. Output: Accommodate three wires, marked with PLUS, MINUS and GROUND SHIELD symbols.
  - e. Transducers requiring external electric power to operate at 120 volts, single-phase, 60 Hertz.
  - f. Transducers requiring external air supply to operate from 20-psi source.
  - g. Housings: Moisture proof and disproof enclosure suitable for environment in which each transducer is located. Transducer nameplate attached to housing.
4. Drainage pumping-station surveillance:
- a. Indicating malfunction upon loss of electric power from both sources.
  - b. Indicating malfunction when both pumps are running.
  - c. Indicating malfunction when water level is above or below preset range.
5. Fan control cabinets:
- a. For subway ventilation-fan controls: NEMA 250, Type 4 steel enclosure with epoxy powdered-resin-coated finish.
  - b. For underplatform exhaust-fan and dome exhaust-fan controls: NEMA 250, Type 1 enclosure.
  - c. Mode-selector switch mounted in front cover:
    - 1) Maintained contact.
    - 2) Oil-tight.
    - 3) Contacts conforming to NEMA ICS 2-1993 rated for 10 amperes continuous current at 120 volts, 60 Hertz.
  - d. Positions of mode-selector switch: Labeled on nameplate as follows: REMOTE/OFF/LOCAL EXHAUST/LOCAL SUPPLY.
  - e. Complete electrical schematic diagram of control cabinet affixed permanently to inner surface of front cover and protected by clear Lucite.
    - 1) Include on schematic diagram parts list for all components of panel and contents, showing complete manufacturer's name, nomenclature and parts number
  - f. Pilot lights mounted in front cover.
    - 1) Polycarbonate lens.
    - 2) Push to test.
    - 3) Legend plate with mode indicated.
    - 4) 20,000-hour 6.3-volt lamp.
  - g. Control panel surface, except for underplatform-exhaust fans and dome-exhaust fans, lighted by fixture permanently mounted on panel.
    - 1) Fixture to include fireproof lampshade extending width of panel.
    - 2) Average lighting level: 40 foot-candles over entire surface of panel.
  - h. Panel constructed of fire-resistant material with nonglare surface
6. Flow sensor:
- a. Diaphragm differential sensor.
  - b. Single-pole, double-throw, snap-acting switch, 10-ampere rating.
  - c. NC contacts.
  - d. Adjustable set point.
  - e. Operating range of zero degree F to 180F.
7. Electric heat tracing: Section 15725.
- D. Traction-Power Substation Ventilating-Unit Controls:
- 1. Two-stage thermostat and automatic alternator.
  - 2. Control sequence:
    - a. When room temperature rises to 80F: Open lead-fan dampers and start lead fan.
    - b. When room temperature rises to 90F: Open lag-fan dampers and start lag fan.

- c. Reverse control process on falling temperature.
    - d. Automatic alternator reverses lead-lag sequence after each lead-fan operating cycle.
  - 3. Selector switch.
- E. AC Switchboard Room Ventilating-Fan Controls:
  - 1. Thermostat, flow switches, time-delay relay, selector switch, automatic alternator and limit switches.
  - 2. During each operating cycle, one fan to serve as primary fan and second fan as standby.
  - 3. Control sequence:
    - a. Dampers on intake and discharge side to remain open when fans are not in operation.
    - b. When room temperature rises to 90F, relief damper(s) open, standby-fan intake damper closes and primary fan starts.
    - c. Control sequence to reverse when room temperature falls.
    - d. After each operating cycle, automatic alternator to reverse functions of automatic and standby fans.
  - 4. Abnormal operation: If primary fan fails to operate, primary-fan intake damper closes, standby-fan intake damper opens and standby fan starts. Relief dampers to remain open during standby-fan operation.
- F. DC Breaker Room and Tie-Breaker Station Ventilating-Fan Controls:
  - 1. Single-stage space thermostat.
  - 2. HAND/OFF/AUTOMATIC switch.
  - 3. Operation:
    - a. Hand: Fan running, dampers open.
    - b. Off: Fan off, dampers closed.
    - c. Automatic:
      - 1) When room temperature rises to 90F, open dampers and start fan.
      - 2) Reverse control process on falling temperature.
- G. Battery Room Fan Controls:
  - 1. Battery room exhaust fan to operate continuously.
  - 2. Magnetic starter.
- H. Fire Alarm for Shutdown Interface Box: Data transmission system (DTS) cabinet specified in Section 16130, with the following additional requirements:
  - 1. Cabinet: Hoffman A161206LP.
  - 2. Terminal strip: Terminal as required mounted in upper right-hand quadrant of cabinet.
  - 3. Exterior finish color: Sherwin-Williams Fire Protection Red.
    - a. Yellow letters, one-inch high on cover: FA-FAN SHUTDOWN.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION:**

- A. Fit equipment and appurtenances within space provided and make readily serviceable. All gauges and indicators to be installed so they can be readily read without use of ladder or other means to reach installed items.
- B. Foundations, platforms, or hangers for apparatus in accordance with Sections 03200 and 03300.

- C. Unless specifically shown otherwise on drawings, provide a complete compressed-air system as required for pneumatic-control system being provided, including air compressor, storage tank, pressure-reducing valves, aftercooler, air dryer complete with prefilter and afterfilter, and all control-air piping from air compressor to controls and operating units. Piping is to be in accordance with Section 15205.
  
- D. Install 18AWG minimum control wiring, as shown and in accordance with Sections 16120 and 16125.
  - 1. Identify each wire at interface cabinet locations.
  - 2. When communication fan-shutdown interface cabinets are installed by others, complete wiring to designated terminals.
  
- E. Automatic Temperature-Control Systems:
  - 1. Install entire automatic temperature-control system, including piping and wiring under supervision of automatic temperature-control equipment manufacturer.
  - 2. Mount damper operators outside of duct or casing with support plates that are completely outside insulation or covering.
    - a. Install support plates so as to prevent condensation on damper operator or on supports.
  - 3. Support valves and damper-operator motor mountings so that operator does not deflect from its normal path when operating under load.
  - 4. Locate sensing elements of duct thermostats where they will respond to representative temperature within duct or casing.
  - 5. Duct thermostats and remote transmitters:
    - a. Install outside of ducts and casings.
    - b. Where ducts or casing are insulated, mount thermostats flush with outside insulation, so that moisture will not condense on thermostats or on supports.
  - 6. Duct thermal capillary tubes and wires:
    - a. Install to pierce thermal insulation at least practicable number of points.
    - b. Seal insulation properly where capillaries and wiring pass through.
  - 7. Capillary tubes:
    - a. Protect by conduit, molding or flexible armor.
    - b. Coil capillary tube neatly and fasten excess lengths out of the way.
  - 8. Apparatus control panel:
    - a. Mount bottom of each panel 30 inches above floor.
    - b. Provide 30 inches clearance between rear of panel and wall where conduit or wiring enters panel from rear.
    - c. Mount controls, instrument gauges, thermostats and relays flush on front of panel.
    - d. Install wiring and tubing connections for accessibility in servicing.
  - 9. Apparatus control cabinets:
    - a. Make wiring and tubing connections to control instruments, indicating instruments and communication equipment inside cabinet.
    - b. Install pilot lights, manual switches, and pushbutton controllers in cabinet door, so they are visible and operable with door closed.
  - 10. Mount framed schematic temperature-control diagram adjacent to each apparatus control panel or cabinet.
  - 11. Mount time clock on control panel in accordance with manufacturer's recommendations.
  - 12. Mount selector switch in motor-starter enclosure of ventilating units in ac-switchboard rooms, traction-power substations and tie-breaker stations.
  - 13. Mount pushbutton station in motor-starter enclosure of exhaust fan in battery rooms.
  - 14. Limit switch:
    - a. Mount on automatic damper blades in ac-switchboard rooms, traction-power substations, tie-breaker stations, vent shafts, fan shafts, underplatform-exhaust fans and dome-exhaust fans.

- b. Set switch contacts to close when damper opens.
  15. Install automatic alternator in ac-switchboard rooms and traction-power substations which have two ventilating units.
  16. Pipe-sensing thermostat for electric tracing:
    - a. Firmly attach remote bulb against pipe at location in which bulb does not touch heating tape.
    - b. Mount thermostat securely on wall at conveniently accessible location.
  17. Install pneumatic-control systems for the following:
    - a. Chilled-water plant.
    - b. Underplatform-exhaust fans.
    - c. Subway-ventilation fans and vent shafts where control air is available.
    - d. Mezzanine and platform air-conditioning units with chilled-water coils.
    - e. Dome-exhaust fans.
  18. Install electric-control systems or functionally equivalent pneumatic-control systems for the following:
    - a. Station ancillary-room heating, ventilating and air-conditioning systems.
    - b. Traction-power substation and tie-breaker station ventilation systems.
    - c. Subway-ventilation fans where control air is not available.
  19. Install flow sensor in designated fans as shown and adjust to open or close contacts as shown at full flow in respective directions.
- F. Remote Surveillance and Control:
1. Coordinate design with the Engineer and provide necessary interface for complete compatibility with DTS system.
  2. Coordinate with the Engineer installation of fire-alarm sensors in air units.
  3. Locate temperature-sensing transducer supervising space temperature in chilled-water plant adjacent to space thermostat.
  4. Locate passenger-station temperature-sensing transducers adjacent to platform thermostat. Coordinate locations with the Engineer.
  5. Provide shielding for sensing and signaling systems to prevent electrical interference.
  6. Install flow sensor in designated fan as shown and adjust to close contacts at full flow in respective directions.
- G. Fire-Detection Controls:
1. Coordinate enclosure interface terminal block with the Engineer.
- H. Post diagrams under Lucite with aluminum-channel frames, waterproof glass-fiber backing adjacent to apparatus control panels.

### **3.02 FIELD QUALITY CONTROL:**

- A. Acceptance Testing:
1. Furnish equipment required to perform tests.
  2. Submit test procedure for approval.
  3. Perform approved tests to verify that control surveillance systems comply with requirements shown and specified.

**END OF SECTION**

## SECTION 15950

### SYSTEM BALANCING AND TESTING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies balancing, adjusting and performance-testing of heating, exhaust, air-conditioning and ventilating systems with ductwork. Water-balancing required only for chilled-water systems.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. NEBB: Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems.
  - 2. ASHRAE III: Practices for Measurement, Testing, Adjusting and Balancing of Building HVACR Systems.
- B. Instrument Calibration:
  - 1. Calibrate instruments required for air and water balance within six months prior to use on this project.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Test and instrument location plans.
    - b. After initial balancing measurements, submit shop drawings for additional equipment such as balancing dampers, pressure taps and balancing cocks necessary to effect proper air and water balance.
  - 2. Certification:
    - a. Complete air and water-balance report certified by professional engineer licensed in the jurisdiction where the work is to be performed. Water balancing and testing includes entire system served by chiller plant in this project.
    - b. Collect data in accordance with referenced standards.
    - c. Submit complete data on standard NEBB testing and balancing report forms without omissions or on approved report forms bearing identical data. Data to include types, serial numbers and calibration dates of instruments and to cover the following:
      - 1) Air-conditioning units: Sections 15733, 15735 and 15737.
      - 2) Ventilating units: Section 15725.
      - 3) Fans: Section 15830.
      - 4) Electric heating coil: Section 15725.
      - 5) Ductwork including transverse and pilot tube test: Section 15810.
      - 6) Air outlets: Sections 15850 and 15806.
    - d. In addition, provide the following data:
      - 1) Air-conditioning supply registers for side platform stations: Three temperature and velocity traverse perpendicular to coffer wall. Traverse consists of simultaneous readings at the following locations:
        - a) Three readings five feet above platform, one each at three feet, five feet and nine feet from train edge of platform.
        - b) One reading at face of register.

- c) One reading twelve feet above edge of platform.
  - 2) Air-conditioning pylons: One temperature and velocity traverse at each air-conditioning pylon. Traverse consists of simultaneous readings at the following locations:
    - a) Twenty readings five feet above platform or mezzanine, one each at three feet, six feet, nine feet, twelve feet and fifteen feet from pylon, at each of four quadrant points around pylon.
    - b) Four readings at supply register one at each of four quadrant points.
    - c) One reading twelve feet above platform or mezzanine, three feet from pylon.
  - 3) Air-conditioning supply registers for mezzanines: One temperature and velocity traverse at centerline of each coffer mezzanine supply register. Traverse consists of simultaneous readings at the following locations:
    - a) Five readings five feet above mezzanine or escalator, one each at three feet, six feet, nine feet, twelve feet and eighteen feet from parapet or on escalator centerline.
    - b) One reading at face of register.
    - c) One reading twelve feet above mezzanine parapet at centerline of station.
- e. Water-balance test reports to include data covering the following:
  - 1) Chilled-water coils: Section 15734.
  - 2) Chillers: Section 15625.
  - 3) Cooling towers: Section 15640.
  - 4) Pumps: Section 15185.
  - 5) Control valves: Section 15900.

## **PART 2 - PRODUCTS**

- 2.01** Provide, as specified in Sections 15810 and 15205, additional equipment, such as balancing dampers, pressure taps and balancing cocks necessary to effect proper air and water balance.
- 2.02** Design, construct and install necessary blanking baffles for air-conditioning pylons.

## **PART 3 - EXECUTION**

### **3.01 BALANCING AND PERFORMANCE TESTING:**

- A. After completion of installation of heating, exhaust and air-conditioning systems, and prior to acceptance by the Engineer, adjust and balance air-handling systems, water systems and appurtenances applicable to those systems to deliver the air and water quantities as specified and as shown. Make final tests after modifications are completed. Seal instrument test holes upon completion of balancing operation.
- B. Air and Water Balance:
  - 1. Perform testing in accordance with referenced NEBB Standard, ASHRAE 111 or other approved standard.
  - 2. Perform tests, adjust and balance when outside conditions approximate design conditions as shown for heating and cooling functions.
  - 3. Balancing cock: Provide reference mark to permit reset after shutoff.

**END OF SECTION**

**DIVISION 16 - ELECTRICAL, TRACTION POWER, COMMUNICATIONS,  
& AUTOMATIC TRAIN CONTROL**

- 16051 SCOPE OF WORK FOR TRACTION POWER
- 16052 BASIC MATERIALS AND METHODS FOR TRACTION POWER
- 16053 OPERATIONS AND MAINTENANCE TRAINING FOR TRACTION POWER
- 16060 GROUNDING AND BONDING
- 16120 WIRE, CABLE AND BUSWAYS
- 16122 CONTACT RAIL CABLE CONNECTOR ASSEMBLIES FOR TRACTION POWER
- 16123 CONTACT RAIL INSULATOR ASSEMBLY FOR TRACTION POWER
- 16124 CONTACT RAIL PROTECTION COVER ASSEMBLIES FOR TRACTION POWER
- 16125 WIRE CONNECTION ACCESSORIES
- 16126 CONTACT RAIL ANCHOR ASSEMBLY FOR TRACTION POWER
- 16127 CONTACT RAIL SYSTEM INSTALLATION FOR TRACTION POWER
- 16128 WIRE AND CABLE FOR TRACTION POWER
- 16130 RACEWAYS, BOXES AND CABINETS
- 16145 WIRING AND CONTROL DEVICES
- 16220 EMERGENCY STANDBY GENERATOR SYSTEM
- 16225 MOTORS
- 16260 UNINTERRUPTIBLE POWER SYSTEM
- 16261 TRANSFORMER-RECTIFIER UNITS FOR TRACTION POWER
- 16270 TRANSFORMERS
- 16291 LOCAL ANNUNCIATOR PANEL FOR TRACTION POWER
- 16292 **DELETED** - REMOTE TERMINAL UNIT (AEMS RTU) FOR TRACTION POWER -  
Replaced by 16601(08/01)
- 16293 MIMIC PANEL FOR TRACTION POWER-STORAGE YARD
- 16294 CONTACT RAIL HEATING SYSTEM FOR TRACTION POWER
- 16320 HIGH-VOLTAGE SWITCHGEAR
- 16321 HIGH VOLTAGE A.C. SWITCHGEAR (13.8 kV) FOR TRACTION POWER

**DIVISION 16 - ELECTRICAL, TRACTION POWER, COMMUNICATIONS,  
& AUTOMATIC TRAIN CONTROL(Cont.)**

16322	HIGH VOLTAGE A.C. SWITCHGEAR (34. 5KV) FOR TRACTION POWER
16341	METAL ENCLOSED D.C. SWITCHGEAR FOR TRACTION POWER
16360	UNIT SUBSTATIONS
16425	MOTOR STARTERS AND CONTROL CENTERS
16435	LOW-VOLTAGE SWITCHGEAR AND SWITCHBOARD
16440	CIRCUIT BREAKERS, PANELBOARDS AND LOAD CENTERS
16441	DRAINAGE AND NEGATIVE SWITCHBOARD FOR TRACTION POWER
16451	SUBSTATION BUSWAY FOR TRACTION POWER
16525	LIGHTING FIXTURES AND MOUNTING POLES
16565	FLASHER AND DIMMER CONTROL SYSTEM
16601	AUTOMATED ENERGY MANAGEMENT SYSTEM (RTU & INTERFACE)
16701	DEFINITIONS OF COMMUNICATIONS SYSTEM TERMS
16702	COMMUNICATIONS ABBREVIATIONS
16703	COMMUNICATIONS STANDARD SPECIFICATIONS – ENGINEERING SERVICES
16704	COMMUNICATIONS STANDARD SPECIFICATIONS – INSTALLATION
16705	COMMUNICATIONS STANDARD SPECIFICATIONS – EQUIPMENT & MATERIAL
16706	COMMUNICATIONS SYSTEM SUBMITTALS & SERVICES
16707	COMMUNICATIONS SYSTEMS QUALITY ASSURANCE & TESTING
16708	CORRECTION OF COMMUNICATIONS SYSTEMS DEFICIENCIES
16710	COMMUNICATIONS GROUNDING
16715	COMMUNICATIONS ELECTRICAL POWER DISTRIBUTION
16721	Removed - IT is responsible
16723	Removed - IT is responsible

**DIVISION 16 - ELECTRICAL, TRACTION POWER, COMMUNICATIONS,  
& AUTOMATIC TRAIN CONTROL(Cont.)**

16727	Removed - See 16728
16728	COMMUNICATIONS - CALL FOR AID
16729	COMMUNICATIONS -PASSENGER INFORMATION DISPLAY SYSTEM
16731	Removed - See 16732
16732	COMMUNICATIONS - FIRE ALARM, DETECTION AND NOTIFICATION SYSTEM
16733	COMMUNICATIONS - KIOSK SYSTEMS
16740	COMMUNICATIONS - ELECTRONIC ACCESS CONTROL SYSTEM (NEW SECTION)
16771	Removed - IT is responsible
16776	Removed - IT is responsible
16791	COMMUNICATIONS -COMPRHENSIVE RADIO COMMUNICATION SYSTEM
16793	COMMUNICATIONS - PUBLIC SAFETY SERVICE DISTRIBUTED ANTENNA SYSTEM
16820	COMMUNICATIONS - PUBLIC ADDRESS SYSTEM
16821	Removed
16851	COMMUNICATIONS - PASSENGER STATION CLOSED-CIRCUIT TELEVISION SYSTEM (REVISED SECTION)
16852	Removed
16866	INTERFACE CRITERIA AND RESPONSIBILITIES
16852	COMMUNICATIONS - PARKING GARAGE CLOSED-CIRCUIT TELEVISION SYSTEM
16900	BASIC DEFINITIONS, CHARACTERISTICS, AND BACKGROUND INFORMATION
16901	DEFINITION OF ATC TERMS
16902	ATC ABBREVIATIONS
16903	ATC - INITIAL METRORAIL SYSTEM
16904	CURRENT AUTOMATIC TRAIN CONTROL SYSTEM
16905	ATC - TRANSIT VEHICLE CHARACTERISTICS
16906	DETERMINATION OF PAYMENT FOR ATC WORK
16910	BASIC WAYSIDE ATC REQUIREMENTS

**DIVISION 16 - ELECTRICAL, TRACTION POWER, COMMUNICATIONS,  
& AUTOMATIC TRAIN CONTROL(Cont.)**

- 16911 SCOPE OF ATC WORK
- 16912 ATC SUBMITTAL REQUIREMENTS
- 16913 ATC BLOCK DESIGN
- 16914 ATC - ENVIRONMENTAL REQUIREMENTS
- 16915 BASIC ATC EQUIPMENT REQUIREMENTS
- 16916 BASIC ATC CIRCUIT REQUIREMENTS
- 16917 BASIC INTERLOCKING REQUIREMENTS
- 16918 SPECIAL ATC REQUIREMENTS FOR SPECIFIC LOCATIONS
- 16919 ATC SYSTEM SAFETY PROGRAM
- 16920 WAYSIDE ATC SYSTEMS
- 16921 ATC POWER DISTRIBUTION SYSTEMS
- 16922 ATC - LIGHTNING/SURGE PROTECTION AND GROUNDING SYSTEMS
- 16923 ATC MAINTENANCE TELEPHONE SYSTEM
- 16924 ATC - NON-VITAL ATO & ATS PROCESSOR SYSTEMS
- 16925 ATC - DATA TRANSMISSION SYSTEM
- 16926 ATC - MICROPROCESSOR SYSTEM FOR NON-VITAL INTERLOCKING FUNCTIONS
- 16927 ATC MICROPROCESSOR SUPPORT SYSTEMS
- 16928 ATC - INTERLOCKING VITAL PROCESSOR SYSTEMS
- 16930 ATC FACILITIES AND SPARE EQUIPMENT
- 16931 ATC MAINTENANCE AND TEST FACILITIES
- 16932 SPARE ATC EQUIPMENT AND SELECTABLE ITEMS
- 16940 ATC ELECTRICAL AND ELECTRONIC COMPONENTS AND MATERIAL
- 16941 BASIC ATC ELECTRICAL AND ELECTRONIC COMPONENT REQUIREMENTS
- 16942 ATC - PRINTED CIRCUIT CARDS

- 16943 ATC - VITAL RELAYS
- 16944 ATC - NON-VITAL RELAYS AND TIMERS

**DIVISION 16 - ELECTRICAL, TRACTION POWER, COMMUNICATIONS,  
& AUTOMATIC TRAIN CONTROL(Cont.)**

- 16945 ATC - PLUGBOARDS AND CABINETS FOR RELAYS AND PC CARDS
- 16946 ATC TRANSFORMERS
- 16947 ATC - GROUND DETECTORS
- 16948 ATC - PLUG CONNECTORS
- 16949 ATC SIGNAL WIRE AND CABLE
- 16950 ATC - EQUIPMENT MODULES
- 16951 ATC - TRANSFER AND BYPASS EQUIPMENT
- 16952 ATC - DC POWER SUPPLIES
- 16953 ATC - ATP TRACK MODULES
- 16954 ATC - SWITCH AND LOCK MOVEMENTS
- 16955 ATC - TRACK AND ALARM INDICATION PANELS
- 16956 ATC - INTERLOCKING CONTROL PANELS
- 16960 ATC - EQUIPMENT LAYOUTS
- 16961 ATC - AUDIO FREQUENCY TRACK AND LOOP CIRCUIT LAYOUTS
- 16962 ATC - IMPEDANCE BOND LAYOUTS
- 16963 ATC - POWER FREQUENCY TRACK CIRCUIT LAYOUTS
- 16964 ATC - TRACK SWITCH OPERATING LAYOUTS
- 16965 ATC - SIGNAL LAYOUTS
- 16966 ATC - WAYSIDE PUSHBUTTON LAYOUTS
- 16967 ATC - MARKER COIL LAYOUTS
- 16968 ATC - TRACK BONDING LAYOUTS
- 16969 ATC - SNOWMELTER LAYOUTS

16970 ATC MECHANICAL COMPONENTS  
16971 ATC - RACKS AND CABLE TRAYS  
16972 ATC - JUNCTION BOXES  
16973 ATC - CONDUIT

**DIVISION 16 - ELECTRICAL, TRACTION POWER, COMMUNICATIONS,  
& AUTOMATIC TRAIN CONTROL(Cont.)**

16974 ATC - LOCKS AND KEYS  
16975 ATC - FOUNDATIONS  
16976 ATC - WAYSIDE SIGNS  
16977 ATC - TAGGING AND MARKING  
16978 ATC - MISCELLANEOUS COMPONENTS AND MATERIALS  
16979 ATC - SURFACE TRENCH  
16980 ATC TESTS, INSPECTIONS AND QUALITY ASSURANCE  
16981 BASIC ATC TEST AND INSPECTION REQUIREMENTS  
16982 ATC - PRELIMINARY AND INTERLOCKING TESTS (LEVEL A)  
16983 ATC - TRAIN SEPARATION TESTS (LEVEL B)  
16984 ATC - ATO AND LOCAL ATS TESTS (LEVEL C)  
16985 ATC - DTS INTERFACE TESTS (LEVEL D)  
16986 ATC - MISCELLANEOUS TESTS (LEVEL E)  
16987 ATC - SYSTEM LEVEL TESTS (LEVEL F)  
16988 ATC QUALITY ASSURANCE  
16990 ATC DOCUMENTATION AND TRAINING, AND SPECIAL ATC APPENDICES  
16991 ATC DRAWINGS AND TRACINGS  
16992 ATC INSTRUCTION MANUALS  
16993 ATC TRAINING COURSES  
16994 ATC APPENDIX "C" INDEX OF ATC DRAWINGS  
16995 ATC APPENDIX "L" ATC DESIGN, SUBMITTAL, ACCESS, ENERGIZATION AND  
COMPLETION SCHEDULE

16996 ATC APPENDIX "TA" ATC TECHNICAL APPENDIX  
16997 ATC APPENDIX "SS" RTU SCAN SHEETS  
16998 ATC APPENDIX "CD" CORRECTION OF ATC DEFICIENCIES

**END OF SECTION**

## SECTION 16051

### SCOPE OF WORK FOR TRACTION POWER

#### PART 1. GENERAL

##### 1.01 SUMMARY

- A. The scope includes all work required to furnish, install, connect, test and energize traction power equipment and appurtenances to ensure safe, complete, workable and operational traction power substation and tie breaker station in facilities of the WMATA Metro Rail System, including furnishing and installation of ancillary material as required.
- B. The work shall include furnishing, installing, connecting, energizing and testing of all materials, equipment, labor, transportation and handling, construction equipment, tools and all other incidentals necessary for the execution, testing, connection, interconnection and energizing of the following
  - 1. Equipment:
    - a. General: The Contractor shall install all required equipment. The work shall be in accordance with the drawings and specifications included in this contract and comply with the "Information Drawings" and equipment vendor drawings.
    - b. When permanent power has not been provided in the traction power substations and tie breaker stations, the Contractor shall provide the necessary temporary power for his work. The Contractor shall protect the equipment. In equipment such as switchgear and bus ducts in which there are internal space heaters, the space heaters shall be kept energized. If permanent power for the space heaters is not available, the Contractor shall provide the necessary temporary power.
  - 2. Equipment, Material and Work Included in this Contract Specification:
    - a. The Contractor shall furnish, install and test all material specified elsewhere in this specification including, but not limited to, the following:
      - 1) High voltage A.C. switchgear 13.8kv, or 34.5kv.
      - 2) Transformer-Rectifier units.
      - 3) Metal-Enclosed DC Switchgear.
      - 4) Drainage and negative switchboard.
      - 5) Substation busways.
      - 6) Local annunciator panel.
      - 7) Wire and Cable.
      - 8) Uninterruptible Power System (UPS).
      - 9) Contact-rail heating system.
      - 10) Remote terminal unit (AEMS RTU) including connection from AC and DC switchgear transducers and AEMS interface panels as shown.
      - 11) Miscellaneous materials including conduit, cable tray, support hardware, DTS and ETS cabinet, ETS lights, ETS enclosures, and wiring system, subfloor pouring/finishing, floor finishing and insulating topping, panelboards, grounding, etc., as shown and specified in Section 16052.
      - 12) Grounding and bonding as shown and specified.
      - 13) Cutting, patching and core drilling: The Contractor shall provide wall and floor openings or enlarge openings as required to accommodate bus duct, cable tray or conduit furnished. All unused conduit, sleeves, openings around bus ducts, cable trays etc. shall be sealed using fireproof material to meet occupancy jurisdictional codes for the room.

- 14) Fabrication of plastic sheets to close sections around bus duct passing through floor opening.
- 15) Assembly of equipment: switchgear shipping sections shall be assembled for proper alignment, leveling, and bonding of adjacent sections. Electrical connections between shipping breaks shall be made according to manufacturer's shop drawings.
- 16) Training program as specified in section 16053.
- 17) Removal of temporary 480v service (if used) including disposal of miscellaneous material such as pole, wire, meter, etc. connection of auxiliary transformer secondary to switchboard and other miscellaneous work shown.
- 18) Removal and disposal of all excess material from jobsite as directed by the Engineer.
- 19) Mimic Panel: storage Yard.
- 20) Power Company interface: Incoming cable, cable terminators, metering CTs/PTs and metering panels are furnished by the power company. The Contractor shall install this equipment as specified or directed by the power company at no additional cost to the Authority. When required by the power company, the Contractor shall fabricate and install a galvanized steel sheet enclosure to protect the incoming high voltage service cables at no cost to the Authority. The enclosure shall be fabricated from 12-gauge galvanized steel sheet with adequate structuring bracing and installed around the stubout up to a height of 6 feet. A detail shall be prepared and submitted through the Engineer for approval.

C. Related Sections

1. Section 16052 - Basic Materials and Methods For Traction Power.
2. Section 16053 - Operation and Maintenance Training.
3. Section 16128 - Wire and Cable For Traction Power.
4. Section 16261 - Transformer-Rectifier Units For Traction Power.
5. Section 16262 - Uninterruptible Power System For Traction Power.
6. Section 16291 - Local Annunciator Panel For Traction Power.
7. Section 16292 - Remote Terminal Unit (AEMS RTU) For Traction Power.
8. Section 16293 - Mimic Panel For Storage Yard.
9. Section 16294 - Contact Rail Heating System For Traction Power.
10. Section 16321 - High Voltage AC Switchgear (13.8kv) For Traction Power.
11. Section 16322 - High Voltage AC Switchgear (34.5kV) For Traction Power.
12. Section 16441 - Drainage and Negative Switchboard
13. Section 16451 - Substation Busways For Traction Power.

D. Payment and Measurement Basis

1. Compensation for work specified in this section will be made in accordance with the Unit Price Schedule.
  - a. Material and Equipment furnished/installed in this contract: As specified in appropriate sections of this specification.
  - b. Installation, testing and energizing : Included in the Lump Sum installation cost for each traction power substation and tie-breaker station.
  - c. Support during testing.
    - 1) Material: Lump-sum
    - 2) Labor: Lump-sum

## 1.02 REFERENCES

- A. Codes, regulation, reference standards and specifications.
1. Codes and regulation jurisdictional authorities.
  2. NEC

3. IEEE: 141,242
4. ANSI: C57.94,C57.93,C57.06
5. ASTM: D877

### 1.03 SYSTEM DESCRIPTION

- A. The work to be performed under this Contract includes the furnishing and delivering to the job site of 13.8 KV and 34.5 KV ac switchgear, 700 Volt dc output transformer-rectifier units, metal-enclosed dc switchgear assemblies, dc negative switchboards, ac and dc busducts, annunciators and other auxiliary equipment for the traction substations and tie breaker stations on the WMATA system. The equipment shall be delivered as completely engineered, fabricated, assembled units, inspected and tested ready for installation and connection to external circuits.
- B. The equipment shall be designed and fabricated for connection per general arrangement shown on the Contract Drawings. The arrangements shall result in minimum space requirements for the substations and tie breaker stations, adequate clearances and accessibility and suitability of arrangement with other equipment. Components, design and construction shall be chosen to provide a pleasing and homogeneous appearance. Units shall be as low in profile as possible. Units of the same type and rating shall be identical and interchangeable
- C. The Contractor shall be responsible for providing all required support from equipment manufacturers during field-assembly, installation, testing and start-up of each traction power facility. This effort will include, but not be limited to, the following:
  1. Provide shop-drawings and test-plans.
  2. Provide manufacturer's field-engineering assistance during installation, field-testing and initial energizing. The services of qualified manufacturer's engineering representative shall be made available in phases, during the entire life of the installation contract.
  3. Provide services of manufacturer's engineering representative during initial energization for verification of all equipment functions during train operation.
  4. Make all changes on the equipment which may result from manufacturing discrepancies noted during equipment installation at no additional cost to the Authority.
  5. Manufacturer's engineering representative shall be provided during Operation and Maintenance Training specified in Section 16053. The exact schedule and location shall be coordinated with the Authority and the Contractor.

### 1.04 SUBMITTALS

- A. Submit the following for approval in accordance with Special Conditions and with the additional requirements as specified for each:
  1. Shop drawings:
    - a. Arrangement Drawings: The contractor shall submit equipment arrangement drawings within 25 days after Notice-to-Proceed for all substations and tie breaker stations. Contractor's equipment shall be designed to fit within the building dimensions and with the minimum clearances shown on the Contract Drawings. The Authority reserves the right to require different arrangements than proposed, provided such changes do not add material or equipment in excess of that covered by the Contract.
    - b. Within 40 days after receipt of NTP, submit a schedule of all shop drawing submittal. Include in the schedule, as a minimum, all items listed in Table 16051-II.
    - c. For equipment furnished in this contract, provide complete shop drawings and documentation as specified elsewhere in this specification.
    - d. Update equipment interconnection wiring diagrams provided by equipment

- manufacturers to include panelboard circuit designations for control power, connections to ETS and DTS cabinets, connections to annunciator from UPS, battery, control and interlock wiring between equipment, etc. Develop and submit composite interconnection diagrams showing terminal blocks, cable type, size and routing, appropriate cross-reference at both ends of cable termination, to the Engineer for approval.
- e. Submit a complete drawing index for each substation and tie-breaker station.
  - f. Submit five (5) sets of shop drawings and relay settings for [13.8 kV], [34.5 KV] ac Switchgear including elementary and interconnection wiring diagrams to the Engineer for Power Company coordination and approval.
  - g. In addition submit to the Engineer five (5) sets of shop drawings for complete substation and Tie Breaker Station equipment, including bus duct, control cable tray, elementary wiring and interconnection diagrams for approval.
2. Documentation:
    - a. Submit short circuit calculations and protective relay coordination study for system protection and selective overcurrent tripping within 150 days of NTP. Submit relay coordination study to the engineer for power company approval.
      - 1) In accordance with IEEE 141 and IEEE 242 for fault calculations and coordinated system protection.
      - 2) Include high-voltage source, relays on high voltage switchgear, transformer-rectifier units and dc switchgear.
      - 3) Available short-circuit currents based on power company contribution 750 MVA for 13.8 KV service and 1500 MVA for 34.5 KV service.
      - 4) Recommended settings and adjustment of protective devices
    - b. Field test plan and documentation:
      - 1) Submit field test plan 60 days prior to testing of equipment, with accompanying documentation in the form of test data recording sheets and list of proposed test equipment for approval by the Engineer.
      - 2) The approved test plan will be used for field-testing after installation is completed.
      - 3) Indicate in scope of test plan how equipment will be tested to ensure safe and orderly transition from installation, through initial energizing, to specified field testing.
      - 4) Accompanying documentation to include standard data recording sheets as used in manufacturer's in-plant testing of equipment and devices or as used by major utilities or large industrial users of specified equipment.
      - 5) Submit certified copies of test data, indexed by facility within ten days after completion of testing.
        - a) Include oscillograph recordings of currents with dc switchgear protective device characteristics superimposed in the test reports.
        - b) Verify schematic diagrams for interconnecting wiring, device labeling and proper operation.
        - c) Submit one complete set of certified schematics at time of initial energizing of equipment.
  3. Operation and Maintenance Manuals: In accordance with Special Conditions; include final relay and trip device settings.

## 1.05 QUALITY ASSURANCE

- A. Qualifications: Select manufacturer (s) /contractor (s) who are regular engaged in

production/ installation of similar equipment and have demonstrated a successful record of providing/installing equipment of equal type and rating for extra heavy duty traction service for at least five similar projects.

- B. For codes, regulations, reference, standards and specifications, refer to article 1.02 above.

## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver and handle equipment as specified on contract documents.
- B. Store all equipment in secure and dry storage facility before installation at no additional cost to the Authority.

## **PART 2 PRODUCTS**

### **2.01 EQUIPMENT**

- A. As specified in other sections of these specifications.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Provide oversight and supervision to ensure that all equipment are installed in accordance with manufacturers' recommendation and approved shop drawings.
- B. Install equipment as shown and specified in other sections of this specification.
- C. Manufacturer's Engineering Representative:
  - 1. Arrange for assistance of manufacturer's engineering representative during field assembly, installation and adjustment/calibration of equipment being furnished under this contract.
  - 2. Initial energizing of the tracks and each station to be under guidance of manufacturer's engineering representative who will advise Authority personnel on step-by-step procedure.
  - 3. Energizing of each station shall be the Contractor's responsibility with guidance from equipment manufacturer's engineering representative.

### **3.02 FIELD QUALITY CONTROL**

- A. Field Testing and Inspection:
  - 1. General requirements:
    - a. Conduct field testing and inspection at each station to ensure proper operation of equipment provided.
    - b. Correct any deficiencies found during field testing and retest at no additional cost to the Authority.
    - c. Relays and trip device setting: Set protective relays and trip devices in accordance with approved coordination study and their calibration for proper operation during field testing.
      - 1) Initial operation is expected to be six-car trains at two-minute headway; vehicles are being designed so that each six-car train when accelerating will draw a peak current of 9,675 amperes for approximately 17 seconds. Future operation is expected to be eight-car trains at two-minute headway; each eight-car train, when accelerating will draw a peak current of 12,900 amperes for

approximately 17 seconds.

2. Field Inspection

- a. Prior to field testing, check equipment installation in accordance with manufacturer's recommendations and IEEE 141 as applicable including, but not limited to, verification of the following:
- 1) Integrity of bus insulation.
  - 2) Tightness of connections.
  - 3) Adequate support of bus bars.
  - 4) Correct grounding, anchoring and alignment of switchgear in accordance with manufacturer's drawings. Correct insulation of rectifier and dc switchgear from ground.
  - 5) Ease of racking draw out breakers in and out of cubicle
  - 6) Physical interchangeability of similar circuit breakers.
  - 7) Adjustment of circuit breaker main and secondary contacts.
  - 8) Functioning of interlock and closing of safety shutter with breaker in disconnect or withdrawn position.
  - 9) Verify mechanical clearances and proper operation of disconnecting and grounding devices associated with potential transformers.
  - 10) Tightness of bolted bus joints by calibrated-torque-wrench method, based on manufacturer's recommended values.
  - 11) Verify proper mounting and capacitive coupling of neon glow tube in A.C. switchgear for proper indication upon energization, make adjustment as required.

3. Field Testing:

- a. The Contractor shall coordinate with the Engineer to establish the specific testing schedule for each facility. Notify the Engineer one week in advance of each test. Conduct test in presence of engineer.
- b. Furnish test equipment, labor and services of manufacturers' engineering representative to perform specified tests.
- c. Submit certified test reports within ten days of substantial completion inspection. For each item, submit for approval and perform approved tests but not limited to those specified.
- d. Perform insulation resistance test of 60-second duration on all equipment in accordance with the following requirements:.
- e. Test voltage:
- |    |                       |                     |
|----|-----------------------|---------------------|
| 1) | <u>Voltage Rating</u> | <u>Test Voltage</u> |
| a) | 150-600V              | 1,000V, dc          |
| b) | 601-5,000V            | 2,500V, dc          |
| c) | Above 5,000V          | 5,000V, dc          |
- 2) Insulation resistance: kV rating plus one megohm but not less than minimum value recommended by manufacturer.
- 3) Ensure insulation resistance is equal to or greater than minimum value specified before performing dielectric withstand test.
- f. Perform functional and set-up tests on metering, control, interlocking, blocking and supervisory circuits, including verification of interconnections between equipment and interface points. Verification of these tests to be substantiated by lined-in schematics, signed by the Contractor and the Engineer.
- g. For high-voltage ac switchgear:
- 1) Perform insulation resistance test between phase-to-phase and phase-to-ground.
  - 2) Test grounding conductors and enclosures for continuity to station ground bus.
  - 3) Test protective relays and trip devices in accordance with IEEE 141 procedures, modified as necessary, for compliance with approved coordination study.

- 4) Test operation of each circuit and control in accordance with approved sequence.
  - 5) Test interlock system as follows:
    - a) Make closure attempt on locked open devices.
    - b) Make opening attempt on locked closed devices.
  - 6) Dielectric withstand tests: Perform dielectric withstand test of 60-second duration on entire assembled and erected switchgear lineup using 60 Hertz voltage level as specified. During this test, electronic equipment may be isolated from the circuit. Perform tests in accordance with reference standards as follows:
    - a) 13.8 KV switchgear: 27,000 volts rms.
    - b) 34.5 KV switchgear: 60,000 volts rms.
    - c) Control wiring: 1,500 volts rms.
  - 7) Test current transformer circuits for polarity, ratio and protective device operation by primary injection method.
  - 8) Test potential transformer ratio and polarity.
- h. Rectifier Transformer:
- 1) Perform insulation resistance test between winding-to-winding and winding-to-ground. Correct resistance value to temperature.
  - 2) Perform ac high-voltage test between high-voltage winding and ground and low-voltage winding and ground. Perform test at 75 percent of factory test voltage for 60-second duration.
  - 3) Test voltage ratio for full winding and taps. Test result not to deviate more than 0.5 percent from calculated ratio. Set transformer tap as necessary.
  - 4) Check polarity or phase relation.
  - 5) Check contacts of dial-type thermometer for indicating normal and over temperature condition of transformers at remote location and to initiate tripping of associated rectifier-transformer feeder breaker under abnormal temperature conditions. Set thermometer contacts as recommended by manufacturer.
  - 6) Test all alarm indications and protective devices for proper operation.
  - 7) Transformer for outdoor use (oil-filled type) :
    - a) Inspect transformer for oil leaks.
    - b) Test samples of insulating liquid from top and bottom of tank.
    - c) Test dielectric strength in accordance with ANSI C57.12 to verify the minimum breakdown voltage is not less than 34kV for 13.8kV service and 70 kV for 34.5kV service.
- i. Silicon Rectifier
- 1) Perform insulation resistance test between phase to phase and phase to ground.
  - 2) Check contacts of 1st stage rectifier overtemperature device to initiate alarm upon excessive temperature increase. Make temperature settings as recommended by the manufacturer.
  - 3) Check contacts of 2nd stage rectifier overtemperature condition (higher than the 1st stage), to initiate alarm and tripping of rectifier transformer ac circuit breaker and the rectifier cathode breaker via lock-out relay. Make temperature settings as recommended by the manufacturer.
  - 4) Check contacts of diode failure device for alarm initiation with the loss of one diode and tripping of ac rectifier-transformer feeder circuit breaker and rectifier cathode breaker via lock-out relay with second diode failure.
  - 5) Check the operation of enclosure ground detection system to initiate alarm for grounding of the metal enclosure and to initiate

- alarm and tripping of cathode circuit breaker, rectifier-transformer feeder ac circuit breaker and rectifier transformer lockout relay under structure energized condition.
- 6) Check the operation of door interlock to trip and prevent closing of the rectifier-transformer feeder breaker and cathode breaker when the enclosure door is open.
  - 7) Test rectifier enclosure insulation to demonstrate proper enclosure insulation from ground. Test at 2500 volts, 60 Hertz from enclosure to ground for a duration of one minute, with the enclosure ground detection relaying disconnected.
- j. Substation busways: AC busducts, positive dc busducts and negative dc busducts.
- 1) Test resistance of all busway connections. Resistance not to exceed value recommended by manufacturer.
  - 2) Test insulation resistance from bus bars to ground and between insulated busbar.
  - 3) Perform dielectric withstand test of one minute duration at 75 percent of specified factory test value.
  - 4) Test cathode bus duct enclosure insulation to demonstrate proper enclosure insulation from rectifier, dc switchgear and ground. Test at 2500 volts, 60 Hertz from enclosure to ground for a duration of one minute. Remove bonding jumper between bus duct enclosure and rectifier or switchgear during test.
- k. Metal-enclosed dc switchgear:
- 1) Test protective devices/relays in accordance with IEEE 141 procedures, modified as necessary, for compliance with approved coordination study.
  - 2) Test operation of each circuit and control in accordance with approved sequence.
  - 3) Test interlock system as follows:
    - a) Make closure attempt on locked-open devices.
    - b) make opening attempt on locked-closed devices.
  - 4) Perform dielectric withstand test of one minute duration on entire assembled and erected switchgear. Test at a voltage of 2775 volts, rms, 60 Hertz or 3900 volts dc on live parts and 1500 volts, rms, 60 Hertz on control wiring. Isolate all electronic timers and devices during the test.
- l. Test switchgear enclosure insulation to demonstrate proper enclosure insulation from ground. Test at 2500 volts, 60 Hertz from enclosure to ground for a duration of one minute. Disconnect enclosure ground detection relaying during the test.
- m. Short-Circuit Test on DC Bus: At each substation, perform a short-circuit test to insure capability of transformer-rectifier units to withstand a bolted fault at the dc switchgear bus and to verify coordination of cathode circuit breaker and ac circuit breakers in ac switchgear. Test with all ac circuit breakers closed except ac bus tie breaker, all dc cathode circuit breakers closed and all dc feeder circuit breakers connected and open. Apply a bolted fault to the dc switchgear at the line terminals of one dc feeder circuit breaker. Record current at each affected breaker with an oscillograph.
- n. Short-Circuit on DC Feeder:
- 1) Perform short-circuit tests in the vicinity of [location - TBD] substations to ensure capability of dc feeder breaker to trip and interrupt a close-in fault under maximum short-circuit conditions and to coordinate with cathode breaker forward trip. Apply a bolted fault at the tracks in the immediate vicinity of the substation between inbound contact rail and a running rail. Demonstrate that the instantaneous trip element of the feeder breaker nearest to the

fault in the substation initiate breaker tripping and rate of rise relay associated with the remote feeder breaker in the tie breaker station initiate breaker tripping and the cathode breaker and AC breakers and the other DC feeder breaker does not trip improperly. Test with all rectifiers in operation and all interconnecting dc feeder breakers closed. As part of the test, record the trip device which operates affected dc feeder breakers. Record current at each affected breaker with an oscillograph.

- a) Provide any additional relays, other than those shown on the one line diagram, which are considered to be necessary to achieve the above protective relaying coordination.
  - 2) Remote Short-Circuit on Feeder: Perform a remote short-circuit test on the remote end of the same section of inbound contact rail midway between Substations, but located as specified. Demonstrate capability to detect and clear a remote fault with settings made on the protective relays, that only the two feeder breakers (one in the substation and one in the tie breaker station) nearest to the faulted section of contact rail trip and that the cathode breaker, and ac breakers and other dc feeder breakers do not trip. Demonstrate that the feeder breakers at the adjacent substations or tie breakers stations do not trip. As part of the test, record the trip device which operates affected dc feeder breakers. Record current at each affected breaker with an oscillograph.
  - 3) Automatic Recloser Field Tests: Test the automatic recloser system for both the near short-circuit test for the remote short-circuit test for on dc feeder and for proper operation under both short-circuit conditions and normal operating conditions.
  - 4) station prior to short-circuit test on dc feeder, remote short-circuit test on dc feeder and automatic recloser field test. Test with two twelve-car trains, without passengers one inbound and one outbound, starting at the passenger station simultaneously. Demonstrate relays and trip devices, as set, do not respond improperly to train starting. Demonstrate that the relay and trip settings required to meet the required short circuit test will not respond improperly when starting a twelve-car train at a passenger station close to a substation. Record current at each affected feeder breaker with an oscillograph.
  - o. Reverse Current Test on Cathode Breaker: Perform a primary current injection test on a cathode breaker to verify proper operation of reverse current protection.
  - p. Test ETS system for proper operation in conjunction with Installation Contractor.
  - q. Graph/record harmonic noise and content of harmonic current on feeder cables and on surrounding ATC equipment. Meet utility and manufacturer standards.
- B. Field Testing Personnel:
1. Provide services of qualified engineering representatives of the equipment manufacturers to conduct specified field testing program.
  2. When more than one representative is involved, the Contractor is responsible for coordination of testing effort.
- C. The short circuit tests shall be planned for minimum interference with Authority's train testing or other track use, and shall be totally accomplished, including all instrumentation and removal, in a total period of three (3) days or less per facility. The actual period shall be coordinated with and established by the Authority.

- D. Authority Tests:
  - 1. The Authority reserves the right to require the Contractor to conduct acceptance tests of voltage regulation and sound level on each transformer-rectifier unit at each substation and a train start test at each passenger station within one year after installation.
  - 2. In order to perform sound level test, the Contractor may recreate test conditions of applicable standards to the extent possible without disturbing existing structure or installed equipment and materials.
- E. Submit five (5) copies of certified test reports within 10 days of Substantial Completion (SCI) for each station.

TABLE 16051-I

SCHEDULE OF SHOP DRAWING REQUIREMENTS

<u>Item</u>	<u>Description</u>	<u>To Be Furnished Within Calendar Days</u>
A	Outline dimensions, including weights and foundation requirements for all equipment furnished	60 after Award
B	Front views, floor plans, and mounting details for all equipment furnished	60 after Award
C	One line diagrams	90 after Award
D	List of standard symbols and nomenclature	90 after Award
E	Elementary and control schematic diagrams and description of operation	90 after Award
F	Interconnection wiring diagrams	120 after Award
G	Wiring diagrams, showing internal wiring of all equipment furnished	120 after Award
H	Wiring diagram, showing interconnection between shipping breaks	120 after Award
I	Cross sections showing internal construction of equipment	60 after Award
J	Physical details of 13.8kV or 34.5 kV connections to transformers	90 after Award
K	Physical details of all ac and both dc positive and negative busducts and bus connections	60 after Award
L	Certified Design and Field Test Reports	10 after Test Completion
M	Rectifier Transformer Data, including: 1. Excitation Current 2. Impedance, percent based on rated kVA 3. Reactance, percent based on rated kVA 4. Resistance, percent based on rated kVA 5. Weights: Core and coils Tank and fittings Insulating oil Total	60 after Award
N	Rectifier Data, including: 1. Diode Ratings: Voltage, Peak Reverse Voltage, Current, Temperature Limit 2. Arrangement of Components	45 after Award

TABLE 16051-I (Continued)

SCHEDULE OF SHOP DRAWING REQUIREMENTS

<u>Item</u>	<u>Description</u>	<u>To Be Furnished Within Calendar Days</u>
O	Dc Switchgear Data, including: 1. Duty cycles before required maintenance: No-load Full-load Rated fault current interruptions 2. Weight of circuit breaker only 3. Certified Design Test Reports	45 after Award
P	AC Switchgear Data, including: 1. Duty cycles before required maintenance: No-load Full-load Rated fault current interruptions 2. Weight of circuit breaker only 3. Certified Design Test Reports	45 after Award
Q	Annunciator Panel	45 after Award
R	Control Power Data for each substation including: 1. Continuous 125-Volt dc load 2. Continuous 115-Volt ac load 3. Closing and Tripping loads of: a. 700-Volt dc circuit breakers, for each rating b. 13.8kV or 34.5 kV circuit breakers	60 after Award
S	Technical Description of Equipment Operation, Control and Protective Functions	90 after Award
T	Bill of Material, with reference to all components indicating part numbers and manufacturer name	90 after Award
U	Equipment Arrangement Drawing; Plan and Elevation for each substation and tie breaker station including busduct sizes and elevation and cable tray plan and elevation for space coordination purposes.	30 after Award
AA	Wire and Cable.	45 after NTP.
BB	Uninterruptible power system.	In accordance with table 16261-1.
CC	Basic materials and methods: Cable trays and mounting details, DTS	45 after NTP.

TABLE 16051-I (Continued)

<u>Item</u>	<u>SCHEDULE OF SHOP DRAWING REQUIREMENTS</u> <u>Description</u>	<u>To Be Furnished</u> <u>Within Calendar Days</u>
	cabinet, ETS enclosures, ETS relay cabinet, ETS system schematic diagram, ETS light fixture and remote ballast, Panelboard, steel panels, glastic barrier/firestop.	
DD	Remote terminal unit, including schematic diagram, connection diagram, layout drawing of control wiring and Internal component, enclosure details.	60 after NTP.
EE	Certified factory test reports.	30 after test completion.
FF	Certificates from manufacturers verifying that products conform to specified requirements.	45 after NTP.
GG	Manufacturers' catalog cuts and literature.	45 after NTP.

SPECIFIER'S NOTE:      NUMBER OF CALENDAR DAYS IS FOR INFORMATION ONLY. SPECIFIER TO COORDINATE NUMBER OF DAYS WITH SPECIAL CONDITIONS.

TABLE 16051-II

SUPERVISORY CONTROL IDENTIFICATION NUMBERS

Location - TDB Substation

<u>DC Switchgear</u>	<u>Supervisory Control Identification No.</u>	<u>DC Switchgear</u>	<u>Supervisory Control Identification No.</u>
Cathode Bkr. No. 1	E-F09-21	Inc. Line No. 1	E-F09-01
Cathode Bkr. No. 2	E-F09-22	Inc. Line No. 2	E-F09-02
Cathode Bkr. No. 3	E-F09-23	Bus Tie	E-F09-03
Feeder No. 1	E-F09-31	Rect. Fdr. No. 1	E-F09-11
Feeder No. 2	E-F09-32	Rect. Fdr. No. 2	E-F09-12
Feeder No. 3	E-F09-33	Rect. Fdr. No. 3	E-F09-13
Feeder No. 4	E-F09-34		
Feeder No. 5	E-F09-35		
Feeder No. 6	E-F09-36		

Location TBD Tie Breaker Station

<u>DC Switchgear</u>	<u>Supervisory Control Identification No.</u>
Tie Breaker No. 1	E-F09-41
Tie Breaker No. 2	E-F09-42
Tie Breaker No. 3	E-F09-43
Tie Breaker No. 4	E-F09-44
Tie Breaker No. 5	E-F09-45
Tie Breaker No. 6	E-F09-46

SPECIFIER'S NOTE: THE IDENTIFICATION NO.'S SHOWN ARE FOR INFORMATION ONLY. OBTAIN THE IDENTIFICATION NO.'S FROM THE AUTHORITY,

## TPS EQUIPMENT TABULATION

### No. of Units AC Switchgear

<u>Name of Substation</u>	Location - TBD
Transformer Location	Outdoor or Indoor
Transformer Rectifier kW	3-3,000
Incoming <u>Lines</u>	2
Rectifier Transformer <u>Feeders</u>	3
Bus <u>Ties</u>	1
Auxiliary Units	2
<u>Name of Substation</u>	Location - TBD
Ac Bus Duct Rating Amperes	3-6,000
Cathode Bus Duct Rating <u>Amperes</u>	3-8,000
Dc Cathode Breakers <u>Amperes</u>	3-8,000
Dc Switchgear Bus Rating Amperes	15,000
No. of Dc Feeder Breakers (Note 1) <u>4,000 Amperes</u>	4 (Note 2)
No. of Dc Feeder Breakers (Note 1) <u>6,000 Amperes</u>	2
<u>Name of Substation</u>	Location - TBD ]
Negative Bus Duct Rating Amperes	3-8,000
Negative Switchboard Bus Rating <u>Amperes</u>	15,000
Negative Disconnect Switches/ <u>Rating</u> <u>(A)</u>	4/4000
Negative Return 1000 KCMIL <u>Cable</u> <u>Connectors</u>	24
Drainage <u>Circuit</u>	6
Name of Location	[ Location - TBD ]
<u>ANNUNCIATOR PANEL</u>	1

Note 1 - All dc feeder breakers shall have terminals for eight (8) 1000 KC MIL feeder cables.

Note 2 - Two acceleration/deceleration gap feeder breakers do not require rate-of-rise trip devices (Device 150).

**EQUIPMENT TABULATION**

**ADDITIONAL CIRCUIT BREAKER REMOVABLE ELEMENTS**

<u>Description</u>	<u>Quantity</u>	<u>To be Located at TPS</u>
15 Kv ac, 1200 amperes breaker	1	Location - TBD
750V dc, 8,000 ampere cathode breaker	1	Location - TBD
750V dc, 4,000 ampere feeder breaker	1	Location - TBD

**TIE BREAKER STATION EQUIPMENT TABULATION**

Name of Tie Breaker Station	Location - TBD
DC Switchgear Bus Rating, Amperes	8,000
DC Feeder Breakers 4000 Amperes (Note 1)	6 (Note 2 and 3)
DC Positive Bus Tie Breaker 6,000 Amperes	1
DC Negative Bus Tie Breaker 6,000 Amperes	1
Annunciator Panel	1

- Note 1 - Each 4000A dc feeder breaker shall have terminals for seven (7) 1000 KCMIL feeder cables.  
Note 2 - Two acceleration/deceleration gap feeder breakers do not require rate-of-rise trip devices (Device 150).  
Note 3 - Tie breaker station feeder for a short rail section at an acceleration sectionalizing gap shall have terminals for five (5) 1000kcmil feeder cables.

SPECIFIER'S NOTE: QUANTITIES AND RATINGS SHOWN IN COLUMNS IS FOR INFORMATION ONLY. SPECIFIER SHALL PROVIDE QUANTITIES AND RATINGS TO SUIT THE TIE BREAKER STATION EQUIPMENT.

**EQUIPMENT TABULATION**

**ADDITIONAL CIRCUIT BREAKER REMOVABLE ELEMENTS**

<u>Description</u>	<u>Quantity</u>	<u>To be Located at TPS</u>
750 dc, 6,000 ampere feeder breaker	1	Location - TBD
15 kV ac, 1200 ampere, Ground, Phasing & Testing Device	1	Location - TBD

**MISCELLANEOUS EQUIPMENT ITEMS TO BE INSTALLED**

AC CD TEST CABINET	1	-ONE AT EACH TPS
DC CB TEST CABINET	1	ONE AT EACH TPS/TBS

END OF SECTION

## SECTION 16052

### BASIC MATERIALS AND METHODS FOR TRACTION POWER

#### PART 1. GENERAL

##### 1.01 SUMMARY

- A. The scope includes furnishing and installing basic materials.
- B. Related Sections:
  - 1. Section 16051 - Scope of Work For Traction Power
  - 2. Section 16128 - Wire and Cable For Traction Power
  - 3. Section 16260 - Uninterruptible Power System (Static)
  - 4. Section 16261 - Transformer-Rectifier Units For Traction Power
  - 5. Section 16291 - Local Annunciator Panel For Traction Power
  - 6. Section 16292 - Remote Terminal Unit (AEMS RTU) For Traction Power
  - 7. Section 16293 - Mimic Panel-Storage Yard
  - 8. Section 16294 - Contact Rail Heating System For Traction Power
  - 9. Section 16321 - High Voltage AC Switchgear (13.8KV) For Traction Power
  - 10. Section 16322 - High Voltage AC Switchgear (34.5KV) For Traction Power
  - 11. Section 16341 - Metal-Enclosed DC Switchgear For Traction Power
  - 12. Section 16441 - Drainage and Negative Switchboard
  - 13. Section 16451 - Substation Busway For Traction Power
- C. Compensation for work specified in this section will be made in the following manner:
  - 1. Basic Materials: Lump Sum.
  - 2. Installation: Lump Sum.

##### 1.02 REFERENCES

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Codes and regulations of jurisdictional authorities
  - 2. NEC
  - 3. UL: 6, 50, 67, 94, 198D, 224, 360, 486, 489, 496, 508, 514, 651, 870, 1029, 1572
  - 4. ASTM: A36, A47, A123, A153, A325, A386, A500, A507, A523, A525, A532, A536, B138, B187, B633, D149, D150, D257, D412, D495, D570, D638, D648, D696, D790, D792, D1000, D1056, D1518, D1682, D1784, D2240, D2583, E84, F593, F594, G21, G235
  - 5. ANSI: C80.1, C80.5, Z55.1, A14.1, B18.21.1, C119.1
  - 6. NEMA: VE1, AB1, PB1, CC1, ST-20, FG-1, 250
  - 7. FS: TT-S-227, FF-S-760, FF-S-325,
  - 8. ACI: 318
  - 9. MS: MIL-I-23053/15

##### 1.03 SUBMITTALS

- A. Submit the following for review in accordance with the instructions elsewhere in this Specification and with the additional requirements as specified for each:
  - 1. Shop Drawings: Shop drawings for cable trays and mounting details, DTS Cabinet, complete ETS Enclosure including all devices and components, ETS light fixture and remote ballast, ETS relay cabinet, panelboards, fiberglass panels, glastic material and through floor barrier/firestop.

2. Submit shop drawings for incoming service cable tray to the Engineer for approval by PEPCO and Virginia Power.
3. Certification: Certificates from manufacturers verifying that equipment furnished conforms to the specified requirements.
4. Product Data: Manufacturer's product data for all materials.
5. Samples: ETS enclosure and light fixture, one of each size nameplate, tags, wire labels, contact rail cable connector assembly, glastic material and danger markers.

#### **1.04 QUALITY ASSURANCE**

- A. Qualifications: Select manufacturers who are regularly engaged in production of specified materials. Select installation contractors who are regularly engaged in the installation of specified materials.
- B. For Codes, Regulations, Reference Standards and Specifications, refer to Article 1.02 above.

#### **1.05 DELIVERY, STORAGE, AND HANDLING**

- A. Mark each item in accordance with applicable reference standard.
- B. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage.
- C. Store products in secure and dry storage facility.

### **PART 2 PRODUCTS**

#### **2.01 MATERIALS**

- A. Floor Sealant:
  1. Floor sealant: Water-epoxy concrete floor protective coating providing good resistance to wear, abrasion, soiling and chemical attack.
    - a. Product: Tennant ECO-LTS (405) coating system mixed with Tennant 413SF solvent-free bonding additive (for first coat only) as manufactured by Tennant Company, Minneapolis, or equal.
    - b. Tennant 409 Pre-Kote cleaner or equal, for floor preparation and better adhesion of the coating.
- B. Insulated Floor Topping:
  1. Description: Insulated floor topping consisting of epoxy resin with filler where indicated. Gray color.
  2. Epoxy resistivity: Minimum  $10^{12}$  ohm-cm.
  3. Epoxy manufacturers: Hallemite Grey Amazite by Hallemite, 25 Holden Street, Providence, R.I., 02908, or FX-70-6EE by Fox Industries, 3100 Falls Cliff Road, Baltimore, MD, 21211, or equal.
  4. Filler: Manufacturer's standard for this service.
- C. Furniture:
  1. Workbench: Heavy duty, 2-5/8 inch laminated maple top, 35 inch high by 60 inches wide by 30 inches deep with steel base which can be bolted to the floor. Provided with three 14-inch wide by 22-inch deep by 6-inch high drawers, one 20-inch deep by 50-inch wide by 20-inch high cabinet with center shelves and two steel doors. Provided with four inch toe clearance.

2. Stool: 14-inch diameter seat with tubular steel adjusting leg extensions that lock securely at one-inch intervals, adjustable from 18 inches to 27 inches.
3. Storage Cabinet: Steel, 36 inches high, 60 inches long and 16 inches deep with one, adjustable height shelf supported every 15 inches. Provided with four doors.
4. Stepladder: Wood, heavy duty, eight-foot. ANSI A14.1, Type 1, industrial.
5. Finish for metallic surfaces: Cleaned, degreased, primed with zinc primer and finished with one coat of light gray enamel, ANSI Z55.1, color 61, minimum dry film thickness: one mil.

## 2.02 EQUIPMENTS

- A. Conduit, Cable Tray, Boxes, Cabinets and Fittings.
  1. General Requirements:
    - a. Size: As shown, minimum conduit size 3/4 inch.
    - b. Materials:
      - 1) Steel sheet: ASTM A507.
      - 2) Zinc-coated steel sheet: ASTM A653, coating G235.
      - 3) Malleable iron: ASTM A47
      - 4) Cast iron: ASTM A532
      - 5) Ductile iron: ASTM A536
      - 6) Fiberglass Reinforced Polyester (FRE): NEMA FG-1
      - 7) Bronze Extrusion: ASTM B455, Alloy C38500
      - 8) Bronze Casting: ASTM B584, Alloy C38600
    - c. Zinc coating:
      - 1) Hot Dip Galvanizing: ASTM A123 and ASTM A386
      - 2) Electro galvanizing: ASTM B633
  2. Galvanized Steel Rigid Conduit and Fittings: UL 6 and ANSI C80.1, zinc coating tested in accordance with reference test in appendix.
  3. Aluminum Rigid Conduit and Fittings:
    - a. ANSI C80.5 and UL6.
  4. Liquid-tight Flexible Conduit and Fittings: (for use with galvanized steel rigid conduit)
    - a. Applicable requirements of UL 360.
    - b. Flexible galvanized steel core with extruded liquid-tight neoprene or PVC jacket overall.
    - c. Sizes up to 1-1/4 inch provided with continuous copper bonding conductor, spiral wound between convolutions.
    - d. Sizes 1-1/2 inch and above provided with separate grounding conductor.
  5. Rigid fiberglass reinforced epoxy conduits and fittings:
    - a. Rigid fiberglass reinforced epoxy conduit, UL 1684, IPS (Iron Pipe Size) based conduit.
    - b. Conduit shall be manufactured by using filament winding process with minimum fiberglass content of 65 percent by weight and no fillers.
    - c. IPS based conduit shall have nominal wall thickness of 0.09 inch for five-inch nominal conduit size.
    - d. Conduits, elbows and fittings manufactured from the same material and using the same manufacturing process.
    - e. Conduit sections formed with integral bell-and-spigot type couplings shall use adhesive epoxy compound to make the joints watertight. Rubber sealing gasket at bell end is prohibited.
    - f. Adhesive epoxy compound as recommended by conduit manufacturer.
    - g. Conduits, elbows and fittings are specified for use throughout a temperature range of -40F to 230F, and they are to be protected from exposure to sunlight by pigmentation uniformly dispersed through the resin material.
    - h. Conduits, elbows and fittings shall be suitable for encasement in concrete below grade and conform to UL 1684, and listed and labeled by UL meeting the requirements of NEC Article 347 for Rigid Nonmetallic Conduit and its

- use.
6. Conduit Expansion Fittings: Weatherproof, fabricated from material compatible with conduit with which fittings are to be used. Metallic fittings equipped with bonding jumper cable to provide electrical continuity.
  7. Conduit Connector Fittings:
    - a. UL 514, material and finish similar to that of conduit with which they are to be used.
    - b. Indoor Locations: For enclosures, cabinets, boxes and gutters: Nylon-insulated bushing and locknut.
    - c. Outdoor Locations: Watertight nylon-insulated bushing and locknut for termination of galvanized rigid steel conduit. Watertight PVC threaded adapter with O-ring and locknut or bushings for termination of PVC conduit.
  8. Conduit seal:
    - a. To provide watertight seal between concrete and conduit where it penetrates wall, floor or ceiling.
    - b. Size as shown or necessary.
    - c. Materials: Body and pressure clamp of malleable or cast iron with a neoprene sealing grommet and PVC-coated or galvanized-steel pressure rings, oversized sleeve of PVC or galvanized.
    - d. Seal between conduit and concrete to withstand pressure from 50-foot head of water without leakage.
  9. Cable and Seal Fittings:
    - a. To provide watertight seal between cable and conduit for use with single-conductor or multiple-conductor cable as necessary.
    - b. Size as necessary, drilled to accommodate cable.
    - c. Pressure discs of PVC-coated steel and sealing ring of neoprene.
    - d. Seal between cable and conduit to withstand water pressure of 50 psi without leakage.
    - e. O-Z type CSBI, CSBE or equal as shown on drawings.
    - f. Seal all unused conduits for traction power and auxiliary power using blank seals.
  10. Seal Compound:
    - a. FS TT-S-227, two-component, fast-setting, polymeric sealing compound to provide watertight seal between cable and conduit.
    - b. Pour-type for horizontal and gun-grade for vertical or overhead application.
    - c. When cured, sealant to have rubber-like flexibility allowing minimum movement of conduit and cable in temperature range of minus 10F to plus 150F without loss of watertight seal.
    - d. Pot life: 15 minutes.
    - e. Minimum ambient temperature for application: 35F.
    - f. Initial cure: 15 minutes.
    - g. Final cure: Seven days.
    - h. Hardness, Durometer A: 20-35.
    - i. Seal between conduit and single-conductor or multiple-conductor cable to withstand water pressure of 50 psi without leakage.
    - j. Fox Industries, Type FX-571G or equal.
  11. Conduit, Cable Tray and Cable Supports:
    - a. Retaining straps and fasteners: FS FF-S-760, with the following additional requirements:
      - 1) Type, style and size: As necessary.
      - 2) Material and finish: Steel or malleable iron, hot-dip galvanized after fabrication, fiberglass reinforced polyester.
      - 3) For separating conduit from masonry surface: Galvanized malleable iron spacer assembled with Style A strap.
      - 4) For vertical run of metallic sheath cable: Basket weave cable support.

- 5) For fastening conduit or cable to channel inserts: Galvanized steel fasteners.
- b. Trapeze type hangers: Consisting of two or more hanger rods, horizontal member, U-bolt clamp and other attachment necessary for securing hanger rods and conduit, with the following additional requirements:
- 1) Material and finish: Steel, hot-dip galvanized after fabrication or Fiberglass Reinforced Polyester conforming to the requirements specified for fiberglass channel struts.
  - 2) Hanger rod: Not smaller than 5/8-inch diameter, threaded for sufficient distance at each end to permit at least 1-1/2 inches of adjustment.
  - 3) Horizontal member: Channel, 1-5/8 inches square by 12 gauge or heavier. Weld two or more channels together for greater strength if necessary.
  - 4) Design: Capable of supporting load equal to sum of weights of conduit, cable and hanger plus 200 pounds. At design load, stress at root of thread on hanger rod 9,500 psi maximum; stress in horizontal member 12,500 psi maximum.
- c. Steel Channel Struts:
- 1) Size and shape as shown, 12-gauge or heavier hot-dip galvanized, with 7/8 inch wide continuous slot, 9/16 inch base slot, two inches on center or solid base with field drilled holes as required with minimum pull out load rating of 1,000 pounds per linear foot.
  - 2) Fittings and accessories compatible with associated steel channel struts and having same material and finish.
- d. Stainless Steel Channel Struts:
- 1) Size and shape as shown, 12-gauge or heavier stainless steel, type 304, with 7/8 inch wide continuous slot, 9/16 inch base slot, two inches on center or solid base with field drilled holes as required with minimum pull out load rating of 1,000 pounds per linear foot.
  - 2) Fittings and accessories compatible with associated channel struts and having same material and finish.
- e. Fiberglass Channel Struts:
- 1) Fiberglass reinforced polyester, self extinguishing, with 7/8" wide continuous slot, 13/32" pre-drilled holes in base on 1-5/8" centers, or solid base with field drilled holes as required with the following additional requirements

<u>Physical Properties</u>	<u>Value</u>	<u>Method</u>
Tensile Strength	30,000 PSI	ASTM D638
Flexural Strength	30,000 PSI	ASTM D790
Barcol Hardness	50	ASTM D2583
Dielectric Constant	200 VPM	ASTM D150
Coefficient of Thermal Expansion	$5 \times 10^{-6}$ in/in/°F	ASTM D696
Specific Gravity	1.7	ASTM D792
Flammability Rating	15	ASTM E84
Moisture Absorption	1% (24 hrs. at 72°F)	ASTM D570

- 2) Fittings and accessories compatible with associated fiberglass channel struts and having same material or approved similar material.
  - f. Cinch anchors: One-piece wedge type, galvanized with threaded stud.
  - g. Cable support brackets: Size and type as shown, 12-gauge or heavier, hot-dip galvanized.
  - h. Cable insulators: Saddle type, high glazed porcelain, designed for use with the brackets provided.
12. Boxes
- a. Outlet boxes:
    - 1) UL 514, capable of accommodating conduit as shown.
    - 2) Material and finish:
      - a) Steel, cast iron, ductile iron or malleable iron.
      - b) Hot-dip galvanized or electrogalvanized after fabrication.
  - b. Junction and pull boxes:
    - 1) Internal volume up to 100 cubic inches, UL 514; internal volume above 100 cubic inches, UL 50.
    - 2) Flush-mounted or surface-mounted as shown.
    - 3) Size: Suitable to accommodate conduit, raceways, ducts, number of cables and splices shown.
    - 4) Material:
      - a) Stainless Steel, Type 316.
      - b) Hot-dipped galvanized or electrogalvanized after fabrication.
13. Cable Trays
- a. General:
    - 1) Dimensions: Minimum four inches inside depth; nine inches rung spacing unless otherwise shown.
    - 2) Maximum load rating: 50 pounds per linear foot with safety factor of 2.0 at 12-foot support span for steel trays. 200 pounds per linear foot with safety factor of 1.5 at 12 foot support span for fiberglass reinforced polyester trays. Support additional concentrated load of 200 pounds at any point without permanent deflection.
    - 3) Bend Radius:
      - a) For incoming service cable: 36 inches or as approved by the utility.
      - b) For all other cable: 24 inches or as shown.
  - b. Fiberglass Cable Tray
    - 1) NEMA FG-1, fiberglass ladder type.
    - 2) Allowed for carrying all dc positive and negative cable except as otherwise noted. Fiberglass material shall be used for all fittings and accessories associated with the installation of fiberglass trays.
    - 3) Fiberglass Reinforced Polyester in accordance with the following:

Physical Properties	Value	Method
Tensile Strength	40,000 PSI	ASTM D638
Flexural Strength	45,000 PSI	ASTM D790
Barcol Hardness	95	ASTM D2583
Dielectric Strength	200 VPM	ASTM D149
Specific Gravity	1.7	ASTM D792
Coefficient of Thermal Expansion (Longitudinal)	5x10 <sup>-6</sup> in./in./°F	ASTM D696
ASTM D696	1% (24hrs. at 72°F)	ASTM D570
Flammability Classification	V-O	UL 94
Flammability Rating	15	ASTM E84

14. Expansion Bolt Anchors: FS FF-S-325C Group II, Stainless Steel-316, type and class as approved, galvanized.
15. Wireways and auxiliary gutters:
- a. Galvanized steel with formed flanges on both body and cover, screw on covers, in accordance with UL870, complete with all necessary fittings, couplings and end pieces.
  - b. Size as shown.
  - c. Electrogalvanized and finished with light gray enamel, ANSI Z55.1, Color 61.
16. DTS Cabinet/Remote Control and Monitoring Cabinet:
- a. Wall-mounted, single-door, NEMA 250, Type 12, with panel, similar to Hoffman Engineering Company or equal, as shown.
  - b. Enclosure: Formed of minimum 14-gauge steel, seams continuously welded and ground, without openings or knockouts, with threaded conduit entrance hubs, lugs for mounting enclosure and collar studs for mounting panel. Rolled lip formed on all sides of door opening. Enclosure and door reinforced when size exceeds 30 inches square. Size as shown. (Note: The Remote Control & Monitoring Cabinet shall be identical to the DTS Cabinet for Tie Breaker Station, except that the nameplate shall be modified to suit.)
  - c. Door: Formed of minimum 14-gauge steel, with rolled lip along top and sides to mate with enclosure. Fitted with removable print pocket. Closed-cell neoprene gasket attached with oil-resistant adhesive and steel retaining clips.
  - d. Hardware: Corrosion-resistant steel continuous piano hinge with removable pin. Hasp and staple for padlocking.
  - e. Panel: Formed of 12-gauge steel.
  - f. Finish: Galvanized enclosure, door, panel and latch mechanism. Painting by manufacturer's standard method in accordance with the following:
    - 1) Outside: Phosphatized, primed and finished with two coats of light gray enamel or epoxy coating, ANSI Z55.1, Color 61; minimum dry film thickness, two mils.
    - 2) Inside including panel: Two coats of white enamel or epoxy coating.
  - g. Breather drain: One 1/2 inch diameter, Crouse-Hinds Catalog No. ECD11 or equal.

- h. Grounding stud: Manganese bronze, ASTM B138, Alloy No. 675 hard, 3/8 inch high; Evedur GSI, American Brass Company or equal.
  - i. Terminations: Assembly rail and modular terminals, Weidmuller Terminations, Incorporated or equal.
    - 1) Terminal: Modular test terminal, Melamine plastic, screw clamp connections, with socket screws; type SAKC4, Catalog No. 3406.2, with the following additional requirements:
      - a) Amperes: 25.
      - b) Volts: 300.
      - c) Wire gauge range: 22 AWG to 12 AWG.
      - d) Thickness: 0.256 inch.
      - e) UL-listed.
      - f) Standard accessories: compatible with terminal, with the following additional requirements:
        - (1) End section: Type AP, No. 1179.2.
        - (2) End bracket: Type EWK1, No. 2061.6.
        - (3) Test plug: Type PS, No. 1804.0
        - (4) Jumpering Combination: Type QB, No. 91455.0.
        - (5) Disconnect plug for SAKC4 terminal: Type TST, No. 413074.
        - (6) Locking pin: Type SST3, No. 1527.0.
    - 2) Assembly rail: Type TS 32 steel standard section compatible with terminals, with fixing slots, Catalog No. 1228.0 and standard rail mounting screws.
    - 3) Marking tags: Horizontal in sequence, Type FW, No. 4681.6 white thermoplastic. Consecutive numbering conforming to that of DTS box.
    - 4) Group marking carrier with paper marking strip and transparent cover.
      - a) Type SCHAT5, Catalog No. 2924.6.
      - b) Type ES05, Catalog No. 2937.0.
      - c) SST5, Catalog No. 2940.0
17. ETS Enclosures:
- a. Enclosure: Nonventilated, single-door fiberglass enclosure NEMA 250, Type 3R, with mounting brackets as shown, complying with applicable requirements of UL 508.
    - 1) Molded fiberglass reinforced polyester material 1/8 inch thickness, minimum, and in accordance with the following:

Physical Properties	Value	Method
Flexural Strength	17,000 PSI	ASTM D790
Deflection Temp	400F	ASTM D648
Water Absorption (24 hours)	0.5%	ASTM D570
Tensile Strength	6,500 PSI	ASTM D638
Specific Gravity	1.8	ASTM D792
Flammability	V-O	UL94
Dielectric Strength	400 Volts/Mil	ASTM D149
Arc Resistance	180 Sec	ASTM D495

- 2) Gasket: Oil-resistant 100 percent neoprene by polymer content, ASTM-D1056 grade SCE-42 with oil-resistant adhesive.
  - 3) Piano hinges: Stainless Steel, one inch wide by 1-3/4 inches high with model pins and fasteners, two per enclosure.
  - 4) Door handle: T-handle, One half turn, Vise Action Type, die cast zinc, matte black, polyester powder finish with stainless steel hardware, SOUTHCO catalog No. E3-10-105-50 or equal.
  - 5) Panels, back plates, barriers and brackets: 10 gauge stainless steel as shown.
  - 6) Hardware: Stainless steel bolts, nuts and screws; ASTM F593, size as shown.
  - 7) For ultra-violet protection of fiberglass box, the material shall contain ultra-violet inhibitor on inside and outside surfaces coated with polyurethane paint, 1.5 mils minimum dry film thickness.
  - 8) Color: Fiberglass material, gray inside and out.
  - 9) Open/Close Decal: Pressure sensitive weatherproof, vinyl tape with 1/4" high red on a white background. "OPEN" shall have red letters, "CLOSE" shall have green letters.
  - 10) Nameplates: Each ETS Enclosure provided with three-ply laminated plastic, multi-layered nameplates inscribed with 1-inch lettering identifying the ETS Box Number, Supervisory Control Identification Nos. of the dc breakers being tripped. A typical example of engraving is as follows:
    - a) EMERGENCY TRIP SWITCH NO.
    - b) E-F07-31
    - c) E-F08-41
- b. Emergency pushbutton: Provide on the backplate, mushroom head trip switch with 4 NC poles similar to Square-D Cat. No. 9001-4-KA-3 with head No. 9001-KR-5R.
- c. Terminal block: Provide on the backplate one 12-point terminal board similar to GE Cat. No. CR151B2 or equal.
18. ETS Relay Cabinets:
- a. Wall mounted, single door, NEMA 250, type 12, with enclosure and back panel similar to Hoffman Engineering Company or equal, as shown.
  - b. Enclosure formed of minimum 14-gauge steel with sufficient structural reinforcements to ensure a plane surface, to limit vibration and to provide

sufficient rigidity during shipment, installation and operation. A print pocket shall be attached to the inside of the door of enclosure.

- c. Door formed of minimum 14 gauge steel with rolled lip formed along top and sides to mate with enclosure. Provided with hasp and staple for padlocking.
- d. Back panel formed of minimum 12 gauge steel.
- e. Relays and Terminal Blocks: The cabinet shall have mounted on its back panel auxiliary relays of hinged armature construction, 125V dc rated coil and electrically held, self reset type with 2 NO and 4 NC contacts similar to GE Catalog No. 12HFA51A42H code No. 24 contact arrangement or equal. Terminal blocks with cover similar to GE Type EB shall be mounted on back panel. Quantity of relays and points on terminal blocks as shown.
- f. Name Plates and Wire Labels: In accordance with Article 2.02.C.

B. Circuit Breakers & Panelboards:

- 1. General Requirements:
  - a. Interchangeability: Components of the same type, size, rating, functional characteristics and make are to be interchangeable.
  - b. Finish for enclosures for panelboards.
    - 1) Clean and degrease metallic surfaces.
    - 2) Prime with zinc primer.
    - 3) Finish with one coat of light gray enamel, ANSI Z55.1, Color 61; two mils minimum DFT.
- 2. Circuit Breaker: NEMA AB1, UL489, molded-case, bolt-on, quick-make/quick-break, mechanically trip-free, switching mechanism, with thermal trip for inverse time delay overcurrent protection and magnetic trip for instantaneous short-circuit protection. Frame size 225 amperes and above equipped with interchangeable thermal trip and adjustable magnetic trip unit. Designed to carry continuous rating in ambient temperature of 40C with the following parameters as shown:
  - a. Number of poles.
  - b. Rated voltage, ac or dc
  - c. Rated interrupting current.
  - d. Trip setting.
  - e. Frame size.
- 3. Enclosed Circuit Breaker:
  - a. NEMA AB1.
  - b. Circuit breaker: As shown and specified. Overcurrent trip device coordinated to provide selective tripping under overload conditions.
  - c. Enclosure:
    - 1) Galvanized steel, surface-mounted, unless otherwise shown.
  - d. Type:
    - 1) Above-ground indoor locations and electrical rooms: NEMA 1.
    - 2) Tunnel areas and underground locations, except electrical rooms: NEMA 12.
    - 3) Outdoor locations: NEMA 3R.
- 4. Panelboard:
  - a. NEMA PB1, UL 67.
  - b. Enclosure:
    - 1) UL 50.
    - 2) Galvanized steel, surface mounted unless otherwise shown.
    - 3) NEMA 250, Type 1
    - 4) Gutter size

Main Bus Rating Amperes	Minimum Top and Bottom Gutter Size in Inches	Minimum Side Gutter in Inches
100 and below	4	4
225	6	4

- 5) Interior components mounted on backplate of reinforced steel for rigid support and accurate alignment.
  - 6) One piece sheet steel front panels with hinged door and lock so constructed that when panelboard door is locked front cannot be removed.
  - 7) Provide latch and handle in accordance with UL 50; screw fastenings will not be accepted in lieu of latch.
  - 8) Provision for enclosure grounding.
- c. Busbars:
- 1) ASTM B187.
  - 2) 98 percent conductivity copper.
  - 3) Contact surface silver-plated or tin-plated.
  - 4) Rating of neutral and ground bus: Equal to that of phase bus.
  - 5) Neutral bus mounted on insulating block.
  - 6) Neutral and ground bus equipped with integral mechanical connectors.
- d. Circuit Directory:
- 1) Neatly typed to identify the load fed by each circuit by number.
  - 2) Mounted on a metal frame with clear plastic cover inside cabinet door.
- e. DC Panelboard: 125 volt dc, 2-wire. Main and branch circuits with 2-pole breakers, quantity and ratings as shown. AIC-10,000 amps minimum.
- C. Nameplates, Tags and Wire Labels:
1. Nameplates:
    - a. Three-ply, laminated phenolic plates, engraved through black face to white core, attached by stainless steel rivets or screws.
    - b. Lettering: Vertical gothic using round or square cutter. V-shape groove is prohibited.
    - c. Size: One-inch high with 1/2-inch high lettering.
  2. Conduit and Cable Tags: Stainless steel, round, punched with cable or conduit number as shown.
  3. Wire labels: Sleeve-type, heat shrinkable, flame retardant Raychem TMS product line, Type XPE or equal and conforming to UL224. Wire identification same as corresponding terminal block identification unless otherwise shown. The labels on 1000 KCMIL cable shall be clear, heat shrinkable with 1/2" height yellow lettering stamped on inside. The labels shall have reference of substation or tie-breaker station breaker Supervisory Control ID number and cable sequence in the branch of the feeder (e.g. BRK. 32-A) at both ends.
- D. Emergency Trip Station Light Fixture Type 9.
1. Lighting Fixture: Enclosed and gasketed mercury-vapor fixture suitable for outdoor locations conforming to UL-1572 and as shown. Hubbell Catalog No. VMWX-50C-R or equal.
    - a. Lamp: Mercury-vapor, 40 watt B-17, medium base, 24,000 hours rated average life, and conforming to applicable ANSI Standards.
    - b. Lampholder: In accordance with UL 496, glazed porcelain base and body, rated 660 watts, 600 volts, medium screw base, and self-retaining neoprene

- c. gasket for dust and moisture-proof seal between lamp and lampholder.  
Housing: Copper free heavy-duty die cast aluminum with 90-degree arm for wall mounting, natural color, threaded to provided a secure fit for the globe and guard.
- d. Globe: Thermal shock and impact resistant blue tempered glass, threaded to ensure secure fit to housing.
- e. Guard: Copper free die cast aluminum to provide protection to the globe and lamp, threaded and provided with a flush mounted set screw for a positive and secure fit to housing.
- f. Ballast: UL 1029, high power factor, H45 type, Class H insulated, capable of starting a 40 watt mercury vapor lamp at an ambient temperature of minus 20F and above, 277 volt, 60 Hertz, suitable for mounting in an enclosure for remote mounting.
- g. Remote ballast enclosure: Fiberglass or aluminum with polyester powder paint finish, front access and weathertight construction with 3/4" conduit entry and exit knockouts, with mounting lugs suitable for mounting on channel inserts or inside interface box as shown.

E. Danger Markers:

1. Danger markers for conduit and cable installed in track areas:
  - a. Danger plate for use on timber ties supporting conduit and cable.
    - 1) Three-ply, laminated phenolic plates, engraved through red face to white core, attached by stainless steel lag screws.
    - 2) Lettering: Vertical Gothic using round or square cutter. V-shape groove is prohibited.
    - 3) Size: Four-inch high with one-inch high lettering as below and applicable.  

DANGER 750 VOLTS
    - 4) Ultra-Violet Protection: coated with polyurethane paint 1.5 mils minimum dry film thickness on all surfaces.
  - b. Danger label for use on conduit:
    - 1) 2-1/2-inch wide pressure sensitive vinyl with red background and white lettering 1-1/4 inch high, Gothic Capital Style as follows and applicable.  

"DANGER 750 VOLTS"

"DANGER 480 VOLTS"
    - 2) Lettering printed with weather resistant ink and shall be durable and scuff resistant.
    - 3) Marker provided with permanent type back adhesive for long term outdoor use.

## 2.03 ACCESSORIES

A. Wire Connection Accessories:

1. Connectors, terminal lugs and fittings.
  - a. In accordance with UL486, and NEMA CC1.
  - b. For 10 AWG and smaller conductors: Compression type, high conductivity copper, tin-plated ring tongues, with nylon self-extinguishing insulating grip with temperature rating equal to that of conductor insulation. Thomas and Betts STA-KON type or equal.
  - c. For 8 AWG to 4/0 AWG conductor cable: Tin-plated copper compression connectors and terminal lugs with nylon insulating sleeve for insulation grip.
  - d. For 250 KCMIL and larger conductor cable: Long barrel double-compression tin-plated copper connectors and terminal lugs with two-hole

- pad.
  - e. For multiple conductor cable: Watertight aluminum fittings with stainless steel pressure ring and set screws or compression cone for grounding of aluminum sheath of MC cable.
  - f. Hardware: High strength silicon bronze, corrosion resistant, non-magnetic, and electrolytic action free when in contact with copper.
  - g. Ground connector:
    - 1) O-Z, Type KG or equal.
    - 2) Two-piece, designed for connecting grounding conductor to bus bar.
    - 3) Copper-alloy bolt and silicon-bronze bolt, nut and lock washer with interlocking clamp.
  - h. Contact rail terminal lugs: Compression type, 98-percent-pure copper, hot-dip tin-coated to 0.3 mils minimum thickness. Tongues not less than two inches square by 1/2-inch thick and drilled for 5/8-inch diameter fastener. Compatible with 1000 KCMIL, extra flexible cable.
2. Bundling Straps:
- a. Self-locking steel barb on one end, with tapered strap of self-extinguishing nylon, temperature rating minus 65F to 250F.
  - b. For outdoor use: Ultraviolet-resistant.
3. Insulating Tape:
- a. Plastic tape: Vinyl plastic tape with rubber-based pressure-sensitive adhesive, pliable at zero degrees F with the following minimum properties when tested in accordance with ASTM D1000:
    - 1) Thickness: 8.5 mils.
    - 2) Breaking strength: 20 pounds per inch width.
    - 3) Elongation: 200 percent.
    - 4) Dielectric breakdown: 10,000 volts.
    - 5) Insulation resistance, indirect method of electrolytic corrosion: 1,000,000 megohms.
  - b. Rubber tape: Silicone rubber tape with silicone pressure-sensitive adhesive, with the following minimum properties when tested in accordance with ASTM D1000:
    - 1) Thickness: 12 mils.
    - 2) Breaking strength: 13 pounds per inch width.
    - 3) Elongation: 525 percent.
    - 4) Dielectric breakdown: 13,000 volts.
    - 5) Insulation resistance, indirect method of electrolytic corrosion: 1,000,000 megohms.
  - c. Arc-proof tape: Flexible and conformable organic fabric tape, coated one side with flame-retardant flexible elastomer, self-extinguishing, non-combustible, with the following minimum properties:
    - 1) Thickness, ASTM D1000: 30 mils.
    - 2) Tensile strength, ASTM D1000: 1500 pounds per square inch @ 23C.
    - 3) Elongation, ASTM D1000: 150 percent @ 23C.
    - 4) Thermal conductivity, ASTM D1518: 0.078 BTU per hour per square foot per degree F.
    - 5) Electrical arc resistance: one half-lap layer capable of withstanding a high current fault arc temperature of 13,000K for 75 cycles.
  - d. Glass tape: Woven glass fabric tape with pressure-sensitive thermosetting adhesive, with the following minimum properties when tested in accordance with ASTM D1000:
    - 1) Nominal width: 3/4 inch.
    - 2) Thickness: Seven mils.
    - 3) Breaking strength: 170 pounds per inch width.

- 4) Elongation: Five percent.
  - 5) Dielectric breakdown: 2,500 volts.
  - 6) Insulation resistance, indirect method of electrolytic corrosion: 5,000 megohms.
4. Epoxy Resin: Suitable for insulating and moisture sealing cable splices, with the following minimum properties:
    - a. Dielectric strength, ASTM D149: 400 volts per mil.
    - b. Volume resistance, ASTM D257:  $2.8 \times 10^9$  ohm per centimeter cube at 30C.
    - c. Water absorption, ASTM D570:
      - 1) 0.193 percent in 24 hours at 23C.
      - 2) 0.62 percent in 24 hours at 53C.
    - d. Tensile strength, ASTM D638: 8,000 psi.
    - e. Elongation, ASTM D638: 2.4 percent.
    - f. Coefficient of expansion, ASTM D696:  $6.8 \times 10^{-5}$  inch per inch per degree C.
  5. Contact rail cable connector assemblies:
    - a. Cable connectors: Compression type, MAC Products, Inc., No. B-9180 or equal, 98 percent pure copper with four hole tongues and necessary silicon-bronze flat washers, lockwashers, nuts and bolts. Tongues not less than 9/16 inch thick and drilled for 1/2 inch bolts on 1 3/4 inch centers.
    - b. Insulating covers and accessories: Two-piece, glass reinforced polyester, orange colored, not less than 0.125 inch thick. Equipped with neoprene gaskets, sealing collars and captive screw fasteners.
    - c. Heat shrinkable tubing: T & B Cat. No. HSB400-225-1 or equal.
    - d. Completed assembly to be watertight and readily disassembled.
  6. Terminal blocks:
    - a. Barrired, screw type equipped with washer head binding screws, white marking strips for terminal identifications and hinged covers; unless otherwise shown or specified.
    - b. Rated 600 volts, 30 amperes per point and designed to accommodate wire sizes 19 AWG through 10 AWG inclusive.
- B. Exothermic mold kit, consisting of mold and handle and Exothermic Weld Cartridge:
1. Exothermic weld mold for making #4 AWG cable connections to the base of the composite contact rail. Erico part No. PB10QITL84C or equal.
  2. Exothermic weld mold for making #4 cable connections to the neutral axis of the running rail, Erico part No. PB13STIL or equal.
  3. Mold handle for holding the exothermic mold to the composite contact rail and the running rail. Erico part No. PBL160 or equal.
  4. Exothermic Weld Cartridge: Consisting of welding powder, steel discs and packing material required to make an exothermic weld of #4 AWG cable to the composite contact rail and running rail. Erico part No. PB65 or equal.
- C. Heat-shrinkable tubing: UL-approved, flame retardant, corrosion resistant thick wall tubing with factory-applied sealant for field insulation on inline splices and taps or wraparound type sleeve for retrofit installation on existing splices and taps to provide a watertight seal and insulating encapsulation, with the following additional properties:
1. Material: Cross-linked polyolefin.
  2. Shrink ratio: 3 to 1 (min.)
  3. Physical properties:

Ultimate tensile strength	2350 psi	ASTM D412
Hardness, Shore D	42	ASTM 2240
Water absorption Method 6.1	0.05%	ASTM D570
Specific gravity	1.28	ASTM D792

4. Electrical properties:
    - a. Dielectric strength 450 volts ASTMD149 per mil
    - b. Volume resistivity  $1 \times 10^{14}$  ASTMD 257 ohm cm
  5. Thermal properties:
    - a. Continuous operating temp. -55C to +135C
    - b. Air oven aging (7 days @ 175C):
      - 1) Tensile strength 2680 psi
      - 2) Elongation 375 %
      - 3) Low temp. flexibility No cracking  
(4 hours @ -55C) when flexed
      - 4) Heat shock (4 hours No cracking,  
@ 225C) flowing or dripping
  6. Chemical properties:
    - a. Corrosivity Non-corrosive MIL-I-23053/15
    - b. Fungus resistance Non-nutrient ASTM G21
- D. Nuts, Bolts, U-Bolts and Miscellaneous Hardware.
1. Material
    - a. All nuts, bolts, u-bolts and washers for outdoor locations including tunnels shall be Type 316 stainless steel in accordance with ASTM F593 and F594.
    - b. All nuts, bolts, and flat washers for indoor locations in TBS and TPS shall be galvanized steel in accordance with ASTM A325.
    - c. The dimensional data and type hardware for all nuts, bolts and miscellaneous parts shall be shown and specified; where not shown as recommended by the manufacturer.
  2. Galvanizing
    - a. All parts to be galvanized shall be galvanized after manufacture. Unless otherwise specified, parts to be galvanized shall be coated in accordance with the requirements of ASTM A123. Bolts and miscellaneous hardware shown or specified to be galvanized shall be coated in accordance with ASTM A153 or alternate method in accordance with ASTM B633
- E. Structural Steel Shapes:
1. Shapes, plates and bars: ASTM A36.
  2. Structural tube: ASTM A500, Grade A, hot-dip galvanized. Galvanizing: Hot-dip galvanized after fabrication in accordance with ASTM A123, zinc coating weight two ounces per square foot, minimum.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Install generally as shown and in accordance with approved shop drawings, the NEC and jurisdictional agencies.
- B. Conduit, Cable Tray, Boxes, Cabinets and Fittings:
  1. General:

- a. Use size, type, general routing, location of conduit, raceways, boxes and cabinets as shown and specified.
  - b. Install metallic raceway, fittings, boxes and cabinets free from contact with reinforcing steel.
  - c. Where aluminum is placed in contact with dissimilar metal or with concrete, separate contact surfaces by means of gasket, non-absorptive tape or coating to prevent corrosion.
  - d. Unless specified or shown otherwise, make metallic conduit, raceways, and cable trays, electrically and mechanically continuous, and grounded in accordance with NEC and as shown.
2. Conduit:
- a. Run exposed conduit parallel to building lines.
  - b. Install exposed conduit to avoid interference with other work.
    - 1) Where shown and as necessary, install cable seal in accordance with the manufacturer's recommendation.
    - 2) Use sealing compound where approved and in accordance with manufacturer's recommendations, with the following additional requirements:
      - a) Before applying sealing compound, prime conduit and cable surface using primer recommended by the manufacturer.
      - (b) Pour or inject compound to prevent voids inside seal and to keep cable centered in conduit.
    - 3) In empty conduit installed for future use, install blank cable seal inside conduit to prevent seepage of water.
    - 4) Ensure conduits are free of water before conduit seals are installed.
  - c. Apply lead-free conductive anti-seize compound to threaded conduit joints.
  - d. For outdoor locations use threaded conduit hub to attach conduit to equipment enclosure. Use watertight conduit fitting for attachment of conduit to enclosure having punched or formed knockout.
  - e. For indoor locations use locknut and nylon-insulated bushing to attach conduit to enclosure.
  - f. Install suitable caps or plugs in empty conduit for future extension.
  - g. Thread and ream ends of field-cut conduit to remove rough edges. Use bushing at conduit entrance to boxes, cabinets and equipment enclosures.
  - h. Bends:
    - 1) Unless otherwise shown or specified, install conduit bends in accordance with reference codes.
    - 2) Bend conduit so that field made bend is free from cuts, dents and other surface damage and does not reduce cross-sectional area of conduit.
  - i. Support horizontal conduit 1-1/2 inches and smaller with one-hole pipe straps or individual pipe hangers.
  - j. Support horizontal conduit larger than 1-1/2 inches with individual pipe hangers.
  - k. Spring steel fasteners, clips or clamps specifically designed for supporting exposed single conduits may be used in lieu of pipe straps or pipe hangers. Use 1/4 inch minimum diameter galvanized steel rods for hanger rods with spring steel fasteners, clips and clamps.
  - l. Secure conduit supported on multi-hangers (trapeze) or channel inserts by fasteners suitable for such purpose.
  - m. Where conduit is attached to masonry surface, use malleable iron spacers with Style A pipe straps.
  - n. Support and secure vertical conduit spanning open areas at intervals not exceeding 10 feet.

- o. Install conduit so as to drain moisture to nearest outlet or pull box.
  - p. Use only metallic conduit in exposed locations in tunnels and buildings.
  - q. Ensure waterproof conduit connection where conduit is installed in outdoor locations.
  - r. Use Schedule 80 PVC conduit for cable which is buried directly in ballast or at trackside locations for contact rail heater segment jumper cables.
  - s. Install expansion fittings in exposed conduit runs longer than 300 feet.
  - t. Use metallic conduit routed between control cable trays and equipment enclosures.
3. Channel Inserts and Spot Inserts:
    - a. Mount outlet boxes.
    - b. Keep number of knock-outs to minimum.
    - c. Clean boxes thoroughly after installation and correct damage to boxes and to finish.
    - d. Install covers on boxes mounted on walls and ceilings.
    - e. Install junction and pull boxes so that covers are readily accessible.
  4. Cabinets:
    - a. Fasten cabinets using expansion bolts, toggle bolts or mounting ears.
    - b. Touch-up damaged painted finish.
  5. Cable Trays:
    - a. For incoming service cable from power company, coordinate with the power company, and install cable tray with covers as approved by the power company.
    - b. Support cable tray straight sections, elbows, tees and crosses at the locations specified in NEMA FG-1 for fiberglass tray. Provide supports on 10 foot centers for horizontal positive and negative cable tray and not more than 12 feet on center for all other cable trays.
  6. Fasteners:
    - a. Fasten equipment and devices to concrete surfaces with lag screw shields, cinch anchors, expansion bolt anchors or lead jacketed tamp-in inserts. Use bolt sizes providing a safety factor of 2.5.
    - b. Fasten equipment and devices to concrete masonry units with toggle bolts.
    - c. Fasten equipment, devices and supports to structural steel with beam clamps, welded studs or drilled and tapped holes no greater than 1/4 inch diameter.
  7. DTS Cabinet and ETS Relay Cabinet:
    - a. Install as shown. Wall-mounted and fixed by expansion bolt anchors or toggle-bolts.
    - b. Terminate all wires as shown, including spares.
    - c. Ground DTS and ETS relay cabinets.
  8. ETS Enclosures:
    - a. Install as shown.
  9. ETS lighting fixtures:
    - a. Install as shown.
  10. Filling of openings:
    - a. Where conduit and raceway (including cable tray and bus duct) pass through fire-rated walls, ceilings or floors, provide approved firestops to prevent passage of fire and fumes and to maintain integrity of fire-rated structure.
    - b. Close unused openings or spaces in floors, walls and ceilings. Plug or cap unused conduit and sleeves.
    - c. Seal unused traction power conduits in ductbank at both ends using OZ Gedney CSBE seals or equal.
  11. Cleaning of raceways:
    - a. Rod and swab raceways and ducts through which cables are to be installed. Use a mandrel with an outside diameter 3/8-inch less than the

inside diameter of the duct and remove all obstructions. Install a non-metallic pull line fish wire, as approved by the Engineer in each raceway or duct immediately after rodding and swabbing and, unless cables are pulled immediately.

- b. The Contractor shall be responsible for the dewatering and removal of all dirt, rocks, track ballasts and trash from trenches, pipe, manholes, pull chambers, cable trough, surface trench, conduit and ductbank prior to and during the installation of cable, at no additional cost to the Authority.
12. Cable Troughs (Track Right-of-Way):
- a. Remove the trough covers, install wire and cables and reinstall the trough covers.
  - b. The Contractor is specifically warned of the following conditions and potential problems with the track right-of-way cable troughs:
    - 1) The covers for these troughs are not of uniform length and locations of drill holes, i.e., each cover section must be replaced on the trough section from where it was removed.
13. Apply anti-corrosion joint compound to connectors, terminal lugs and bolting pads before installation. Install lockwasher under each bolt head and nut.
14. Install terminal fittings on multiple-conductor cable in accordance with manufacturer's recommendation. Completely seal cable from moisture.
15. Attach contact rail cable connector assembly compression connectors to the cable with manufacturer's recommended tooling. Install a lockwasher under the head of each bolt and under each nut when bolting tongues together. Tighten bolted connections to a uniform torque of 450 inch-pounds.
16. Prior to assembly of contact rail cable terminal lugs to composite contact rail, coat mating services with oxide-inhibiting paste, NO-OX-ID, Dearborn Chemical, or equal. Coat all interfaces of the compression fasteners. Fasten terminal lugs to the composite compact rail using methods and equipment recommended by the rail manufacturer.
17. Exothermic Welded Connections: Make connections using exothermic mold kit and cartridge in accordance with the manufacturer's recommendations. Remove all extraneous weld metal and test connection for mechanical strength by striking twice with a two-pound hammer.
18. The splicing of power and control cables is not permitted in manholes, ductbanks and cable troughs. However, if permitted by the Engineer, make water tight splices as approved.
- C. Panelboards:
- 1. Install panelboards at locations shown.
  - 2. Mound panelboards with front straight and plumb.
  - 3. Connect branch circuit wires as shown. Connect neutral wire of branch circuit to neutral bar in panelboard.
  - 4. Make power cable connections to circuit breakers, neutral and ground bus bars in panelboard by means of integral mechanical connectors. If such items are not furnished with integral mechanical connectors, make connections using compression connectors.
  - 5. Ground panelboards.
  - 6. Apply matching touch-up paint where necessary.
  - 7. Provide directory for each panelboard.
- D. Furniture:
- 1. Provide one workbench, two stools, one storage cabinet and one stepladder for each traction power substation. Provide one storage cabinet and one stepladder for each tie breaker station. Place furniture inside each location where directed by the Engineer.

- E. Insulated Floor Topping:
1. Job Conditions:
    - a. Maintain substrate temperature within limits recommended by the flooring materials manufacturer.
    - b. Provide adequate ventilation during installation and curing.
  2. Inspection: Examine substrate and conditions under which flooring materials are to be prepared and installed. Do not proceed with the installation until all unsatisfactory conditions have been corrected.
  3. Surface Preparation:
    - a. Inspect all surfaces to determine that entire area to receive insulating floor topping is structurally sound. Remove loose sections down to the substrate.
    - b. Remove grease, oil, asphalt, mastics, and other contaminants that may prevent adhesion, by scrubbing with degreasers, detergents, or solvents. Grinding, scarifying, or sandblasting are other acceptable methods.
    - c. Repair cracks, holes, eroded and damaged areas with patching materials recommended by the insulating flooring manufacturer.
    - d. Prepare concrete surface by acid etching, grinding, sandblasting, scarifying, or other approved method.
    - e. Saw cut at all termination points.
    - f. Prior to applying base coats and top coats, apply marking tape at all termination points and adjacent surfaces not to be coated.
    - g. Remove tape immediately after broadcasting and after top coating.
  4. Materials Protection: Mix and prepare materials in accordance with manufacturer's written instructions.
  5. Application: Mix and apply each component of the insulating flooring system in accordance with the manufacturer's written instructions and as indicated to provide an uninterrupted, uniformly thick, seamless, and monolithic surface.
  6. Contraction Joints: When floor insulating topping material crosses contraction joints in the floor slab, a contraction joint shall be provided in the topping. Provide a vee shaped groove, 1/2 inch wide at the base of the groove, but not less than the width of the contraction joint, and insure the groove is 1/2 inch wider at the top than at the bottom. A bond breaker shall be provided to top of the concrete. An epoxy shall be used to seal damp surfaces before application of the primer and polysulfide. The groove shall then be filled with two component, self-leveling, gray polysulfide. Epoxy primer and polysulfide material shall be as recommended by the floor topping manufacturer. Surface preparation, and mixing and installation of materials shall be in accordance with manufacturer's instructions. Sheets of Haysite, not less than 1/16 inch thick, and 1/4 inch narrower than the groove at the top, shall be placed on top of the polysulfide and flush with the top of the insulated floor topping.
  7. Cleaning: After completion of insulating flooring installation, clean free of residue those surfaces not required to receive insulating flooring materials.
  8. Protection: Close to all traffic for 24 hours, minimum, completed insulating flooring installation. Protect it for 3 days from acid, alkali, or solvent which may spill on the flooring.
- F. Install appropriate power company furnished metering panel as shown and in accordance with power company instructions. Ground metering panel to substation ground bus. Connect to 120V, AC, 1-phase circuit in emergency panel as shown.
- G. Nameplates, Tags and Wire Labels:
1. Nameplates: Attach nameplates to all panelboards, DTS cabinets, remove control and monitoring cabinet, ETS enclosures and ETS relay cabinets.
  2. Cable Tags: Attach cable tags to each cable at all pull boxes, manholes and terminations.
  3. Wire labels: Attach wire labels at all control, annunciation and supervisory wiring at each terminal point. Attach label to a clean, dry section of wire as close as possible

to the terminal point.

- H. Danger Marker:
  - 1. Attach danger marker plate on top of timber ties on both ties where contact rail heater conduit transition occurs.
  - 2. Attach conduit danger label on each exposed conduit carrying contact rail heater control and power cable installed in track area at a maximum interval of five feet as noted below:
  - 3. Conduit carrying DC power cables: DANGER 750 VOLTS.
  - 4. Conduit carrying AC power and control cables: DANGER 480 VOLTS.
- I. Arc-Proofing:
  - 1. Cover all cables installed in manholes and pits with arc-proof tape, applied in a single layer, half-lapped with the coated side next to the cable and held in place with random wrap of glass cloth electrical insulating tape.
- J. Floor Sealant:
  - 1. Apply to finished floor surfaces in all traction power substations and tie breaker stations excluding areas with insulating floor topping.
  - 2. Prepare floor by removing compacted dirt.
  - 3. Treat with 409 Pre-Kote cleaner, mixed in ration one part 409 to nine parts water. Apply mix solution to the floor liberally (100 square fee per gallon) with a spray. Allow to soak for 10 minutes but do not allow it to dry. Scrub floor clean and vacuum using a wet vacuum. Scrub and rinse with clear water and repeat the scribe/rinse/vacuum process to ensure removal of all residue. The texture of floor should feel like sand paper before applying sealant.
  - 4. Let the floor dry completely.
  - 5. Mix Tennant ECO-LTS Parts A and B and Bond Additive (for the first coat) as recommended.
  - 6. Applicator or airless sprayer. Ensure ambient temperature is 65°F or higher during application. Apply two additional coats of the mix with four hours drying time in between.
  - 7. Allow to cure for 16 hours at 75°F before opening up the floor to traffic.

### 3.04 FIELD QUALITY CONTROL

- A. Submit test procedure for approval and perform approved tests. Do not perform tests without approved test procedure. Schedule tests through the Engineer with minimum of 14 days prior notice. Furnish the necessary equipment and perform the following tests:
  - 1. Test metallic conduit and boxes for electrical continuity.
  - 2. Panelboards: Perform insulation resistance tests of each bust section phase-to-phase and phase-to-ground for one minute using 1,000 volt megger. Insulation resistance not less than manufacturer's recommended value, two megohms minimum. Test enclosure for continuity to substation ground bus. Test circuit connections in accordance with wiring diagrams.
  - 3. Molded case circuit breakers: Perform pole-to-pole and pole-to-ground insulation resistance tests with a 1,000 volt megger. Insulation resistance: 50 megohms minimum.
  - 4. Prior to installation, test two contact rail cable connector assembly compression connections, prepared under the direction of foremen who will supervise the installation, as follows:
    - a. Measure the electrical resistance between distal end of the cable and the connector tongue. Resistance shall not be greater than that of an equivalent length of uncut cable.
    - b. Subject the test connections to a sustained tension of 5000 psi for three hours. At the end of three hours, verify that there has been no slipping of

- the cable in the connector, deforming or loosening of the connection or increase in the electrical resistance beyond that specified.
- c. Should any sample fail to meet the specified test requirements, the qualification of the foreman and the equipment shall be disapproved.
5. Test contact rail, DC switchgear and negative switchboard 1,000 KCMIL cable terminal lugs as specified for contact rail cable connector assembly compression connectors.
  6. Testing of Exothermic Connections of Composite Contact Rail and Steel Running Rail:
    - a. All exothermic connections shall be tested for mechanical strength using a two-pound hammer. A minimum of three sharp blows fifteen inches in stroke shall be directed to the weld nugget. The weld shall sustain the blows without cracking weld metal or at the interface with the steel contact rail. Defective welds shall be removed and the rail and cable thoroughly cleaned before rewelding.
    - b. Electrical Resistance: Using a megohmmeter, measure and record the insulated flooring electrical resistance to ground at four points designated by the Engineer. Resistance not less than 100 megohms for a 12-inch by 12-inch floor area.
- B. Submit Certified test reports within 10 days of completion of tests.

**END OF SECTION**

## SECTION 16053

### OPERATION AND MAINTENANCE TRAINING FOR TRACTION POWER

#### PART 1 - GENERAL

##### 1.01 SUMMARY

- A. This section specifies requirements for training of Authority personnel.
- B. Training shall be conducted according to the following classes:
  - 1. Operations and maintenance ("O&M") training, to include preventive and corrective maintenance, adjustment of all equipment in its anticipated installed environment and relay coordination study..
  - 2. Engineering and technician training, for performing reliability-oriented inspection, maintenance, diagnostic tests, calibration, trouble-shooting and repair of the traction power substation equipment classes in accordance with applicable IEEE, ANSI, ASTM standards and applicable INETA test procedures.  
Engineering and technician training shall include training in utilization of diagnostic test equipment, Software Applications in conjunction with appropriate test, function/signal generation, measurement hardware to calibrate and test the operation of traction power substation equipment as well as the setting of Power Digital Meter for monitoring purpose.
  - 3. Engineering training shall include a complete Traction Power Substation short circuit and coordination study.
- C. Payment and Measurement Basis(if scheduled) or included in the lump sum installation cost of each facility: Compensation for work specified in this section will be made in accordance with the Unit Price Schedule.

##### 1.02 SUBMITTALS

- A. O&M training: Submit five copies of all training material and resume(s) of instructor(s) for approval prior to commencement of training. Each resume shall outline the instructor's qualifications, skills, and experience in training.
- B. Engineering and Technician training:
  - 1. Submit five copies of training course descriptions and syllabus, training plan, instructor's guide, recommended class size, course provider's qualifications and instructors' resumes prior to commencement of training.
  - 2. Submit plans, equipment lists and software-generated signals and wave forms necessary for a training mock-up of laptop PC based relay testing and calibration system for approval.
  - 3. Provide a copy of the short circuit and coordination study software with a minimum of two licences. For initial training, provide 30 days temporary licence for 10 power engineers.

##### 1.03 QUALITY ASSURANCE

- A. Standards: applicable industry standards of IEEE, ANSI, ASTM, and INETA (InterNational Electrical Testing Association).

- B. O&M Training Instructor Qualifications: Instructors shall:
  - 1. Have in-depth knowledge of the design, packaging, operations, maintenance and trouble-shooting of the systems to be taught.
  - 2. Have schooling in adult education teaching methods or previous satisfactory experience in teaching with emphasis on the subject matter to be covered in the course of instruction.
  
- C. Engineering and Technician Training, Course Provider and Instructor Qualifications:
  - 1. The course instructors shall have schooling in adult education methods or previous satisfactory experience in adult education with a minimum of 2 years in-depth and professional experience in the following components of utility, industrial or traction power systems as they apply to the selected course:
    - 1. software applications for signal and waveform design procedures as applicable to the DC relay testing procedures, and Power quality meters.
    - 2. Theory of protective relay design, operation and calibration procedures as applied to DC power systems
  - 2. Preferred providers are National Technology Transfer, Inc., AVO Training Institute or approved equal.
  
- D. Engineering Short Circuit and Protective Relay Coordination Training Course Provider and Instructor Qualifications:
  - 1. The course instructors shall be a professional engineer with extensive experience in traction power substation system protective relay study. Preferred provider is the equipment manufacturer's consultant providing the short circuit and coordination study for the current contract.

## **PART 2 PRODUCTS**

### **2.01 MATERIALS**

- A. O&M Concept of Training:
  - 1. Classroom and field instruction shall be designed to cover, in detail, the functions of each item of equipment. Fault isolation and trouble-shooting techniques will be covered to the extent necessary to permit a technician to diagnose and repair faulty modules. Instruction shall be designed to provide Authority maintenance personnel with practical experience in the performance of preventive and corrective maintenance. Trouble-shooting and fault isolation of simulated faults shall be provided for each type of equipment in the traction power substation and tie breaker station, including all AC and DC switchgear, rectifiers, and transformers.
  - 2. The Contractor shall develop and provide all operation and maintenance training necessary for Authority-designated personnel to support the power equipment. Classroom instruction shall include not only the anatomy and functioning of the parts under discussion, but the essentials of their routine care including lubrication schedules, adjustments, limits, test frequency, inspection frequency, trouble-shooting, identification by manufacturer's part number, removal and replacement. Instruction shall cover theory of operation of the power systems, individual modules and special protective circuits. Flow diagrams must be used to show sequence of events and time required to complete each event.
  - 3. The course shall include performance of preventive maintenance operations on the equipment and hands-on trouble-shooting of all subsystems.
  - 4. The Contractor shall assume that the Authority's employees have no knowledge of the features of the new equipment. For the purpose of course development and presentation, the Contractor shall assume all Authority students are high

school graduates (or equivalent), and that maintenance personnel will possess the ability to use basic hand tools and electronic test equipment.

5. The Authority shall be permitted to videotape all class presentations.
6. Instruction shall include an evaluation device(s) (written and/or practical tests) designed to measure the extent to which students have met the learning objectives, with an answer key for each of the tests developed. Tests should use a multiple choice format, and have been validated in a pilot course or by some other means agreed to by the Authority (OPER TRNG). Whenever possible, a practical hands-on test shall be developed to demonstrate the transference of operational/mechanical skills.

B. O&M Training Materials

1. First generation reproducible training material shall be developed as specified herein. Training should be conducted using final manuals approved by the Authority and certified by the Contractor as being correct and conforming to as-manufactured (and where appropriate, as-built and as-adjusted) conditions. Manuals shall become the property of the Authority at the end of program. The following training materials for the course shall be developed:
  - a. Instructor material: Instructor material shall be provided for the course.
  - b. Course outline: A course outline with measurable learning objectives shall be provided. The course outline shall provide a topic outline for each item of equipment. Maintenance training shall include a section devoted to system fault analysis and trouble-shooting. The learning objectives shall be stated for each topic.
  - c. Lesson plans: A set of lesson plans shall be developed for each item of equipment corresponding to the topic outline and shall contain the following information: Lesson title, instruction time, objectives, training aids required, instructing sequence (outline), tests, and summary.
  - d. Training aids: Optimum use of visual aids, including 8-inch by 10-inch transparencies, 35-millimeter slides, videos, mockups, and functional representations are required for any equipment which requires theoretical discussion. This may be in the form of an animated schematic, a model of the equipment, an actual device, an interactive video training device or an Authority-approved (TRNG) substitute. All mock-ups become the property of the Authority. Training aids which can be conveyed in electronic file format are preferred, and for any such items, the electronic files shall be provided to the Authority. Any drawings which are not available in electronic file format but which are needed for the course of instruction shall be provided to the Authority in transparency.
  - e. Instructional material: The primary source of instructional material shall be the applicable equipment operation and maintenance manuals, as-built equipment drawings and as-built power and control circuit schematic drawings. In addition, the Contractor shall develop notebooks containing such additional drawings, descriptive information and procedures necessary to ensure that all learning objectives are met in an orderly and timely manner. Workbook material shall be arranged by item of equipment and according to the topic outline.
  - f. Course topic outlines and schedules: The topic outline and schedule for the course shall include the following:
    - 1) Description of course including course objectives and training program level.
    - 2) Course length and recommended number of students per course.
    - 3) List of training materials required including documentation and equipment.

- 4) Objective for each topic and the time allotted for each topic.
  - 5) Schedules listing the major topics and sub-topics with a time allocation for each topic and sub-topic.
- g. Instructor guides and training aids: The instructor guide for the course shall include:
- 1) Table of contents listing each topic and the time allotted.
  - 2) List of applicable documents.
  - 3) List of training materials.
  - 4) Course learning objectives including course length and recommended number of students.
  - 5) Each topic with a cover sheet listing topic, objective, time allotted, and training aids required.
  - 6) Training aids.
- h. Student workbook: Copies of operations and maintenance procedures, as-built diagrams, drawings and schematics shall be reproduced from engineering data and manuals by the Contractor for inclusion in a student workbook.
- C. Engineering and Technician Training Concept of Training:
1. Classroom instruction shall be designed to cover, in detail, the following procedures and design criteria:
    - a. AC / DC Protective Relay Calibration Procedures
    - b. The theory and application of AC/ DC traction power system protective device coordination studies including the interpretation and application of AC and DC protective device timing curves to equipment protection within transit authorities
    - c. The design, operation, testing, trouble-shooting, repair and calibration of AC/DC over-current and rate of rise protective relays, recloser relays and energized/grounded structure relays. The provided mockup is to be used for instructional purposes to demonstrate the process of troubleshooting and calibrating the AC and DC relays
    - d. The methods for performing tests on installed and operational AC/ DC Switchgear with particular emphasis on electrical isolation equipment and techniques to perform multiple measurements concurrently without causing ground loops
  2. At the conclusion of the course the students should be able to recognize and correct relay operating problems, calibrate AC/DC relays and obtain test measurements on operating AC/DC switchgear using laptop PC based measurement software and associated hardware, setup the provided power quality meter, retrieve store data in the power quality meter using laptop PC based provided software.
  3. Instruction shall include an evaluation device(s) (written and/or practical tests) designed to measure the extent to which students have met the learning objectives, with an answer key for each of the tests developed. Tests should use a multiple choice format, and have been validated in a pilot course or by some other means agreed to by OPER TRNG. Whenever possible, a practical hands-on test shall be developed to demonstrate the transference of operational/mechanical skills.
  4. For the purpose of course development and presentation, the Contractor shall assume all Authority students are high school graduates (or equivalent), and that maintenance personnel will possess the ability to use basic hand tools and electronic test equipment.
  5. Training courses shall be conducted on Authority property. Necessary training material, mockups, AC/DC protective relays and contractor-supplied test equipment may be shipped to and stored at the training facility in coordination with the Authority (OPER-TRNG).

D. Engineering and Technician Training- Training Materials

1. Course Outline: A course outline with measurable learning objectives shall be provided. The course outline shall provide a description of the course and duration, recommended class size, instructor qualifications, list of training materials including documentation and equipment, topic outline for each item of equipment and time allotted for each topic.
2. Instructor's Guide: An instructor's guide for the course shall include a table of contents for each topic and the time allotted; a list of applicable documents and training materials; course learning objectives; course length and recommended number of students; training aids.
3. Student Manual / Workbook shall include all materials necessary for student interaction in the learning process and may serve as a field reference at the conclusion of the course. A copy of the Student manual / Workbook will be provided to each participant enrolled in training classes and one copy shall be provided to OPER TRNG for archival purposes. It shall contain, at a minimum:
  - 1) Program Overview / Introduction
  - 2) Statement of overall course goals
  - 3) Learning Objectives, stated in measurable terms, that describe desired skills or knowledge to be obtained
  - 4) Prose treatment, not outline format, of a fully developed content presentation, developed in the same modular format as the instructor's guide.
  - 5) Illustrations, charts, graphics and duplication of visual aids used during the course presentation in order to enhance content presentation and provide a course reference during later field use.
  - 6) A Problems or Frequently Asked Questions section related to lesson content, as appropriate.
4. Visual Aids: Handouts, transparencies, slides, films or computer presentations are required for each circuit or wiring diagram and all activities not demonstrable in lecture or hands-on instruction.
5. Supplemental Materials: A functional mockup of the installed switchgear containing the subject relays. Auxiliary relays and indicating lights may be used to simulate circuit breaker operation within the mockup. Theoretical discussion of the operation of the system should be supplemented with an animated schematic or an interactive video training device or a TRNG-approved substitute.
6. In addition to the training mockup, a sufficient number of each type of relay should be supplied so as to allow students to acquire hands-on familiarization while at their desks/tables during training lecture and discussion periods.

E. Engineering Training: Concept of Training and Material

1. Training shall be scheduled through the Traction Power Assistant Chief Engineer's office.

2. Training shall be conducted using the final short circuit and protective devices coordination study approved by the Authority and certified by the Contractor as being correct and conforming to as-manufactured (and where appropriate, as-built and as-adjusted) conditions.
3. Manual / Workbook shall include all materials necessary to present in a step-by-step, simplified, yet comprehensive work fashion, the principles of system protection and the proper application and coordination of those components that may be required to protect traction power substation systems. A copy of the manual / Workbook will be provided to each participant enrolled in training classes and one copy shall be provided to the assistant chief engineer's office for archival purposes. It shall contain, at a minimum:
  - 1) Program Overview / Introduction
  - 2) Statement of overall course goals
  - 3) The theory and application of AC/ DC traction power system protective device coordination studies including the interpretation and application of AC and DC protective device timing curves to equipment protection within extra heavy transit traction power substation.
  - 4) AC and DC short circuit calculation.
  - 5) AC and DC protective device coordination.
  - 6) Application of commercial software for power system analysis.

## **2.02 O&M COURSE OF INSTRUCTION:**

- A. The course of instruction shall be developed and conducted by the Contractor and given by the Contractor to those individuals designated by the Authority. It shall consist of in-depth instruction on the fundamentals involved in the design of the complete system combined with practical aspects of operation and maintenance. It shall also include the following:
  1. Practical exercises that require the trainees to make use of the operation and maintenance manuals and parts identifiers.
  2. Familiarization with the assembly, subassembly and components that make up a total system. This part of the course shall include instruction and practical exercises in trouble-shooting at a level higher than that performed by equipment operators.
  3. Use and replacement of original assemblies, subassemblies and components with compatible assemblies, subassemblies and components manufactured by others where applicable.
  4. Handouts to all trainees that include information drawings, shop drawings, catalog cuts, manufacturers literature, equipment maintenance check lists and other literature describing the total system.
  5. Video and color slide presentations showing system installation, operation, trouble-shooting, maintenance, module removal and replacement.
  6. Tools and test equipment necessary to conduct operation and equipment maintenance trouble-shooting.

- B. Supplemental Training: In the event the Contractor changes or performs modifications to the equipment subsequent to the training that impact form, fit and/or function, the Contractor shall provide supplementary training to the Authority's training instructor on a one-time basis.

### **2.03 ENGINEERING AND TECHNICIAN COURSE OF INSTRUCTION**

- 1. The course of instruction shall be developed and conducted by the contractor or the contractor's approved representative to those individuals designated by the Authority. It shall consist of in-depth instruction of the fundamentals involved in the design of the complete system combined with practical aspects of operation, maintenance, testing and calibration. It shall also include the following:
  - a. practical exercises that require the trainees to make use of software to develop and apply wave forms, operation and maintenance manuals, parts identifiers, schematics, time curves, published industry standards and procedures and other applicable reference materials
  - b. familiarization with the assembly, subassembly and components that make up a total system
  - c. use and replacement of original assemblies, subassemblies and components with compatible assemblies, subassemblies and components manufactured by others where applicable
  - d. handouts to all trainees that include information drawings, shop drawings, catalog cuts, manufacturer's literature, equipment maintenance and calibration check lists, parts lists and other literature describing the total system
  - e. video and color slide presentation showing system installation, operation, trouble-shooting, maintenance, module removal and replacement
  - f. recommended tools and test equipment necessary to conduct operation and equipment maintenance trouble-shooting both in the field and at the bench.

### **2.04 O&M TRAINING EQUIPMENT**

- A. Installed equipment shall be used in the course of instruction.
- B. Training shall include practical exercises that permit the trainees to perform hands-on work using installed equipment under normal operating conditions.
- C. Training equipment: Any special tools required for maintenance training shall be supplied by the Contractor and delivered to the Authority after completion of the course.
- D. Test equipment: Test equipment required for maintenance training shall be supplied by the Contractor and delivered to the Authority after completion of the course.

### **2.05 ENGINEERING AND TECHNICIAN TRAINING EQUIPMENT**

- A. Necessary training equipment, mockups, contractor-provided relays and contractor-supplied test equipment may be shipped to and stored at the training facility in

coordination with OPER-TRNG. Installed Authority-owned typical protective relays may be provided in coordination with and conditionally based on the approval of OPER-TRNG.

- B. Installed Authority-owned equipment may be used in coordination with and conditionally based on the approval of OPER- TRNG.
- C. Training shall include practical exercises that permit the trainees to perform hands-on work using contractor-supplied equipment or Authority-owned installed equipment conditional to OPER-TRNG approval.
- D. Training equipment: Any specialized tools, other than basic hand tools, laptop/notebook computers, application software, connection and interface devices required for training shall be supplied by the contractor.
- E. Test Equipment: Specialized test equipment, other than standard VOMs, laptop/notebook computers, application software, connection and interface devices required for training shall required for maintenance training shall be supplied by the contractor.
- F. All computers received and owned by WMATA shall be procured and processed per Authority Published P/I (Policy and Instruction).

**PART 3 EXECUTION**

**3.01 TRAINING APPLICATION**

- A. The training program shall consist of the following:

Course Title	Course Length	Class size in persons	Number of Courses	Total number of course hours per person per class
Operation and Maintenance Training	80 hours	25	2	80
Engineering and Technician Training	32 hours	10	1	32
Engineering	24 hours	10	1	24

- B. Practical training on equipment shall be not less than 60% of the course duration.
  - 1. Location: The contractor shall provide training facility with disclaimer allowing WMATA to select and provide a facility for certain selected courses at the engineers discretion.
  - 2. Times: Class times will be at the convenience of the Authority.

**END OF SECTION**

## SECTION 16060

### GROUNDING AND BONDING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing complete grounding and bonding system.
- B. Related Work Specified Elsewhere:
  - 1. Fencing: Section 02820.
  - 2. Earth tunneling: Section 02415.
  - 3. Fabricated gray iron and ductile iron segmental tunnel lining: Section 02416.
  - 4. Fabricated steel segmental tunnel lining Section 02417.
  - 5. Concrete reinforcement: Section 03200.
  - 6. Piping systems: 15205
  - 7. Wire, cable and busways: Section 16120.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. National Electrical Code (NEC)
  - 3. ANSI/IEEE 80-2000, IEEE Guide for Safety in AC Substation Grounding.
  - 4. UL 467, Grounding and Bonding Equipment..
  - 5. American Standards of Testing and Materials (ASTM) B187-00, Standard Specification for Copper Bar, Bus Bar, Rod and Shapes.
  - 6. ITS: Directory of ITS Listed Products.
- B. Source Quality Control:
  - 1. Each item, except for exothermic-welded electrical connections, listed per referenced UL or ITS directory.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings.
  - 2. Certification.
    - a. Certified test reports verifying that ground resistance of each ground grid when installed and each ground bus when connected to ground grid does not exceed specified values.

##### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Mark each item in accordance with applicable reference standard.
- B. Ship each unit securely packaged and labeled for safe handling and to avoid damage.
- C. Store equipment in secure and dry storage facility.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. Grounding and Bonding Equipment:
1. General Requirements:
    - a. UL 467.
  2. Ground rods: Solid steel, with stainless steel or copper jacket, one-inch or 5/8-inch diameter as shown, by 10 feet long or of necessary length in 10-foot sections.
  3. Grounding conductor:
    - a. Grounding electrode conductors:
      - 1) Insulated or bare conductor, as shown, in accordance with the following:
        - a) Insulated conductor: As specified in Section 16120 for single-conductor cable.
        - b) Bare conductor: Section 16120.
      - 2) Size:
        - a) For use in ground grid and for connecting of ground grid to ground bus: 4/0 AWG.
        - b) For connection of ground bus in train-control, communications, electrical, dispatcher, Bell system and mechanical rooms to main ground bus in ac-switchboard rooms: 2/0 AWG.
        - c) For other grounding electrode conductors: In accordance with NEC Table 250-66.
    - b. Equipment grounding conductor:
      - 1) Sized in accordance with NEC Article 250-122 unless otherwise shown.
      - 2) Insulated equipment grounding conductor: Single-conductor cable as specified in Section 16120.
      - 3) Bare equipment grounding conductor integral with multiple-conductor cable: Section 16120.
    - c. Bonding conductor for stray current and cathodic protection and electrical continuity:
      - 1) Insulated or bare conductors, as shown, in accordance with the following:
        - a) Insulated conductors: As specified in Section 16120 for single-conductor cable.
        - b) Bare conductor: Section 16120.
      - 2) Size: As shown or as specified.
  4. Bus bar: ASTM B187-00, 98-percent-conductivity copper bus bar, size two inches wide by 1/4-inch thick, length as necessary.
  5. Terminal lugs:
    - a. For 4/0 AWG and smaller conductors: Copper compression terminal lugs.
    - b. For 250 MCM and larger: Long-barrel, copper, double-compression terminal lugs.
  6. Ground connector:
    - a. O-Z, Type KG or equal.
    - b. Two-piece, designed for connecting grounding conductor to bus bar.
    - c. Copper-alloy body and silicon-bronze bolt, nut and lock washer with interlocking clamp.
  7. Jumpers: Copper braided or leaf-type flexible jumper, size as necessary.
  8. Bus-bar insulators: Fiberglass reinforced-polyester insulator with 1/2-inch diameter threaded holes at both ends for bus-bar installation.
  9. Exothermic welded electrical connections:
    - a. Exothermic process using powdered metals contained in a mold to form a molecular bond between materials to be connected without application of an external source of heat or power in accordance with ANSI/IEEE 80-2000.

- b. Molds, weld metal and associated accessories designed for making electrical connections between copper and copper, copper and steel, copper and cast iron and copper and ductile iron as required.
- c. Welding system designed for making connections suitable for the application as follows:
  - 1) Connections made outdoors for grounding using the standard process and not containing phosphorous or any caustic, toxic or explosive materials.
  - 2) Connections made indoors or in confined spaces for grounding using a low-smoke, low-emission process.
  - 3) Connections made specifically for cathodic protection applications using the standard process.
- d. Molds made of graphite with permanent marking indicating name of manufacturer, model, conductor size, and type and size of welding mixture compatible with the welding process. Mold connection type suitable for making connections between various configurations of items as shown or specified.
- e. Weld metal consisting of copper oxide and aluminum contained in a moisture-resistant container along with other necessary materials required for the specific application as determined by the manufacturer. Container for applications other than low-smoke, low-emission process to also include suitable starting material.
- f. Container for weld metal identified with part number, type of metals to be connected and application such as standard outdoor, low emission or cathodic application.

### **PART 3 - EXECUTION**

#### **3.01 GROUNDING:**

- A. Ground Connections:
  - 1. Weld buried ground connections exothermically, in accordance with manufacturer's recommendations. Clean and coat with coal-tar epoxy before backfilling. Encapsulate with epoxy resin buried ground connection of grounding electrode conductors running to ground bus.
  - 2. Use terminal lug to connect grounding conductor to equipment enclosure. Use ground connector to connect grounding conductor to ground bus. Secure connector or terminal lug to the conductor so as to engage all strands equally. Install terminal lug using tools and pressure recommended by the manufacturer. Indent mark terminal lug with the number of die used for installation.
  - 3. Exothermically weld connections to ground rods in handholes, junction boxes and manholes, frame columns of bus passenger and bus supervisor shelters and station entrance pylon (type B) and light poles.
  - 4. Splices in grounding conductor are prohibited.
  - 5. For making ground connections located indoors and in confined spaces located outdoors such as manholes, use exothermic welds with low-smoke, low-emission process.
- B. Ground Grid:
  - 1. Install ground grid consisting of ground-grid conductors and ground rods buried in earth in pattern and at locations shown.
  - 2. Use ground rod one-inch in diameter by 10 feet long or of greater length in 10-foot sections as shown.
  - 3. Bury top of ground rod 24 inches minimum below unfinished surfaces.

4. Ensure 24-inch minimum separation between ground rods or bare grounding conductors and concrete structures or soldier piles bonded for stray current and cathodic protection.
5. Interconnect ground rods using 4/0 AWG insulated or bare grounding conductor as shown.
6. For connecting ground grid to ground bus in associated traction-power substation and ac-switchboard room, provide minimum of four 4/0 AWG insulated grounding electrode conductors as shown.
7. For connecting ground grid to ground bus in dc tie-breaker station, chiller plant, fan shaft and drainage-pumping station, provide two 4/0 AWG insulated grounding electrode connections.
8. For additional grounding of service transformer in outdoor location, provide one grounding electrode conductor from nearest ground grid to transformer pad.
9. Unless otherwise shown, leave pigtail, three-feet six-inches minimum length, above finished floor for connection to ground bus or service-entrance equipment.
10. When ground grid is provided for electrical room, connect ground grid to ground bus in electrical room with two 4/0 AWG insulated grounding electrode conductors.

C. Ground Bus:

1. Install ground bus bar, two inches wide by 1/4-inch thick, around the inside periphery of traction-power substation, dc tie-breaker station, ac-switchboard room and electrical rooms; on full length of wall adjacent to service equipment such as switchboard and motor controls in chiller plants and mechanical rooms.
2. Install ground bus bar, two inches by 1/4 inch by 24 inches long in train-control, communications, dispatcher, Bell system and mechanical rooms, kiosk, fan shafts, drainage-pumping stations, escalator pits, elevator rooms, battery rooms and where shown.
3. Mount ground bus bar on insulators two feet above finished floor, unless otherwise shown, using cap screws and expandable threaded anchor.
4. Provide insulator support at each end of ground bus and at three-foot intervals.
5. In traction-power substation, dc tie-breaker station, ac-switchboard room, chiller plants, fan shafts, and drainage-pumping station, connect the ground bus to 4/0 AWG grounding electrode conductor running from associated ground grid.
6. In train-control, communications, electrical, dispatcher, Bell system and mechanical rooms, escalator pits, elevator rooms, battery rooms and other locations shown, connect ground bus to main ground bus in associated ac-switchboard room, traction-power substation or dc tie-breaker station, using 2/0 AWG insulated conductor.
7. Install 4/0 AWG insulated ground conductor, sub-ground bus, with one end connected to ground bus in ac-switchboard room, at following locations:
  - a. In each tunnel for mainline track, support grounding conductor on channel inserts in tunnel wall.
  - b. In each cable trough and ductbank along mainline track, install grounding conductor in cable-trough area and conduit reserved for ac power.
  - c. In each cable space under station platform, install grounding conductor on channel inserts on wall.
8. Installing grounding connections in train-control and communication rooms:
  - a. The only ground connection on the bus bar provided for train control and communication equipment grounding is the cable leading to the A. C. Switchboard room.
  - b. Do not bond equipment or metallic structure to the ground bus provided for train control equipment.
  - c. For items requiring bonding, have the bonding conductors go to the nearest ground bus beyond the ground bus provided for train control equipment.
  - d. Grounding transformers to the dedicated train control and communication room ground bus bars is not permitted.

- D. Equipment Grounding Conductor: Provide insulated equipment grounding conductor for following services and as shown:
1. Feeders.
  2. Branch circuits.
- E. Grounding of Service Equipment:
1. Ground in accordance with NEC.
  2. Ground enclosure and ground bus in switchgear, switchboard, motor-control center or panelboard to ground bus provided in substation or room using insulated grounding electrode conductor.
  3. Install copper bonding jumper between neutral and ground bus as shown.
- F. Grounding of Separately Derived AC System:
1. Ground in accordance with NEC.
  2. Ground secondary neutral and enclosure of transformers to nearest ground bus or sub-bus using insulated grounding electrode conductor.
  3. For transformer located outside of building, install additional grounding connector between transformer secondary neutral/enclosure and ground bus or grid using insulated grounding electrode conductor.
- G. Grounding for Personnel Safety:
1. In substation, electrical and mechanical rooms, tie-breaker stations, chiller plants, fan shaft and pumping stations, bond exposed metallic structure, motor frame, ac-equipment enclosure, ductwork and metallic piping to local ground bus, using minimum of 6AWG insulated grounding conductor as follows:
    - a. Ground multiple items of exposed metallic structure to local ground bus using a separate grounding conductor for each item or by using series-connected grounding conductors to connect two or more items.
    - b. Ground each ac equipment enclosure to local ground bus using a separate grounding conductor.
    - c. Connection of grounding conductor for ac equipment enclosure in series with grounding conductor for exposed metal structure is prohibited.
  2. Bond escalator's and elevator's motor frames, ac-equipment enclosures and metallic structures to equipment grounding conductor in ac-power feeder and to local ground bus bar. Provide a second ground path, connecting trusses and guide rails, using a #1/0 AWG insulated ground conductor connected to ground bus bar in A. C. Switchboard room. Leave 20-foot length of conductor coiled up in pits or wellway for making the grounding connections to trusses and guide rails by the escalator stage contractor.
  3. Bond metallic ladders and stairs in fan shafts, vent shafts and other locations to local ground bus, using insulated grounding conductor, 6AWG minimum.
  4. Bond and ground exposed metallic structures in open areas to separate grounding electrode in accordance with the following requirements:
    - a. Metal pole for mounting light fixtures: Bond and ground each metal pole to separate 5/8-inch diameter by 10-foot long ground rod, buried with top two feet below grade with two-foot separation from footing, using 6AWG insulated grounding conductor.
    - b. Cable troughs alongside track: Bond and ground metal cable troughs to 5/8-inch diameter by 10-foot long ground rod, buried with top two feet below grade, at approximate 50-foot intervals and at each end with two-foot separation from reinforced or buried metallic structures, using 4AWG insulated grounding conductor. At expansion and contraction joints, install 4AWG insulated grounding conductor for electrical continuity.
    - c. Metallic railings and fences alongside track: Bond and ground railings and posts for galvanized steel fence to 5/8-inch diameter by 10-foot long ground rod, buried with top two feet below grade, at approximate 50-foot intervals

and at each end, with two-foot separation from railing and fence-post footing and other reinforced structure, using 4AWG insulated grounding conductor. For electrical continuity, where necessary, install flexible copper braided or leaf-type jumper or 4 AWG insulated grounding conductor. In addition to the above requirements for grounding galvanized steel fences, provide the following for grounding PVC-coated steel fences:

- 1) Bond and ground each fence post to bottom tension wire using 6AWG bare grounding conductor, O-Z Type CG, Burndy Type GAR or equal connector at fence post, and Burndy Type KS or equal tap connector at tension wire.
  - 2) At connections of grounding conductors to posts and tension wires, remove vinyl coating at contact surfaces before making connections and apply vinyl coating over finished connections to match original coating.
- d. Railing, cable trough and metallic-deck structure at aerial track:
- 1) In each abutment and pier, install 4/0 AWG insulated grounding conductor with one end connected to pile or one-inch diameter by 10-foot long ground rod, buried with top two feet below grade, with two-foot separation from concrete structure and three-foot pigtail on the top of pier or abutment for bonding and grounding of deck structure.
  - 2) Bond and ground deck structure, cable trough and hand railing to 4/0 AWG insulated grounding conductor installed at each abutment and pier using 4AWG insulated grounding conductor. For providing electrical continuity, where necessary, install flexible copper braided or leaf-type jumper or 4AWG insulated grounding conductor.
5. In underground locations, bond and ground hand railing and metallic safety walk grating at each end and at approximate 50-foot intervals to nearest ground bus or sub-bus, using 6AWG insulated grounding conductor. For electrical continuity, where necessary, install flexible copper braided or leaf-type jumper or 6AWG insulated grounding conductor.
6. Bus passenger and supervisor shelters equipped with light fixtures: Provide multiple ground paths as follows:
- a. Bond and ground two separate frame columns of each single or double bus passenger shelter or supervisor shelter to two separate ground rods using 6AWG insulated grounding conductor. Drive 5/8-inch diameter by 10-foot long ground rod with top of rod six inches below finished grade.
  - b. Bond and ground each shelter to equipment grounding conductor in branch circuit.
7. Passenger shelter equipped with illuminated diorama and receptacle at station platform: Provide multiple ground paths as follows:
- a. Bond and ground two separate frame columns of each shelter to nearest ground bus in electrical room or sub-bus or to 5/8-inch diameter by 10-foot long ground rod driven so that the top of rod is three inches above finished floor of under platform space using 6AWG insulated grounding conductor unless otherwise shown.
  - b. Bond and ground each shelter to equipment grounding conductor in branch circuit.
8. Illuminated diorama, station pylon equipped with light fixtures, map case and telephone enclosure: Provide multiple ground paths as follows:
- a. Bond and ground illuminated diorama frame, column of station pylon equipped with light fixtures, map case and telephone enclosure to nearest ground bus in electrical room or sub-bus or to 5/8-inch diameter by 10-foot long ground rod driven so that the top of rod is three inches above finished floor of under platform space using 6AWG insulated grounding conductor unless otherwise shown.

- b. Bond and ground frame of each illuminated diorama, pylon equipped with light fixture, map case and telephone enclosure to equipment grounding conductor in branch circuit.
- 9. Station entrance pylon (Type B): Provide multiple ground paths as follows:
  - a. Bond and ground the pylon frame using 6AWG insulated grounding conductor to 5/8-inch diameter by 10-foot long ground rod driven so that top of rod is six inches below finished grade.
  - b. Bond and ground the pylon frame to equipment grounding conductor in branch circuit.
- 10. Handhole, manhole and junction box metallic body, cover frame and cover: Provide a minimum of two ground paths as follows:
  - a. Bond and ground handhole, manhole and junction box metallic cover frame and metallic body to 5/8-inch diameter by 10-foot long ground rod driven with top of rod three inches above bottom of manhole, handhole and junction box using 6AWG insulated grounding conductor.
  - b. Provide a minimum of 6AWG insulated grounding conductor and a bronze or brass chain with 210-pound breaking strength in a 1/2-inch or 5/8-inch rubber hose to bond metallic cover to metallic cover frame. Length of cable, chain and hose as required to allow removal of cover adjacent to and clear of handhole and/or manhole opening.
  - c. When cable is spliced in handhole, manhole or junction box, bond metallic cover frame and body to equipment grounding conductor.
- 11. Exothermically weld or gas torch braze grounding and bonding connection to exposed metallic structure, metallic cable trough, galvanized steel fence, hand railing, metallic safety walk grating, map case and telephone enclosure, frame columns of shelter, pylon and diorama, and metallic cover, metallic cover frame and metallic body of handhole, manhole and junction box. Repair damaged galvanized coating in accordance with Section 02820. Repair finish of shelter, map case and telephone enclosure and diorama frame to match existing finish.

### **3.02 BONDING FOR STRAY CURRENT AND CATHODIC PROTECTION:**

- A. Reinforcing Steel in Tunnel, At-Grade and Aerial Sections:
  - 1. Bond reinforcing steel using 250 MCM, Class G, stranded bare conductor exothermically welded to steel straps as shown, in accordance with Section 03200.
- B. Floating-Slab Expansion Joints:
  - 1. Bond floating-slab expansion joints, using 1/0 AWG, Class G, stranded bare conductor exothermic welded to longitudinal bar.
- C. Fabricated Gray-Iron or Ductile-Iron Tunnel-Lining Segments:
  - 1. Bond gray-iron or ductile-iron segments as shown in accordance with Sections 02415 and 02416.
- D. Fabricated Steel Tunnel-Lining Segments:
  - 1. Bond steel segments as shown in accordance with Sections 02415 and 02417.
- E. Metallic Pipe:
  - 1. Bond across joint for the following pipe, pipe fittings and pipe appurtenances, except those welded or soldered joints, using 2AWG insulated conductor as shown and in accordance with Section 15205.
    - a. Buried pipe, except soil pipe unless shown bonded.
    - b. Pressure pipe.
    - c. Pipe parallel to and within 20 feet of centerline of track.

2. Do not bond District of Columbia, Department of Public Works (DCDPW), buried piping systems
- F. Permanent Metal Piles:
1. Interconnect permanent metal piles, except those used in ground grid, using 4/0 AWG insulated conductor exothermically welded to piles. At each end of line of bonded piles, connect 4/0 AWG insulated conductor and terminate it in box inside line structure. Identify conductor termination using non-metallic tags or plastic labels attached to conductor with slip-free plastic lacing or nylon bundling strap.
- G. Drainage Cables in Tunnel, At-Grade and Aerial Sections:
1. Between bonded reinforcing steel and negative switchboard in traction-power substation, install stray-current discharge cable in accordance with the following requirements:
    - a. Adjacent to each traction-power substation, install two 250 kcmil, Class G, stranded bare conductors, one end of each conductor welded to the reinforcing steel which has been bonded as specified herein, and the other end terminated in 12-inch by 18-inch by 4-inch junction box.
    - b. From the junction box, install two 250 kcmil insulated cables in FRE conduit to dc negative switchboard area of the traction-power substation for future connection by others.
- H. Separate reinforcing steel and other buried metallic structures, bonded for stray current and cathodic protection, from ground grid, grounding electrode, or exposed metallic structures grounded for personnel safety. Metallic contact or electrical bonding between two systems is prohibited.

### **3.03 FIELD QUALITY CONTROL:**

- A. Test ground resistance of each ground grid after installation and each ground bus when connected to ground grid, using approved test procedure.
- B. Ground resistance not to exceed the following:
1. Ground grid/bus in ac-switchboard rooms, chiller plants, and traction-power substations: Two ohms.
  2. Ground grid/bus in fan shafts, drainage-pumping stations, electrical rooms, dispatcher rooms, Bell system rooms, mechanical rooms and dc tie-breaker stations: Five ohms.
- C. To meet resistance requirements, install additional ground rods or use permanent metal piles as ground rods.
- D. Isolate permanent metal piles used for grounding from those bonded for stray-current and cathodic protection.
- E. Test metallic conduits and raceways, metallic enclosures for equipment, metallic cable troughs, fences, metallic hand railings, metallic safety walk gratings, metallic structures, metallic covers, cover frames and bodies of manholes, handholes and junction boxes, frames of shelters, pylons and dioramas, map case and telephone enclosures, and poles for mounting lighting fixtures for continuity to grounding system.
- F. Test resistance of connection between ground bus in train-control rooms/communications rooms and ground bus in associated ac-switchboard rooms, traction-power substations or dc tie-breaker stations for resistance not to exceed one ohm.

- G. Conduct tests in presence of Engineer.
- H. Inspect and test exothermic welds as follows:
  - 1. Inspect finished exothermic welds for visual characteristics that are consistent with a properly made connection in accordance with the manufacturer's instructions and recommendations. Remove welds that do not meet minimum visual requirements as acknowledged by the Engineer, and reweld after cleaning the area to be welded.
  - 2. Test mechanical strength of exothermic weld by applying three sharp blows to the weld with a two-pound hammer using 15-inch strokes. Acceptable welds to sustain the blows without cracking the weld metal or the bond between the two connecting materials. Remove defective welds and reweld after cleaning the area to be welded.

**END OF SECTION**

## SECTION 16120

### WIRE, CABLE AND BUSWAYS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing wire, cable and busways.
- B. Definitions:
  - 1. Cable: Cable having low smoke generating characteristics.
- C. Requirements for single-conductor cable and for multiple-conductor cable as stated except as otherwise specified.
- D. Related Work Specified Elsewhere:
  - 1. Grading, excavating and backfilling: Section 02320.
  - 2. Wire connection accessories: Section 16125.
  - 3. Raceways, boxes and cabinets: Section 16130.

##### 1.02 QUALITY ASSURANCE:

- A. Qualifications: Select a manufacturer who is engaged in production of similar wire, cable and busways.
- B. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. National Electrical Code (NEC).
  - 3. Insulated Cable Engineers Association (ICEA): S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, S-81-570.
  - 4. IEEE: 1202-1991 IEEE Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies, 383-1974 IEEE Standard for Type Test of Class 1E Electrical Cables, Field Splices, and Connections for Nuclear Power Generating Stations.
  - 5. National Electrical Manufacturers Association (NEMA): BU1, WC70, WC71, WC74.
  - 6. American National Standards Institute (ANSI): *C37.20.1, Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear; C37.20.2, Metal-Clad and Station-Type Cubicle Switchgear; C37.20.3, Metal-Enclosed Interrupter Switchgear; Z55.1, Gray Finishes for Industrial Apparatus and Equipment.*
  - 7. UL: 44, Rubber-Insulated Wires and Cables Thermoset-Insulated Wires and Cables; 62, Flexible Cord and Fixture Wire; 857, Electric Busways and Associated Fittings; and 1581, Standard for Electrical Wires, Cables, and Flexible Cords.
  - 8. American Standards of Testing and Materials (ASTM): B3-95, Standard Specification for Soft or Annealed Copper Wire; B8-99, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft; D471-98e1, Standard Test Method for Rubber Property-Effect of Liquids, E662-97, Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials.
  - 9. ITS: Directory of ITS Listed Products
- C. Source Quality Control:
  - 1. Cable and busways: Listed or labeled per UL or ITS directory.

### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings.
  - 2. Samples:
    - a. Smoke-density test sample for jacket material: Specified sample will become property of the Authority.
  - 3. Certification:
    - a. Certified flame-retardancy test reports (VW-1, IEEE 383, and IEEE 1202, Article 18) and data for tests performed not more than 12 months prior to submittal, for materials which are identical to those of cable furnished. Include test reports with submittal of shop drawings.
    - b. Submit smoke-density test reports and data for tests performed on the jacket material not more than 12 months prior to the submittal, for materials which are identical to those of the furnished cable. Include test reports with submittal of shop drawings.
    - c. Certified test reports demonstrating that cable complies with specified requirements and those of referenced ICEA Standards. Submit test reports prior to cable shipments.
    - d. Certificates from manufacturers verifying that products conform to specified requirements. Include certificate with submittal of shop drawings and with each cable shipment.

### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Mark each single-conductor cable, each multiple-conductor cable and each busway to show label per referenced UL or ITS directory, size, voltage, manufacturer and number of conductors or phases in accordance with NEC requirements.
- B. Ship each unit securely packaged and labeled for safe handling and shipment.
- C. Store products in a dry and secure facility.

## PART 2 - PRODUCTS

### 2.01 PRODUCTS AND MATERIALS:

- A. General Requirements for Single-Conductor and Multiple-Conductor Cable:
  - 1. Type and size: As shown.
  - 2. Rated voltage: 600 volts.
  - 3. Conductors:
    - a. ASTM B3 or B8 annealed copper.
    - b. Size 10 AWG and smaller: Solid or Class B or Class C stranded.
    - c. Size 8 AWG and larger: Class B stranded.
  - 4. Standards: Except as modified, wires and cable complying with the following standards:
    - a. Cross-linked polyethylene (XLPE) insulated cable: ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, S-81-570.
    - b. Other cable: ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, S-81-570.
  - 5. Non-metallic jacket for single-conductor cable and an overall covering on multiple-conductor cable:
    - a. Chlorosulfonated polyethylene or cross-linked polyolefin.

- b. Cross-linked polyolefin complying with the following physical requirements. Properties tested in accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, and S-81-570 if ethylene-propylene-rubber (EPR) insulation is used, or with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692 if cross-linked polyethylene insulation is used. Jacket material free of PVC and PVC-based compounds.
    - 1) Tensile strength, minimum pounds per square inch: 1,800.
    - 2) Elongation at rupture, minimum percent: 150.
    - 3) Aging requirement: After 168 hours in air oven test at 100C, plus-or-minus one degree C:
      - a) Tensile strength, minimum percentage of unaged value: 100.
      - b) Elongation at rupture, minimum percentage of unaged value: 80.
    - 4) Oil immersion: 18 hours at 121C, plus-or-minus one degree C, ASTM D471, Table 1, No. 2 oil:
      - a) Tensile strength, minimum percentage of unaged value: 80.
      - b) Elongation at rupture, minimum percentage of unaged value: 80.
  - c. Jacket materials other than cross-linked polyolefin complying with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692. Jacket material free of PVC and PVC-based compounds.
6. Flame retardancy: Single-conductor and multiple-conductor cable tested by independent agency demonstrating flame retardancy in accordance with the following:
- a. Single-conductor cable and individual conductors of multiple-conductor cable passing vertical wire (VW-1) flame test in accordance with UL1581 or ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692. Cable size for testing: 14AWG.
  - b. Single-conductor cable, size 1/0 AWG and larger, passing vertical tray flame test, using ribbon gas burner in accordance with IEEE 1202 or IEEE 383. Cable size for testing: 1/0 AWG.
  - c. Multiple conductor cable passing vertical tray flame test using ribbon gas burner in accordance with IEEE 383 or IEEE 1202. Cable size for testing: 7/C or 9/C with No. 12 AWG or No. 14 AWG conductors.
7. Smoke generation: Single and multiple-conductor cable jacket materials demonstrating low-smoke generation when tested in accordance with ASTM E662 by independent, nationally recognized testing agency.
- a. Conduct tests on specimens of overall jacket material for multiple-conductor cable and of jacket material for single-conductor cable.
  - b. Prepare slab specimens for each material .100 inch, plus-or-minus .005-inch thick, identical to those of finished cables and meeting minimum physical requirements specified.
    - 1) Prior to testing, submit six-inch square portion of each specimen. Tag sample with manufacturer's jacket or insulation identification code or number.
  - c. Test values for chlorosulfonated polyethylene not to exceed the following:
    - 1) Flaming mode:
      - a) Uncorrected maximum specific optical density during first four minutes of test: 325.
      - b) Uncorrected maximum specific optical density for entire 20-minute test: 400.
    - 2) Nonflaming mode:
      - a) Uncorrected maximum specific optical density during first four minutes of test: 325.

- b) Uncorrected maximum specific optical density for entire 20-minute test: 480.
      - d. Test values for cross-linked polyolefin not to exceed the following:
        - 1) Flaming mode:
          - a) Uncorrected maximum specific optical density during first four minutes of test: 150.
          - b) Uncorrected maximum specific optical density for entire 20-minute test: 300.
        - 2) Nonflaming mode:
          - a) Uncorrected maximum specific optical density during first four minutes of test: 150.
          - b) Uncorrected maximum specific optical density for entire 20-minute test: 300.
8. Applied voltage testing:
  - a. Single-conductor cable and individual conductors of multiple-conductor cable to be given applied ac voltage dielectric-strength test, i.e., six-hour water-immersion test.
  - b. For single conductors of multiple-conductor cable, conduct tests prior to assembly as multiple-conductor cable.
  - c. Test procedures:
    - 1) Polyethylene-insulated conductors: In accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692.
    - 2) Other conductors: In accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, and S-81-570.
- B. Single-Conductor Cable:
- 1. Insulated with ethylene-propylene-rubber with non-metallic jacket as specified. UL-Labeled as Type RHW-2.
  - 2. Color coding: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.
- C. Multiple-Conductor Cable:
- 1. Individual conductors:
    - a. Number of conductors: As shown.
    - b. Construction: Complying with one of the following:
      - 1) Insulated with ethylene-propylene-rubber, with or without non-metallic jacket.
      - 2) Insulated with composite compound of ethylene-propylene-rubber and polyethylene, without outer jacket.
      - 3) Insulated with filled cross-linked polyethylene without jacket.
    - c. Phase and neutral conductors: Individually insulated.
    - d. Neutral conductors: Same size as phase conductors.
    - e. Bare ground conductors: Sized in accordance with the NEC, unless otherwise shown.
    - f. UL Listed as Type RHW-2 or XHHW-2.
  - 2. Conductors assembled with nonwicking, flame-retardant filler to form cable of circular cross section.
  - 3. Metallic sheath:
    - a. Provide one of the following:
      - 1) Size 1 AWG and larger:
        - a) Interlocked aluminum-tape armor.
        - b) Continuous corrugated aluminum sheath conforming to ICEA S-19-81, Table 4-26A.
      - 2) Size 2 AWG and smaller: As specified for 1 AWG and larger or continuous smooth aluminum sheath conforming to ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692.

- b. Metallic covering not required for multiple-conductor TC cable with overall non-metallic jacket when installed in cable tray.
  - 4. Multiple-conductor cable provided with overall non-metallic jacket as specified.
  - 5. Cable UL-listed as follows:
    - a. Non-metallic-sheathed cable: Type TC, suitable for wet and dry locations.
    - b. Metallic-sheathed cable: Type MC, suitable for wet and dry locations.
  - 6. Color coding:
    - a. Power cables: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.
    - b. Control cables: In accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692.
- D. Fixture Wire: UL 62, with the following additional requirements:
  - 1. Type: SF-2 silicone-rubber insulated or as necessary to suit temperature rating of lighting fixture, minimum 90C.
  - 2. Conductor: Stranded copper conductor 16AWG or larger as shown.
- E. Bare Conductors: ASTM B3 or B8, annealed copper conductor; 8AWG and larger, Class B stranded, unless otherwise shown or specified.
- F. Busway (Busduct) and Fittings:
  - 1. UL 857, NEMA BU1.
  - 2. Totally enclosed, three-phase, four-wire feeder busway system, as shown, with necessary fittings, hanging devices, accessories and provision for flange bolting over circuit breaker.
  - 3. Continuous current rating:
    - a. Secondary tie duct for use in combined substation: Sized in accordance with ANSI C37.20.1, C37.20.2, C37.20.3, and NEC.
  - 4. Voltage rating: 480/277 volts.
  - 5. Busway system braced to withstand minimum short-circuit current of 75,000 amperes symmetrical, unless otherwise shown.
  - 6. Maximum allowable temperature rise in busway at continuous full load above maximum ambient temperature of 40C: 55C.
  - 7. Housing: Nonventilated, fabricated from galvanized sheet steel. Removable gasketed cover provided at transformer connection for maintenance and test. Hardware galvanized or cadmium-plated.
  - 8. Joints:
    - a. Single-bolt pressure joint designed for optimum electrical contact and mechanical strength.
    - b. To permit safe testing of its tightness without de-energizing systems.
    - c. To permit removal of duct sections without disturbing adjacent pieces.
    - d. To permit making up joint from one side when busway is installed against wall or ceiling.
  - 9. Busbars: Fabricated from 98-percent-conductivity copper and insulated over entire length except at joints and contact surface. Joints and contact surfaces tin-plated or silver-plated. Neutral bar same size as phase bar. Ground bar half size of phase bar.
  - 10. Entire busway system polarized.
  - 11. Expansion fittings provided where necessary.
  - 12. Flexible connections, braided or laminated, provided for connecting bus conductor to transformer terminals.
  - 13. Finish: Light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.

### PART 3 - EXECUTION

### **3.01 INSTALLATION:**

- A. Install type cable as specified.
- B. Install single-conductor cable in conduit, underfloor duct or wireway. Install UL Type TC multiple-conductor cable in cable trays only. Install UL Type MC multiple-conductor cable and ground cable on channel inserts, cable trays, racks, trench or trough using straps and fasteners as specified in Section 16130. Install UL Type MC multiple-conductor cable in conduit where shown or required. On walls or ceilings, fasten cable and bus duct directly to channel inserts, or use expansion-bolt anchors to attach to concrete and toggle bolts to attach to concrete masonry unit walls. Splice cable only when unavoidable.
- C. Install motor feeders, service connections and extensions in accordance with reference codes. Install motor feeder in 18-inch minimum length liquid-tight flexible conduit at motor conduit box.
- D. Use nylon straps to bundle and secure wire and cable located in panelboards, cabinets, switchboards, motor control centers and switchgear.
- E. Minimum bending radius 12 times outer diameter of cable. Where shown, use shorter bending radius as permitted by NEC, ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692, and cable manufacturer.
- F. To facilitate pulling cable, use listed per UL or ITS directory lubricant recommended by cable manufacturer.
- G. Use direct-burial cable only for stray current and cathodic protection.
- H. To install direct-burial cable, prepare trench of uniform width and free of sharp projections and rocks and place three-inch bed of sand. Do not pull cable directly into trench from stationary reel; unreel cable beside trench. Place cable on sand bed and backfill with three-inch deep sand cover. Fill remainder of trench with approved fill material and compact in accordance with Section 02320. Provide temporary supports in trench as necessary to prevent damage to insulation or jacket during installation.
- I. In damp and dusty indoor locations, tunnel areas, manholes and outdoor locations, seal cable at conduit termination using duct-sealing compound.
- J. Where shown or necessary, install cable-seal fitting specified in Section 16130 to prevent entry of water into electrical facilities. Where approved, use seal compound specified in Section 16130.

### **3.02 IDENTIFICATION:**

- A. Identify cable terminations, feeders and power circuits using non-metallic fiberboard tags or plastic labels. Attach tags to cable with slip-free plastic lacing or nylon bundling straps. Use designation shown.

### **3.03 FIELD QUALITY CONTROL:**

- A. Furnish equipment required to perform tests. Prior to insulation and high-potential tests, disconnect instruments and equipment which might be damaged during such tests. Conduct tests in presence of the Engineer.
- B. Submit test procedure for approval and perform approved tests including, but not limited to, the following:

1. Single-conductor cable and multiple-conductor cable:
    - a. Test continuity of cable conductors using ohmmeter.
    - b. Proof-test insulation resistance to ground and between insulated conductors for minimum of one minute using 1,000-volt megger. Insulation resistance: 200,000 ohms minimum.
    - c. When cable shows unsteady insulation resistance of less than 200,000 ohms, perform high-potential test at 80 percent of factory ac test voltage or as recommended by cable manufacturer.
  2. Busway:
    - a. Clean contact surfaces before making connections. For bolted connections, apply torque recommended by manufacturer.
    - b. Test resistance of busway connections. Resistance not to exceed value recommended by manufacturer.
    - c. Test insulation resistance to ground and between insulated busbars for minimum of one minute using 1,000-volt megger. Insulation resistance: One-megohm minimum. When busway shows insulation resistance of less than one-megohm minimum, perform high-potential test.
- C. Submit certified test reports.

**END OF SECTION**

## SECTION 16121

### DC SWITCHBOARD, STINGER SYSTEM AND CONTROLS, DC PEDESTAL AND WALL MOUNTED CONTACTOR SYSTEMS FOR S&I SHOP

#### PART 1 - GENERAL

##### 1.1 DESCRIPTION:

- A. This Section covers specifications for furnishing all labor, materials, equipment, services, and tools necessary and required for electrical construction of the following S&I shop traction power systems.
  - 1. 750VDC Switchboard
  - 2. 750 VDC Stinger system for traction power to married pairs for movement inside the shop.
  - 3. 750 VDC Pedestal and wall mounted contactor system

##### 1.2 RELATED SECTIONS

- 1. 16128 - Wire and Cable for Traction Power
- 2. 16130 - Raceways, Boxes and Cabinets
- 3. 16341 - Metal Enclosed DC Switchgear
- 4. 16051 - Scope of Work for Traction Power

##### 1.3 QUALITY ASSURANCE

- A. Qualification: Select a manufacturer how is regularly engaged in the production of "DC switchboard, Stinger system and controls and DC pedestal and wall mounted contactor systems" equipment of the types and ratings described in these specifications using the latest technology and who has proven record of successful manufacturing and testing of same or similar type equipment for the last five (5) years. The equipment manufacturer shall have and maintain ISO9001 or ISO9002 certification.
- B. The work of this Section, including the products, shall satisfy the applicable requirements of the following standards and regulations of Jurisdictional Authorities:
  - 1. National Electrical Code (NFPA 70)
  - 2. ANSI/IEEE
  - 3. OSHA
  - 4. NEMA including WC8
  - 5. UL
  - 6. NESC C2 (Safety Code)
  - 7. IP code ( Ingress protection)

- C. Inspections and Tests:
1. The Engineer and his representatives reserve the right to witness all tests and manufacturer inspections that the Engineer deems necessary.
  2. The Contractor and his supplier shall grant the Engineer, or the Engineer's representative, free entry at all times while work under this Specification is being performed.
  3. The Contractor shall provide, free of cost, reasonable facilities to satisfy that materials and equipment are being furnished in accordance with these Specifications.

#### 1.4 SUBMITTALS

- A. Submittals shall be made in accordance with the requirements of Section 16051 of these specifications.
- B. In addition to the requirements set-forth in other section of the contract and section 16051 of these specifications, the Contractor shall submit to the Engineer, prior to final acceptance of work, a drawing(s) showing the complete layout of the 750 VDC switchboard, stinger system, DC pedestals and wall mounted contactors as well as all UL listings.
- C. The Contractor shall include shop drawings, manufacturer's descriptive literature and published details with performance and capacity rating schedules on chart, for all product specified in Part 2 of this Section. Product shop drawings shall indicate fabrication detail and proposed layouts for shop or field fabrication. Include electrical wiring diagrams, details and all necessary dimensions from assembly and from installation.
- D. Operation and Maintenance Manuals
1. The Contractor shall include the following element in each manual; however not necessarily in the order listed:
    - a. Table of Contents.
    - b. Erection or installation instructions.
    - c. Start-up procedures.
    - d. Schedule of preventive maintenance requirements.
    - e. Detailed maintenance procedures and schedule for any routine periodic maintenance.
    - f. Detailed trouble shooting procedures.
    - g. Corrected and approved control and wiring diagrams.
    - h. Data sheet listing pertinent equipment or system information.
    - i. Color photographs (4"x6") of the constructed and functional stinger system in detail. The photographs shall be bound in a suitable loose-leaf photograph album having individual transparent pages for insertion of the photographs.

j Name, address, and telephone number for each major supplier/manufacturer of the equipment, where spare parts may be obtained for the equipment.

2. The Contractor shall submit the final operation and maintenance manuals to the Engineer or authorized representative. These manuals shall be technically accurate and complete and shall represent the "As-Built" system, piece of equipment, or material. All illustrations, text, and tabular material shall be in final form; copies of all Shop Drawings shall be included for each major piece of equipment.
3. The contractor shall provide six copies of the complete operation, maintenance and repair instruction manuals in paper copies as well as in electronic file media on CDROM. Manuals shall include complete equipment layout drawings, one-line diagrams, elementary diagrams, control schematics, interconnection wiring diagrams, inventory part list with component number, part nomenclature, manufacturer's part number and any third party's part number. Maintenance instructions shall include full descriptive and pictorial literature and all parts of the equipments.
4. The electronic file media shall be in the following formats:
  - a. Drawing in editable AUTOCAD format.
  - b. Text in Word
  - c. Image in Tiff

E. Spare Parts Lists:

1. A list of suggested spare parts for each section to include all items given part number, model number, component name, manufacturer's name, price, phone numbers and suggested quantities.
2. Parts numbers by others shall be identified.

F. Certification:

1. The Contractor shall furnish to the Engineer, the certified copies of the results of all tests and measurements made to determine the quality and serviceability of the manufactured equipment listed in this Specification Section, at no additional cost to WMATA.
2. Certification shall include, as a minimum, the following items:
  - a. DC Stinger System and control - system integration, to include operation with the wheel truing and car progression systems if Provided.
  - b. DC switchboard
  - c. DC Pedestal and wall mounted contactor system

## PART 2 - PRODUCTS

### 2.1 DC SWITCHBOARD:

#### A. DC Switchboard:

1. The shop dc switchboard shall be a dead front, free-standing, metal enclosed assembly, suitable for indoor service. Ambient temperature will not exceed 40°C. The switchboard shall contain dc positive bus and bus connections, a minimum six (6) combination fusible branch circuit switches and magnetic contactors to supply power to a minimum six (6) individual stingers as required, and a minimum twenty (20) fusible branch circuit switches for receptacles at 750 V, dc. The switchboard shall contain terminal connectors and other auxiliary equipment and devices required. Shipping sections including shipping skids shall not be longer than 11'-0".
2. Except as otherwise noted herein, the switchboard shall be designed constructed and tested in accordance with the applicable provisions of ANSI Standard C37.20 and its supplements a, b and c (IEEE Standard No. 27) "Switchgear Assemblies Including Metal Enclosed Bus".
3. The switchboard shall have the following ratings from ANSI C37.20.
  - a. Rating Nominal Voltage 750 volts dc
  - b. Rating Maximum Voltage 800 Volts dc
  - c. Insulated Test Level 2,775 volts dc
  - d. Withstand 3, 900 volts dc
  - e. Short Circuit Rating
    - a. Peak 75,000 amperes
    2. Steady-State 75,000 amperes
    3. Rate-of-rise 2,000,000 amperes per second
    4. Continuous Current Ratings
- F. The switchboard assembly, including all components, shall be designed to safely withstand the available short circuit currents without damage and to limit the available short circuit currents without damage to the dc contactors specified.
4. Description and Materials
  - a. Metal enclosed switchboard structure shall be rigid, self supporting, self contained steel, constructed in accordance with ANSI C37.20 "Standards for switchgear assemblies including metal-enclosed bus". Each branch combination feeder switch and magnetic contactor and each branch feeder switch shall be fully compartmentalized so that they permit isolated access while serving load and confine faults to a single compartment. All switches shall be externally operable. The nominal height of the switchboard shall not exceed 90 inches. The enclosure shall be insulated from and anchored to a concrete floor which will be covered by an insulating topping(Leveling channels will be required). The supplier shall provide the means for insulated anchoring to the finish floor. Wherever the switchboard enclosure is less than three feet from any vertical building surfaces such as a wall or column, the Contractor shall form sheet insulation of a non-hygroscopic type required to insulate the vertical building surfaces to a height of nine feet above the

floor. A 2500 volt 60 Hz high-potential insulation test will be given to the insulation between enclosure and ground and also between the surface of the wall insulation and ground, upon completion of installation.

#### 5. Design

- a. The switchboard shall be designed and arranged to provide convenient access to all components for normal operation and maintenance. The switches, fuses and contactors shall be accessible from the front of the switchboard, but they shall be enclosed behind full height front doors. The front doors shall be full height, not more than 36 inches wide, with viewing windows so that the positions of the switches will be visible without opening the doors. All compartments shall have a hinged doors interlocked with the handle so the door cannot be opened while the switch is in the "ON" position. The front doors shall be key-interlocked with the dc main circuit breaker so that the doors cannot be opened without the insertion of a key, which shall be available from the circuit breaker only when the breaker is open. The key shall be retained in the front door until the door is closed and locked to prevent closing of the circuit breaker with the door open. The front doors shall be designed so that they can be closed and locked when the switches are either open or closed. The bus work and cable connections shall be accessible from the rear of the switchboard. The rear of the switchboard shall be provided with removable covers.

#### 6. Branch Circuit Switches

- a. Each branch switch shall be single pole, Bolted pressure (BPS), non-load break with current limiting fuse. The fuse compartment shall have a hinged door interlocked with the handle so the door cannot be opened while the switch is in the "ON" position. Provisions shall be provided to padlock the switch in the "Off" position.
- b. Branch Circuit switches and fuses supplying power to the stingers shall be rated at 600 amperes at 750V dc. Branch circuit switches supplying power to receptacles shall be rated at 150 amperes at 750V dc.

#### 7. Terminal Connectors

- a. The combination switches, contactors and switches shall be provided with solderless terminal connectors for outgoing cables. Connectors shall be of the long barrel, double indentation, compression type. The connectors shall be of one piece tubular construction formed of pure electrolytic copper and tin-plated to resist corrosion. Each contactor shall be provided with two (2) 250 MCM connectors; each 150 ampere switch with one (1) No. 1/0 connector.

#### 8. Nameplates

- a. Each switch shall be provided with a circuit identifying nameplate attached to the equipment with bolts, screws or rivets. Nameplates shall consist of three-ply laminated phenolic plates (2 1/2"x 6 1/2") engraved through black face to white core. Lettering shall be 1/2" high condensed vertical gothic using a rounded or square cutter. V-shaped grooves are not acceptable. Nameplate legends shall be as follows:
  1. DC STINGER NO. 1 (etc. through No. 6)
  2. DC RECEPTACLE POWER - NO. 1 (etc. through No. 20)

#### 9. DC Bus Section

- a. DC switchboard isolated from the DC switchgear( e.g. separate rooms) shall be provided with a DC bus section which shall include provisions for the connections of a total of six (6) 1000 MCM copper cables to the switchboard bus, entering from the top. Connectors shall be of the long barrel, double-indentation, compression type. The connectors shall be of one piece tubular construction formed of pure electrolytic copper and tin-plated to resist corrosion. Connectors shall be NEMA standard. The switchboard enclosure shall not be insulated from ground.
- b. The switchboard shall be provided with a bus connection to the DC switchgear when both switchboard and switchgear enclosures are in the same room and bonded. The switchboard enclosure shall then be insulated from ground. The enclosure will be bonded to the dc switchgear, to that the switchgear-mounted ground relay shall monitor and protect the switchboard, as well as the switchgear, from accidental grounding and accidental energizing of the enclosures.

#### 10. Description of Contactors

- a. Switchboard-mounted dc contactors shall be normally open, magnetically held, single pole, load break with 8-hour enclosed rating of 600 amperes inductive load at 750 volts dc and shall be NEMA size 6. The contactor shall be used to control the dc current to the stinger systems. Each contactor shall be provided with silver alloy, adjustable and readily replaceable contacts. The contactor shall have a minimum life under full load conditions of 100,000 cycles. Each pole shall be equipped with a current coil type magnetic blow-out which will provide directed control of the arc away from the current carrying contact surfaces. Each of the contactors shall be supplied with two (2) N.O. and (2) N.C. auxiliary contacts rated at 10 amperes. The short-circuit withstand capability shall be coordinated with the available peak-through current of the dc distribution switchboard and shall be sufficiently large so that no damage to the contactor or its enclosure is done during the time it takes the feeder circuit fuse to clear the fault. The contactor shall be controlled with a 120V ac rated coil capable of remote control operation. An internally-mounted 120 volt ac toggle switch which shall disconnect the control power shall be provided. Each contactor shall be designed to control the dc current to a single stinger system only.

#### 11. Testing

- a. The dc distribution switchboard shall be tested with fuses in place and shall withstand for one minute, without breakdown, a 60 cycle alternating potential of 3.7 times the maximum rated voltage. The switchboard shall also withstand for one minute, without breakdown, a direct current test voltage of 5.2 times the maximum rated voltage. The test potential is to be increased gradually from zero until the required test value is reached and is to be held at the value for one minute.

#### B. Receptacle Contactors

- 1. Provide 750 volt dc contactors in accordance with the following specifications.
  - a. DC contractors shall be normally open, magnetically held, single pole , load break rated as listed below at 750 volts dc. The contractor shall be used to control the DC current to the receptacle circuits. Each contractor shall be provided with silver alloy, adjustable and readily replaceable contacts. The contactor shall have a minimum life under full load conditions of 100,000 cycles. Each pole shall be equipped with a current coil type magnetic blow-out which will provide directed control of the arc away from the current carrying contact surfaces.
  - b. Contactors supplying power to receptacle circuits shall have 8 hour enclosed ratings of at least 150 amperes inductive load at 750 volts dc and shall be NEMA size 4. The

short-circuit withstand capability shall be coordinated with the available peak-through current of the dc distribution switchboard and shall be sufficiently large so that no damage to the contactor or its enclosure is done during the time it takes the feeder circuit fuse to clear the fault. The contactor shall have a 120 volt ac coil operation.

c. Enclosure

1. Each contactor shall be enclosed in a NEMA type 12 ventilated self supporting fiberglass enclosure suitable for wall mounting. Each 150 ampere rated contactor enclosure shall be provided with one key operated momentary contact switch to energize the control coil and one mushroom head stop pushbutton. The switch and pushbutton shall be located on the front cover and shall be accessible with the enclosure door closed. The door shall be suitable for padlocking. An internally-mounted 120 volt ac toggle switch which shall disconnect the control power shall be provided. Enclosure shall be manufactured of glass-reinforced polyester and shall have the following minimum strength.
  - a. Tensile strength 13,000 psi
  - b. Flexural strength 23,000 psi
  - c. Compression strength 17,000 psi
  - d. Impact strength 15 ft. lbs. Per inch
2. Enclosures shall be provided with a gasket hinged front door, suitable for padlocking. Enclosures shall be as manufactured by the Vynco Division of the English Electric Corporation, Crouse-Hinds, or Hoffman, or an approved equal.

## 2.2 DC STINGER (CONDUCTOR/COLLECTOR) SYSTEM

A. General:

1. The conductor/collector system components shall be UL listed, and shall meet or exceed UL-94 for Combustibility (self-extinguishing characteristics).
2. The conductor/collector system shall be protected against direct contact in accordance with "finger-safe standard" (UL-E99342, and/or D1N57470).
3. The conductor/collector system shall consist of standardized interchangeable units - track section, coupling sets, dead end caps, track hangers and power takeoff and control trolleys (including cables and cable support/relief assemblies)
4. This application requires a system of sturdy mechanical design, able to withstand the everyday operating environment common to transit maintenance facilities and as found in areas of vehicle maintenance lifts.
5. The conductor/collector system shall be of sufficient size to conduct all intermittent peak current requirements and a conductor of a cross sectional area of sufficient size for required mechanical strength.
6. No special tools should be required for installation.
7. The conductor system shall consist of all necessary conductor sections, hanger supports, insulators, anchor supports, feeder assemblies, expansion joint assemblies, collector (trolley) assemblies and/or special components.

8. The Contractor shall submit to the Engineer and the Car Maintenance Department(CMNT) plan and details of the Stinger System for review and approval, prior to procurement and installation.

B. Acceptable Manufacturers

1. The following manufacturers are approved for manufacture of the DC Stinger power and control system:
  - a. MAC Products, Inc. or approved equal
  - b. WAMPFLER Products, Inc. or approved equal

C. Construction:

1. Internal air clearance or solid dielectrics sufficient to withstand 4500 volt transient potentials on the DC power bus.
2. Electrical rating of 600 Amperes, 800 VDC nominal.
3. Design shall maintain pressure tolerances between bus bars and collector trolley pickups without frequent adjustment.
4. Construction shall allow for longitudinal thermal expansion movement between bus structure and other assembly supporting components or housings. The design shall provide a continuous track giving the control trolley and the power take-off trolley complete freedom of travel over the entire length without any binding.
5. The design shall maintain the full current carrying capacity throughout the system structure.

D. Power Conductor:

1. The conductor rail shall be a one piece copper trolley trough with a self "V" groove contact surface for the trolley collector assembly, and shall be suitable for the voltage rating.
2. The conductor rail shall have an intermittent current carrying capacity of 1250 amperes, with a DC resistance of 16.6 micro-ohms/ft, having sufficient thermal capacity to withstand 300% overload for intermittent duty cycles. Expansion joints shall not be required for lengths up to 660 feet. Each rail section shall be 16.4 feet in length in order to reduce the number of connection joints. All rail connectors shall be a bolted design. Rail shall be rated IP23 for indoor or outdoor use.
3. Designed utilizing collectors having sufficient mechanical strength to support and electrically feed a 100 amp (nominal) rated trolley/collector assembly.
4. The conductor bar hangers material shall be macrolon with galvanized hardware. The hanger shall swivel to self align with the rail and allow for the rail to snap in to the clamp during installation. The hanger will support the rail without "pinching" the rail side. Hanger design must provide free conductor movement to accommodate the thermal expansion or contraction of the conductor.
5. No drilling or welding of the conductor rail at time of erection shall be necessary, only bolted connections. Splice joint, anchors, expansion joints and all other required appurtenances shall be provided and shall be manufactured from the same material as the conductor rail.
6. The electrical efficiency of the components, e.g. splice joints, feeders and expansion joints shall not be less than an equal length of conductor.

7. The internal and external supporting insulators of fiberglass reinforced polyester compound shall have a flash over strength of four times nominal system voltage when tested per ANSI C29.1 (1988) Electrical Power Insulators, Test methods.
  8. The roof truss-supported Stinger system shall have the conductor rail supported at 7.5 ft. intervals (maximum) between support members center to center.
- E. Stinger Power Collector Trolley:
1. Rated 1000 Volt DC, 600 amperes capacity and compatible with the DC power conductor.
  2. The collector or trolley shall be of a captive type design in that the complete assembly shall be supported by and guided by sets of roller wheels within pair of "C" channel mounted in tandem with the power conductor.
  3. The trolley housing shall be of NEMA type 4 /IEC 1 P65 enclosure construction.
  4. Contact with the power bus shall be by pairs of contact shoes that are spring-loaded with minimum contact pressure of 6 pounds and shall be adjusted to permit free longitudinal movement of the complete trolley assembly along the power conductor.
  5. Provide horizontal and vertical guide wheels with sealed ball bearings, as an integral part of the trolley assembly. Supply support wheels designed to carry the dead and come-along dynamic weight of trolley, power cable, and stinger assembly, including pull-off force of stinger from the traveling vehicle shoe. Design shall prevent a 20 degree angle side pull-along force from creating abnormal pressure and shall maintain contact shoe alignment.
  6. Collector assembly to accommodate one power conductor. Provide solderless type pressure cable connectors and insulate connections using heat-shrinkable sleeves as manufactured by Raychem, 3M products, or Engineer approved equal.
  7. The complete trolley assembly will consist of two auxiliary support and movement rollers mounted to a common bracket held in alignment by the captive trolley.
  8. The cable connection between the trolley assembly and the stinger cable will be such that the force required to move the trolley assembly longitudinally along the conductor will not be fully placed on the connection itself. Provide strain-relief Kellems grip connectors to support the power cable at the trolley.
  9. Collector shoes shall be simple to replace without the use of tools.
- F. Control Conductor:
1. The conductor rail shall be a one piece copper trolley trough with a self "V" groove contact surface for the trolley collector assembly, and shall be suitable for the voltage rating.
  2. A current carrying capacity of 100 amperes, with impedance rating of  $1.1 \times 10^{-4}$  ohms/ft. The assembled conductor shall be enclosed in a safety orange, extruded PVC cover.
  3. Designed utilizing collectors having sufficient mechanical strength to support and electrically feed a 100 amp (nominal) rated trolley/collector assembly.
  4. The conductor bar hangers material shall be macrolon with galvanized hardware. The hanger shall swivel to self align with the rail and allow for the rail to snap in to the clamp during installation. The hanger will support the rail without "pinching" the rail side. Hanger design

must provide free conductor movement to accommodate thermal expansion or contraction of the conductor.

5. No drilling or welding of the conductor rail at time of erection shall be necessary, only bolted connections. Splice joint, anchors, expansion joints and all other required appurtenances shall be provided and shall be manufactured from the same material as the conductor rail.
6. The cable connection between the trolley assembly and the stinger cable will be such that the force required to move the trolley assembly longitudinally along the conductor will not be fully placed on the connection itself. Provide strain-relief Kellems grip connectors to support the power cable at the trolley.
7. Collector shoes shall be simple to replace without the use of tools.

G. Stinger Control Station Collector Trolley:

1. The control of the DC power stinger shall be provided by a separate 3-pole AC collector assembly, control trolley take-off system that shall be constructed in tandem with the DC power stinger assembly as shown on the Drawings.
2. (3) conductors rated 600VAC with a UL rated current capacity of 250 amperes at 100% duty cycle and at 35 degree C. All bar must be copper. with resistance greater than  $2.78 \times 10^{-4} \Omega/m$  at 20°C. Expansion joints shall not be required for lengths up to 660 feet. Each rail section shall be 13 feet in length in order to reduce the number of connection joints and shall be compatible with the AC multi-conductor control cable. All rail connectors shall be a bolted design. Rail shall be rated IP23 for indoor or outdoor use.
3. The collector or trolley shall be of a captive type design in that the complete assembly shall be supported by and guided by sets of roller wheels within pairs of "C" channel mounted in tandem with the power conductor.
4. The trolley housing shall be of NEMA type 4 /IEC IP65 enclosure construction.
5. Contact with the AC control bus shall be by pairs of contact shoes that are spring-loaded with a minimum of contact pressure of 4 pounds and shall be adjusted to permit free longitudinal movement of the complete trolley assembly along the control conductors.

Provide horizontal and vertical guide wheels with sealed ball bearings, as an integral part of the trolley assembly. Supply support wheels designed to carry the dead and come-along dynamic weight of trolley, power cable, and stinger assembly, including pull-off force of stinger from the traveling vehicle shoe. Design shall prevent a 20 degree angle side pull-along force from creating abnormal pressure and shall maintain contact shoe alignment.

Collector assembly to accommodate three (3) control conductors. Provide solderless type pressure cable connectors or terminal strip.

6. The complete control trolley assembly will consist of two auxiliary support and movement rollers mounted to a common bracket held in alignment by the captive trolley.
7. Collector assembly to accommodate three (3) control conductors as indicated on the drawings. Collector shoe lead wire shall be bolted direct to collector shoe to eliminate any potential of hot spots or thermal overloads. Provide solderless type pressure cable connectors and insulate connection using heat shrinkable sleeves as manufactured by Raychem, 3M Products or engineer approved equal.

8. The cable connection between the trolley assembly and the control cable will be such that the force required to move the trolley assembly longitudinally along the conductor will not be fully placed on the connection itself. Provide strain-relief Kellems grip connectors to support the control cable at the trolley.

#### H. Stinger Assembly

1. The DC power stinger assembly shall be provided with power cable, and service power tip. The control of the DC power stinger shall be provided by a separate 3-pole AC collector assembly, control trolley take-off system that shall be constructed in tandem with the DC power stinger assembly as shown on the Drawings.
2. The design shall meet space restrictions of vehicle lifts and vehicle clearances for safe working procedures for transit vehicle in the elevated and at floor positions on the car hoists.
3. Connection of the power and control cables to the stinger power cable and to the control pushbutton station and collector trolleys shall be via strain relief Kellems grip connectors.
4. Stinger assembly shall be furnished with an extra flexible, rope lay, stranded (class K in accordance with ASTM B 172) #4/0 AWG, coated, annealed copper power cable, having low smoke and low toxic silicon rubber insulation thickness rated for 2kV in accordance with ICEA NEMA WC8. Provide low smoke, zero halogen cross linked modified polyolefin jacket.
5. Provide hook on stinger and cable-mounted hanger for storage to facilitate operator to return trolley to starting position for next vehicle movement.
6. Provide end-of-run shock absorber assembly for both the stinger power trolley and the stinger control trolley.
7. Provide one (1) stinger assembly for each mobile collector trolley assembly and one (1) control station assembly for each mobile collector trolley assembly. The stinger assemblies and control station assemblies shall be furnished by the manufacturer of the collector busway and trolley assembly. Each stinger assembly shall have an independent 600A DC contactor. A single DC contactor shall not supply two stinger assemblies.
8. Provide all required means to permit passage of overhead crane loads between adjacent shop tracks.

#### I. Control Station Assembly

1. The control station assembly shall be provided with control cable, and pendant-mounted single pushbutton control station.
2. The design shall meet space restrictions of vehicle lifts and vehicle clearances for safe working procedures.
3. Connection of the power and control cables to the stinger power cable and to the control pushbutton station and collector trolleys shall be via strain relief Kellems grip connectors.

#### J. Supporting Insulators:

1. The mechanical and electrical properties of the DC conductor supporting insulator and the external mounting insulators shall meet the following requirements:

a. tensile strength	5000 lbs.
b. cantilever strength	9000 inch lbs.
c. compression strength	65000 lbs.
d. torsional strength	150 (+) ft.-lbs.
e. arc resistance	190 seconds - ASTM D495
f. tracking resistance	1200 min. - ASTM D2302
g. flame resistance	ASTM D635 Self-Extinguishing Federal LP406b - 164/31
h. creep distance	plate to plate - 4.75 inches (min) insert to insert 6.25 inches (min)
i. dielectric strength	(a) dry - 40 kV minimum (b) wet - 19 kV minimum
j. impulse	80 kV minimum - (1.5 x 40 wave)

K. Additional System Parameters

1. Operational safety of the stinger system shall require any personnel to be remote from the vehicle movement. It also requires that disengagement of the vehicle shoe clamp be accomplished as a NON-LOAD BREAK operation.
2. Trolley end stop bumper will permit "pull-off" of the stinger from the vehicle collector shoe and will stop trolley traveling at a speed of 5 mph without damage to trolley or overhead busway system (power and control conductors).

L. System Operation:

1. All stinger cable assemblies, control station cable assemblies, power and control system wiring, and auxiliary devices shall permit the following sequence of operation.
  - a. 750 DC voltage to the service power tip is off.
  - b. To make a move, the operator places the stinger service power tip on the vehicle shoe.
  - c. The operator then presses the control station momentary pushbutton and continues to press it. Immediately the green lights switch off, alarm will sound, rotating red lights will start flashing. After a preset time delay (15 seconds), DC traction power is available at the service tip and the vehicle will begin to move.
  - d. Movement is permitted to continue as long as the momentary pushbutton is pressed.
  - e. The control circuit "power on" function is disabled if any of the three (3) emergency (maintained) pushbutton stations are pressed.
  - f. Only one (1) stinger systems can be operated at any given time.

- g. After the move is made, the stinger control station momentary pushbutton is released red lights stop flashing and the green lights come on. The stinger is stored on its cable hanger.
- h. Alarm/horn activation is maintained when the 750V DC contactor malfunction and fail to de-energize the stinger system .

#### M. Control Stations

- 1. Cord-mounted pendant-type single pushbutton control stations shall have NEMA 4/4X stainless steel enclosure.
- 2. Flush head momentary pushbutton with 10 ampere rated contacts in accordance with NEMA A600.
- 3. Acceptable manufacturers shall be Allen-Bradley or Engineer approved equal.

#### N. Relays and Timers

- 1. All control relays and timers for the operation of the stinger system shall be of the heavy duty industrial type having screw type wire terminals or plug-in sockets. Provide sockets and all mounting hardware for the complete control system. Cube relays are not acceptable.
- 2. Acceptable Manufacturers
  - a. Agastat
  - b. Square D Co.
  - c. ASCO
  - d. Potter Brumfield
  - e. Allen Bradley
  - f. GE
  - g. Approved equal.

#### O. Stinger Control Panel

Provide Stinger Control Panel (SCP) as described herein. The SCP shall be manufactured by the same manufacturer as the DC Stinger System and Controls.

- 1. SCP - Provide a completely engineered assembly that is arranged in a manner that affords safety for the maintenance personnel and operators. The components and wiring are to be well identified and shall reflect the exact configuration as the control ladder diagrams, wiring diagrams and assembly diagrams.

- a. The minimum wire size for control wiring within the SCP shall be #14 AWG rated 2000 VAC.
  - b. Control wiring shall be EPR insulated, stranded copper wire.
- 2. Multi-Conductor Control Cable (SCP - DC Switchboard).
  - a. Provide an 8-conductor #10 AWG
- P. Warning Devices
  - 1. Provide warning devices to indicate presence of 750 VDC in areas having controlled DC stinger power. Maintain activation of the alarm/horn where stinger system is energized even when hand-held momentary push button switch is released, where contactors in DC Switchboard malfunction.
  - 2. All stinger areas shall be provided with rotating red lights for visual indication and warning horns for audible indication.
- Q.. Spare Parts
  - 1. The Contractor shall furnish spare components, parts and service tools as follows:
    - a. (1) - Stinger Power Trolley assembly, complete.
    - b. (1) - Stinger Control Trolley assembly, complete.
    - c. (2) - DC Stinger power cable assemblies, complete (service power tip furnished by WMATA).
    - d. (2) - DC Stinger control cable assemblies, complete with control station.
  - 2. All spare parts shall be packaged in manufacturer's standard cartons, properly labeled and delivered to a location designated by the Engineer that is within 20 miles of the Project's location.

## **2.3 DC PEDESTAL AND WALL MOUNTED CONTACTOR SYSTEM**

### **A. DC CONTACTOR ASSEMBLY**

- 1. 150 Amp, 800 Volts, DC, electrically operated contactor, 120 Volts AC operated solenoid. Provide 120 VAC from external source for control circuit operation as shown on the Contract Drawings. Control relays shall be as manufactured by General Electric Company, Allen-Bradley, ASCO, or approved equal.
- 2. Internal air clearances or solid dielectrics sufficient to withstand 4500 volt transient potentials on the circuit.
- 3. Acceptable Manufacturer's:
  - a. Microelectrica Scientifica; Model LTC-250-M-ADA.

- b. General Electric Company
- c. Cutler Hammer
- d. Approved Equal

**B. POWER CABLE**

- 1. 1/C # 1/0 extra flexible Class K copper stranded conductor with low smoke, zero halogen silicon rubber insulation, rated 2 kV.
- 2. Power cable shall be 30 feet long. Power cable shall be equipped with a spring-loaded clamp and protective 2 kV insulated boot over clip.

**C. ENCLOSURE - DC CONTACTOR**

- 1. Provide a Fiberglass, NEMA Type 4X wall-mounted enclosure having the following minimum dimensional characteristics: 20.19" high, 16.25" wide, and 12.00" deep. (Provide internal mounting panel, (17"high x 13" wide)). Provide a larger enclosure if required by the contactor manufacturer for its equipment and circuit arrangement.
- 2. Provide wire way to guide 1/0 AWG conductors within the enclosure.
- 3. Acceptable Manufacturer's:
  - a. Hoffman Engineering Co. A-20H1612GQRLP with A-20P16 Panel.
  - b. Approved Equal.

**D. CONTROL AND INDICATION**

- 1. Key Operated "ON" Pushbutton
- 2. Position, cylinder lock momentary (oil tight) pushbutton with key removable in "LOCK" position only.  
  
Allen Bradley 800T-E11A or equal, with extra large legend plate.
- 3. "OFF" non-illuminated extended head oil tight pushbutton, red color, Form B contact block.  
Allen Bradley 800MR-N26 or equal, with extra large legend plate.
- 4. "ON" Pilot Light, oil tight, red lens, push-to-test, full voltage 120 Volt LED, with extra large legend plate.  
Allen Bradley 800T-QTH10R or equal.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

- A. Refer to wire and cable sizes or single line diagrams and control ladder diagrams for size and quantity of wires required for the installation.

- B. Clean installed PRODUCTS of this Specification Section where deposits of oil, grease, dirt, dust, mud or debris is present after installation.
- C. Follow the recommendations of the stinger equipment manufacturer that pertain to the start-up and operation of the DC stinger systems.

**3.2 FIELD TEST FOR EQUIPMENT OPERATION**

- A. Perform the following tests and submit certified test reports to the Engineer. Furnish, at no cost to WMATA, all test equipment, materials, and labor required to perform the tests.
- B. Test performance and operation of the DC stinger system and DC contactor systems and operating procedures, to the satisfaction of the Engineer.
  - 1. Testing of controls shall consist of operating each control not fewer than five times.
  - 2. Testing of power circuits and operational procedure shall consist of energizing each stinger bus and provide actual traction power to a married-pair.
- C. The Contractor shall provide final testing under power subsequent to completion. The Contractor shall coordinate the interconnection between the DC Stinger System and the DC Switchboard power and control circuits. The contractor shall be responsible for final connections to the DC Switchboard power and associated commissioning, and final acceptance of the DC Stinger System by WMATA.

\* \* \*

## SECTION 16122

### CONTACT RAIL CABLE CONNECTOR ASSEMBLIES FOR TRACTION POWER

#### PART 1. GENERAL

##### 1.01 SUMMARY

- A. This section specified fabricating, testing and furnishing contact rail cable connector assemblies as shown and specified.
- B. Related Sections
  - 1. Section 16123 - Contact Rail Insulator Assembly For Traction Power
  - 2. Section 16124 - Contact Rail Protection Cover For Traction Power
  - 3. Section 16126 - Contact Rail Anchor Assembly For Traction Power
  - 4. Section 16127 - Contact Rail System Installation For Traction Power
  - 5. Section 16128 - Wire and Cable For Traction Power
- C. Payment and Measurement:
  - 1. Cable Connector Assembly: Lump sum, no separate measurement.

##### 1.02 REFERENCES

- A. Codes, regulations, references, standards and specifications:
  - 1. Does not apply.

##### 1.03 QUALITY ASSURANCE

- A. Testing: Conduct specified testing at no additional cost to the Authority.
  - 1. Compression connectors:
    - a. Prototype testing:
      - 1) Prior to production, assemble three compression connectors on 1,000-KCMIL 2,000-volt cable for use as test connections.
      - 2) Electrical resistance test:
        - a) Procedure:
          - (1) Remove insulation from cable portion of test connectors.
          - (2) Measure resistance between the cable and connector tongue with digital low resistance ohmmeter.
          - (3) With a 10 amp test current, digital low resistance ohmmeter (Kelvin Bridge Type) measure resistance of equivalent length of 1,000-KCMIL 2,000-volt cable.
        - b) Acceptance criteria:
          - (1) Electrical resistance for connection equal to or less than that of equivalent length of 1,000-KCMIL 2,000-volt cable.
    - 3) Tension test:
      - a) Procedure:
        - (1) Subject test connections to sustained tension of 5,000 psi of the nominal conductor cross-sectional area for three hours.
        - (2) Retest for electrical resistance after three hours.
      - b) Acceptance criteria:

- (1) No slipping of cable in connector.
- (2) No deformation.
- (3) No increase of electrical resistance beyond that specified.
- 4) Production Testing:
  - a) After successful prototype testing, production may commence.
    - (1) Prior to delivery, randomly select one percent of each production lot and subject to specified electrical resistance and tension tests.
- 5) Insulating covers:
  - a) Production testing:
    - (1) Procedure:
      - (a) Prior to delivery, randomly select one percent of each production lot of insulating covers and test insulation resistance at thinnest portion with 1,000-volt dc megohmmeter.
    - (2) Acceptance criteria:
      - (a) Insulation resistance: 1,000,000 ohms minimum.
      - (b) If one insulator cover of a lot fails insulation resistance test, entire lot will be rejected.

#### 1.04 SUBMITTALS

- A. Submit the following in accordance with the Division 1 and with the additional requirements specified for each.
  - 1. Shop Drawings:
    - a. Fabrication of cable connector assemblies.
    - b. Use of drawings for manufacture or fabrication prior to approval is not permitted.
  - 2. Certification:
    - a. Certifications that all cable connector assemblies meet or exceed specified requirements.
    - b. Test procedures.
    - c. Certified test reports.
    - d. Method of packaging: Submit prior to packaging and shipping.

#### PART 2: PRODUCT

##### 2.01 MANUFACTURERS

- A. Cable Connector Assembly
  - 1. MAC Products, Inc. No. B-9180 or equal.
  - 2. SELCO Manufacturing Corp., No. 2610 or equal.

##### 2.02 COMPONENTS

- A. Furnish cable connector assemblies in accordance with the following requirements:
  - 1. Lug: Compression type.
  - 2. Material: 98-percent pure copper. Tongue:
  - 3. Not less than 9/16-inch thick, with fourholes and drilled for 1/2-inch bolts on 1-3/4

4. inch centers.  
Complete with silicon-bronze flat washers, lock washers, nuts and bolts.

### **2.03 INSULATING COVER AND ACCESSORIES**

- A. Furnish insulating cover and accessories in accordance with the following requirements:
  1. Type: Two-piece.
  2. Material: Glass-reinforced polyester.
  3. Thickness: Not less than 0.125-inch.
  4. Color: Orange.
  5. Watertight.
  6. Complete with neoprene gaskets, sealing collars and captive screw fasteners.
  7. Each assembly, except sealing collar, capable of easy disassembly.

### **2.04 FABRICATION**

- A. Procedures and tooling to be recommended by the manufacturer and strictly complied with by the installer.

### **PART 3: EXECUTION - Not Used**

**END OF SETION**

## SECTION 16123

### CONTACT RAIL INSULATOR ASSEMBLY FOR TRACTION POWER

#### PART 1 - GENERAL

##### 1.01 SUMMARY

- A. This section specifies fabricating, testing and furnishing plastic and porcelain contact rail insulator assemblies as shown and specified.
- B. Related Sections:
  - 1. Section 16122 - Contact Rail Cable Connector Assemblies For Traction Power
  - 2. Section 16124 - Contact Rail Protection Cover Assemblies For Traction Power
  - 3. Section 16126 - Contact Rail Anchor Assembly For Traction Power
  - 4. Section 16127 - Contact Rail System Installation For Traction Power
  - 5. Section 16128 - Wire and Cable For Traction Power
- C. Payment and measurement:
  - 1. Compensation for work specified in this section will be made in the following manner:
    - a. Materials: Lump sum, no separate measurement.

##### 1.02 REFERENCES

- A. Codes, regulations, references, standards and specifications.
  - 1. ASTM A47.
  - 2. ASTM A153.
  - 3. ASTM A164.
  - 4. ASTM D149.
  - 5. ASTM D229.
  - 6. ASTM D256.
  - 7. ASTM D495.
  - 8. ASTM D570.
  - 9. ASTM D638.
  - 10. ASTM D648.
  - 11. ASTM D695.
  - 12. ASTM D790.
  - 13. ASTM D2000.
  - 14. ASTM D2303.
  - 15. ANSI B4.1.
  - 16. ANSI B18.2.1.
  - 17. ANSI B18.2.2.
  - 18. ANSI C29.1.
  - 19. ANSI C29.5.
  - 20. UL 94

##### 1.03 QUALITY ASSURANCE

- A. Testing
  - 1. Perform specified testing by a nationally recognized independent testing laboratory at no additional cost to the Authority.
  - 2. The Contractor shall notify the engineer fourteen (14) days in advance of the commencement of testing, including preparation of the test equipment for testing. Testing shall be performed in the presence of the Engineer unless otherwise approved by the Engineer in writing.

B. General testing

1. Randomly select a minimum of one percent of each production lot of 500 insulators of each type as test specimens.
2. Subject specimens to the following tests:
  - a. Electrical resistance test:
    - 1) Procedure:
      - a) Immerse each specimen in water at room temperature.
      - b) After 70 hours, remove and dry thoroughly.
      - c) Provide complete contact by use of wet clay pads on top and bottom of specimen.
      - d) Measure resistance to each specimen with 1,000-volt dc megohm meter or other approved device.
    - 2) Acceptance criteria:
      - a) Electrical resistance: Not less than eight megohms.
      - b) If one insulator of a lot fails, entire lot will be rejected.
  - b. Impulse withstand voltage test.
    - 1) Procedure: In accordance with ANSI C29.1.
    - 2) Acceptance criteria:
      - a) Dry withstand voltage: 30 kV at 60 Hertz for one minute.
      - b) Wet withstand voltage: 20 kV at 60 Hertz for ten seconds.
      - c) If one insulator of a lot fails, the entire lot will be rejected.
3. Insulators used as test specimens prohibited as part of quantity furnished.

C. Plastic Insulators

1. Material testing

<u>TEST ITEM</u>	<u>PROCEDURE</u>	<u>ACCEPTANCE CRITERIA</u>
Arc resistance	ASTM D495	180 seconds
Dielectric strength	ASTM D149, short-time test	100 volts per mil
Water absorption	ASTM D570, 24 hours at 23C	Weight increase: 0.3 percent maximum
Flammability	UL 94	Class 94V-O
Flame resistance	ASTM D229, Method II	Ignition time: 80 seconds minimum Burning time: 60 seconds maximum
Heat distortion	ASTM D648	Deflection temperature 390F at 264 psi
Izod Impact	ASTM D256, Method A	Average impact strength: 16 foot-pounds per inch width of specimen
Flexural strength	ASTM D790	24,000 psi
<u>TEST ITEM</u>	<u>PROCEDURE</u>	<u>ACCEPTANCE CRITERIA</u>
Tensile strength	ASTM D638	12,000 psi
Compressive strength	ASTM D695	20,000 psi

Tracking resistance      ASTM D2303

Time to track: at 2,500  
volts ac 600 minutes

\* Minimum unless otherwise specified.

2. Production testing:

a. General Requirements:

- 1) Production testing specified constitutes minimum requirements.
- 2) All insulators subject to full or partial testing at the discretion of the Engineer.
- 3) Insulators used for testing are not to be included in quantities furnished.
- 4) All facets of production testing, particularly location of facility and repair, capacity and calibration of test equipment, subject to approval.
- 5) Notify Engineer fourteen calendar days prior to scheduled testing dates.
- 6) If one insulator of a lot fails, the entire lot will be rejected.

b. Randomly select a minimum of one percent of each lot of 500 insulators as test specimens.

c. Load test:

1) Procedure:

- a) Mount 50% of the specimens on a rigid vertical support with centerline of holes on a horizontal plane.
- b) Mount 50% of the specimens on a rigid vertical support with centerline of holes on a vertical plane.
- c) Vertically apply a steady, even, downward pressure on the insulator head until it fails.
- d) Record pressure being exerted when first crack occurs in specimen.
- e) Record pressure being exerted when specimen fails.

2) Acceptance criteria:

a) Withstand:

- (1) To first crack: 1,200 pounds minimum.
- (2) To failure: 2,400 pounds minimum.

d. Compressive load test:

1) Procedure:

- a) Mount insulator on flat horizontal surface.
- b) Mount steel plate one-inch thick by 4-1/2 inches diameter on top of insulator.
- c) Conduct test in accordance with ASTM D695.

2) Acceptance criteria:

a) Withstand:

- (1) To first crack: 10,000 pounds minimum.
- (2) To failure: 20,000 pounds minimum.

e. Dielectric strength test:

1) Procedure:

- a) ASTM D149, Short-time Test.

2) Acceptance criteria:

a) Dielectric strength:

- (1) Perpendicular chair 100 volts per mil.
- (2) Perpendicular cap: 100 volts per mil.

f. Insulators used for testing are not to be included in quantities furnished.

D. Porcelain insulators:

1. Impulse flash-over voltage test:

- a. Subject all insulators to routine flash-over test.
  - b. Procedure: In accordance with ANSI C29.1.
  - c. Acceptance criteria:
    - 1) Insulator and glazing to remain intact.
    - 2) If an insulator fails the flash-over test, it will be rejected.
2. Mechanical test:
- a. Randomly select a minimum of one percent of each lot of 500 insulators as test specimens.
  - b. Procedure:
    - 1) Attach each insulator and mounting base to oak block.
    - 2) Mount each assembly on rigid foundation simulating service conditions.
    - 3) Place on top of each insulator one of the following type pads:
      - a) Lead: 1/4 inch thick
      - b) Canvas: 1/16 inch thick
    - 4) Attach to malleable iron cap a hardened steel disc ½ inch thick and equal in diameter to cap. Place both atop each insulator pad.
    - 5) Subject each test specimen to 10 blows of 15-pound spherical iron weight dropped from height of 36 inches.
  - c. Acceptance criteria:
    - 1) No cracks or fractures.
    - 2) If 50 percent or more of specimens fail, entire kiln-lot represented by specimens tested will be rejected.
3. Porosity test:
- a. From insulators destroyed in other tests, randomly select ten specimens.
  - b. Procedure: In accordance with ANSI C29.1.
  - c. Acceptance criteria:
    - 1) No evidence of penetration of dye into test specimen to an extent visible to the unaided eye.
    - 2) If one insulator of a lot fails, entire lot will be rejected.
4. Insulators used as test specimens prohibited as part of quantity furnished.
5. Verification:
- a. Compatibility of components of porcelain insulator assemblies:
    - 1) Prior to shipment, randomly select a minimum of one percent of each production lot of 500 of each component.
    - 2) Assemble to ensure that components mate properly.
    - 3) If one assembly fails to meet compatibility requirements, entire lot will be rejected.

#### 1.04 SUBMITTALS

- A. Shop Drawings:
  - 1. The Contractor shall submit for approval shop drawings for fabrication of the component and assemblies of the contact rail insulators, showing tolerances for all dimensions. No fabrication or manufacture shall be performed prior to drawing approval.
- B. Samples:
  - 1. One complete insulator assembly for each type.
- C. Documentation:
  - 1. Certification that all insulator assemblies furnished meet or exceed specified requirements.
  - 2. Detailed engineering data on materials used in the manufacture of insulator assemblies.
  - 3. Fabrication details.

4. Name of proposed independent testing laboratory.
5. Detailed description of quality control program. Work performed prior to approval is undertaken at the Contractor's risk.
6. Calibration certificates for quality control testing equipment.
7. Certified test reports. Submit no later than seven days after completion of tests.
8. Method of packaging. Submit prior to packaging and shipping.

## **PART 2 - PRODUCT**

### **2.01 MATERIALS**

- A. Furnish contact rail insulator assembly in accordance with the following requirements:
1. General Requirements
    - a. New and undamaged.
    - b. Symmetrical
    - c. Free of cracks, voids, air pockets, lamination, metallic substances or other defects rendering them unsuitable for intended service.
    - d. Meeting or exceeding acceptance criteria of specified tests.
    - e. Indelibly marked on underside with model number and identification of manufacturer.
    - f. Rated for a nominal voltage of 750 volts dc.
    - g. Minimum creepage distance over external surface of insulator from energized metal components to ground or to insulator fasteners: Eight inches minimum.
    - h. Resistant to weathering and sudden changes in atmospheric temperature from plus 150F to minus 20F.
    - i. Impervious to moisture, acid and alkali.
    - j. Suitable for use on wood ties and for direct fixation to concrete invert.
    - k. Color: Uniform gray matching sample available from the Engineer.
    - l. Designed for composite rail specified in Section 05661 with free-end-to-anchor distance of 500 feet and temperature range of plus 150F to minus 20F.
    - m. Compatible with protection cover assemblies specified in Section 16124, contact Rail Protection Cover Assembly.
  2. Plastic Insulators
    - a. Polyester resin reinforced with fibrous glass and inert fillers.
    - b. Compression-molded.
    - c. Appearance: Smooth and uniform.
    - d. Dimensions: As shown.
    - e. Tolerance: Plus-or-minus 1/32-inch.
  3. Porcelain Insulators
    - a. Design porcelain insulator assemblies as a system.
    - b. Manufacture components to tolerances ensuring that each component is compatible with all other components.
    - c. Insulators:
      - 1) Material:
        - a) Wet process porcelain, ANSI C29.5.
        - b) Close grained, homogenous and non-absorbent.
      - 2) Dimensions: As shown.
      - 3) Tolerances:
        - a) Variation of maximum dimension between top and bottom face: Plus or minus one percent.
        - b) Variation of diameter of holes from that shown: Plus or minus 1/8 inch.
        - c) Variation of other dimensions: Plus or minus one percent.

- 4) Glazing:
  - a) Smooth, hard, firmly adherent coating of uniform thickness.
  - b) Continuous over entire surface except as shown.
  - c) Free of checks and bubbles which extend completely through glaze.
  - d) Thermal expansion properties equal to porcelain material used.
- d. Other components:
  - 1) Malleable iron castings:
    - a) ASTM A47, Grade 32510.
    - b) Free from imperfections.
    - c) Finished surface: Smooth. Grinding to ensure accurate fit with adjoining parts is permitted.
    - d) Galvanized.
  - 2) Tolerances: ANSI B4.1.
  - 3) Hardware:
    - a) Dimensions and type: As shown.
    - b) Bolts: Steel, chemical and mechanical requirements in accordance with ANSI B18.2.1, galvanized.
    - c) Nuts: Steel, ANSI B18.2.2, galvanized.
    - d) Neoprene cushions, rings and pads: ASTM D2000, 1BC415.
  - 4) Galvanizing:
    - a) ASTM A153 or ASTM A164, Type GS.
    - b) Prior to coating perform the following:
      - (1) Shot blast finished parts in accordance with SSPC-SP-6, except maximum grit size to be SAE G-18, or pickle finished parts in diluted sulfuric acid.
      - (2) Thoroughly remove scale.
      - (3) Thoroughly clean with cold running water.
    - c) Immerse parts in solution of zinc chloride or hydrochloric acid.
    - d) Dry thoroughly.
    - e) Subject parts to zinc bath.

**PART 3 - EXECUTION Not Used**

**END OF SECTION**

## SECTION 16124

### CONTACT RAIL PROTECTION COVER ASSEMBLIES FOR TRACTION POWER

#### PART 1 - GENERAL

##### 1.01 SUMMARY

- A. This section specifies designing, fabricating, testing and furnishing contact rail protection cover assemblies, including expansion joint protection cover assemblies, as shown and specified.
- B. Related Sections
  - 1. Section 05661 - Contact Rail and Appurtenances For Traction Power
  - 2. Section 16123 - Contact Rail Insulator Assembly For Traction Power
  - 3. Section 16126 - Contact Rail Anchor Assembly For Traction Power
  - 4. Section 16127 - Contact Rail System Installation For Traction Power
  - 5. Section 16128 - Wire and Cable For Traction Power
  - 6. Section 16294 - Contact Rail Heating System For Traction Power
- C. Payment and measurement:
  - 1. Compensation for work specified in this section will be made in the following manner:
    - a. Material - Lump sum, no separate measurement.

##### 1.02 REFERENCES

- A. Codes, regulations, references, standards and specifications:
  - 1. ASTM - A123
  - 2. ASTM - A153
  - 3. ASTM - A313
  - 4. ASTM - A325
  - 5. ASTM - B633
  - 6. ASTM - D149
  - 7. ASTM - D229
  - 8. ASTM - D256
  - 9. ASTM - D570
  - 10. ASTM - D1499
  - 11. ASTM - E84
  - 12. ASTM - G23

##### 1.03 SYSTEM DESCRIPTION

- A. Type A: is full protection cover for installation in underground locations.
- B. Type B: is a top protection cover for installation in at-grade locations to accommodate the contact rail heating system.

##### 1.04 SUBMITTALS

- A. Submit the following for review in accordance with the Division 1 and with the additional requirements as specified for each.
  - 1. Shop Drawings:
    - a. The Contractor shall in accordance with Division 1 submit for approval shop drawings showing the design and fabrication of contact rail protection cover

- assembly.
2. Documentation:
    - a. Certification that protection cover assemblies furnished meet or exceed specified requirements.
    - b. Detailed engineering data on materials used in manufacture of protection covers.
    - c. Fabrication details.
    - d. Name of proposed testing laboratory.
    - e. Detailed description of quality control Program. Work performed prior to approval is undertaken at the Contractor's risk.
    - f. Calibration certificates for quality control testing equipment.
    - g. Certified test reports. Submit no later than seven days after completion of tests.
    - h. Method of packaging. Submit prior to packaging and shipping.

## 1.05 QUALITY ASSURANCE

- A. Testing: Have specified testing performed by a nationally recognized testing laboratory at no additional cost to the Authority. The Contractor shall notify the Engineer fourteen (14) days in advance of the commencement of testing, including preparation of the test equipment for testing. Testing shall be performed in the presence of the Engineer unless otherwise approved by the Engineer in writing.
  1. Material testing: Prior to fabrication, furnish one test specimen for performance of the following tests:
    - a. Water absorption test:
      - 1) Procedure: Test in accordance with ASTM D570.
      - 2) Acceptance criteria: Maximum absorption rate not exceeding 0.50 percent in 24 hours.
    - b. Flammability tests:
      - 1) Flame resistance:
        - a) Procedure: Test in accordance with ASTM D229.
        - b) Acceptance criteria: Maximum burning time: ten seconds.
      - 2) Flame spread:
        - a) Procedure: Test in accordance with ASTM E84.
        - b) Acceptance criteria:
          - (1) Flame spread: UL-listed, Class A Incombustible with classification not exceeding 25.
          - (2) Chlorine content: Not exceeding that which will emit more than 10 ppm.
    - c. Dielectric test:
      - 1) Procedure: Test in accordance with ASTM D149, Short Time Method.
      - 2) Acceptance criteria: Not less than 250 volts per mil.
  2. Type testing: Prior to fabrication, furnish five rail protection cover assemblies of each type and five expansion joint Type A protection cover assemblies with brackets set at widest spacing shown, as test specimens for performance of all specified tests on contact rail protection cover assemblies and specified mechanical load tests on expansion joint protection cover assemblies.
    - a. Mechanical load test:
      - 1) Procedure: Perform the following in the order given:
        - a) Mount protection cover assembly on length or contact rail or approved equivalent.
        - b) Static load test:
          - (1) Use 250-pound weight with bottom measuring six inches by twelve inches.

- (2) Place weight on protection cover at point selected by Engineer.
      - (3) One cycle consists of applying weight to assembly for 30 seconds, removing it, and reapplying it 60 seconds later.
      - (4) Test duration: Fifty cycles.
    - c) Impact resistance test:
      - (1) Use 250-pound weight with bottom measuring 18 inches square.
      - (2) Drop weight from height of 18 inches onto portion of protection cover directly above centerline of rail and directly above bracket.
      - (3) Subsequently, drop weight from height of 18 inches onto point on protection cover midway between two adjacent support brackets.
  - 2) Acceptance criteria:
    - a) Maximum permissible deflection at centerline of rail: 1-½ inches, at all times.
    - b) No splits, cracks or breaks.
    - c) Permanent deformation: Not exceeding 1/8 inch.
    - d) No violation of clearance envelope shown.
- b. Insulation resistance test:
  - 1) Procedure:
    - a) Conduct after mechanical load test.
    - b) Measure resistance between a point in contact with rail and a point on surface of protection cover assembly with 1,000-volt dc megohm meter.
  - 2) Acceptance criteria:
    - a) Resistance: 1,000,000 ohms minimum.
- c. Longevity test:
  - 1) Procedure:
    - a) Expose test specimens to light and water in accordance with ASTM G23 and ASTM D1499.
    - b) Total exposure time: 3,600 hours.
    - c) With 1,000-volt dc megohm meter, test insulation resistance through thinnest portion of protection cover.
  - 2) Acceptance criteria:
    - a) No visible evidence of deterioration.
    - b) Resistance: 1,000,000 ohms minimum.
- d. Izod impact strength test:
  - 1) Procedure:
    - a) Perform after longevity test in accordance with ASTM D256, Method A.
  - 2) Acceptance criteria:
    - a) Average izod impact strength: Four foot-pounds per inch of width.
- e. Production testing:
  - 1) General requirements:
    - a) Production testing specified constitutes minimum requirements.
    - b) All components subject to full or partial testing at the discretion of the Engineer.
    - c) Items used for testing not to be included in quantities furnished.
    - d) All facets of production testing, particularly location of facility and repair, capacity and calibration of test

- e) equipment, subject a approval.
- e) Notify Engineer 14 calendar days prior to scheduled testing dates.
- 2) Procedure:
  - a) Select one percent of protection covers produced in such a way that each group of five specimens represents identifiable lots of 500 lengths of protection cover and 1500 support brackets.
  - b) Subject test specimens to specified mechanical load and resistance rests specified under type testing.
- 3) Acceptance criteria:
  - a) As specified for type testing for mechanical load and resistance.
  - b) If one protection cover assembly of a lot fails to meet requirements, test additional 10 specimens from same lot. If one assembly of additional specimens fails to meet specified requirements, entire lot will be rejected.

## PART 2 -PRODUCTS

- A. Design: Design protection cover assembly to meet the following requirements:
  - 1. Prevention of accidental contact with energized rail components.
  - 2. Assurance of unimpeded passage of current collector mounted on transit vehicle.
  - 3. Resistance to sagging produced by intrinsic weight or external loads and forces.
  - 4. Ease of dismounting and remounting without disassembly of support bracket. Fasteners to be easily removable and reusable.
  - 5. Configuration:
    - a. Similar to configuration shown.
    - b. Cover not to be integral part of support bracket.
    - c. Basic geometry of cover, curved or chorded.
    - d. Fabricated in 10-foot lengths.
    - e. Continuous and uniform. Gaps at support brackets not exceeding 1/16 inch.
    - f. Support brackets at three-foot four-inch intervals, for Type B protection cover and at five-foot intervals for Type A protection cover, and as shown.
    - g. Arrangement of brackets at expansion joints as shown.
    - h. Assembly to lie within clearance envelope shown.
  - 6. Compatible with the composite contact rail specified in Section 05661.
- B. Material: Fabricate protection covers of material meeting the following requirements
  - 1. Glass-reinforced plastic.
  - 2. No separation or warpage under service conditions during 30-year life expectancy.
  - 3. Flame spread, flame resistance, chlorine content, water absorption and dielectric strength: In accordance with specified testing.
  - 4. Outer surface coated with polyurethane paint, 1.5 mils minimum dry film thickness.
  - 5. Color: Gray, to match specimen available from the Engineer.
- C. Support Brackets: Furnish support brackets meeting the following requirements:
  - 1. Design: Two-piece consisting of bracket and clamp as shown.
    - a. Configuration: Compatible with protection cover and with composite contact rail specified in Section 05661.
  - 2. Material: Same as that of protection cover.
- D. Nuts, Bolts, and Miscellaneous Hardware:
  - 1. Material
    - a. All nuts, bolts, and flat washers shall be manufactured in accordance with ASTM A325.

- b. The dimensional data and type hardware for all nuts, bolts and miscellaneous parts shall be recommended by the manufacturer. All steel bolts, nuts, screws and washers shall be galvanized as specified.
  - c. Spring washers shall be manufactured in accordance with the requirements of ANSI B18.21.1.
  - d. Hair pin cotter pins shall conform to the requirements of ASTM A313, Stainless Steel 304.
2. Galvanizing:
- a. All parts to be galvanized shall be galvanized after manufacture. Unless otherwise specified, parts to be galvanized shall be coated in accordance with the requirements of ASTM A123.
  - b. Bolts and miscellaneous hardware shown or specified to be galvanized shall be coated in accordance with ASTM A153 or alternate method in accordance with ASTM B633 Type I SC-2 for threaded items and SC-3 without threads.
  - c. Before galvanizing, the finished parts shall be pickled or sandblasted and the scale and adhering impurities removed. The pickling shall be done in properly diluted sulfuric acid, after which the parts shall be thoroughly cleaned in running cold water. Sandblasting shall meet or exceed Steel Structures Painting Council SSPC-SP-6, except that the maximum grit size shall be SAE No. G-18. The parts shall then be immersed in a solution of zinc chloride or hydrochloric acid. Immediately following thorough drying, the parts shall be dipped into the zinc bath before corrosion starts again.

**PART 3: EXECUTION- Not Used**

**END OF SECTION**

## SECTION 16125

### WIRE CONNECTION ACCESSORIES

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing wire-connection accessories, such as connectors, terminal lugs and fittings, bundling straps, insulating tape and resin.

##### 1.02 QUALITY ASSURANCE:

- A. Qualifications: Select a manufacturer who is engaged in production of similar wire connection accessories.
- B. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. National Electrical Code (NEC).
  - 3. UL: 486A, Wire Connectors and Soldering Lugs for Use With Copper Conductors.
  - 4. American Standards of Testing and Materials (ASTM): D149-97a, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies; D257-99, Standard Test Methods for DC Resistance or Conductance of Insulating Materials; D412-98a, Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers-Tension; D570-98, Standard Test Method for Water Absorption of Plastics; D638-00, Standard Test Method for Tensile Properties of Plastic; D696-98, Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30°C and 30°C with a Vitreous Silica Dilatometer; D792-00, Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement; D1000-99, Standard Test Method for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications; D1518-85(1998)e1, Standard Test Method for Thermal Transmittance of Textile Materials; D5034-95, Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test); D5035-95, Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method); D2240-00, Standard Test Method for Rubber Property-Durometer Hardness; and G21-96, Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
  - 5. American National Standards Institute (ANSI): C119.1, Sealed Insulated Underground Connector System 600V
  - 6. ITS: Directory of ITS Listed Products.
- C. Source Quality Control:
  - 1. Connectors, terminal lugs and fittings listed, per referenced UL or ITS directory.
  - 2. Factory testing: Submit certified copies of test report for cable splice and tap-insulation/sealing kits as specified.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings.
  - 2. Certification.

#### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Mark each item in accordance with applicable reference standard.
- B. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage.
- C. Store products in secure and dry storage facility.

### PART 2 - PRODUCTS

#### 2.01 PRODUCTS AND MATERIALS:

- A. Connectors, Terminal Lugs and Fittings:
  - 1. In accordance with UL 486A.
  - 2. For 10AWG and smaller conductor cable: Tin-plated copper pressure connectors with nonflammable, self-extinguishing insulation grip with temperature rating equal to that of conductor insulation.
  - 3. For 8AWG to 4/0 AWG conductor cable: Tin-plated copper compression connectors and terminal lugs with nylon insulating sleeve for insulation grip.
  - 4. For 250 Kcmil and larger conductor cable: Long-barrel, double-compression tin-plated copper connectors and terminal lugs with two-hole pad.
  - 5. For multiple-conductor cable: Watertight aluminum fittings with stainless-steel pressure ring and set screws or compression cone for grounding of aluminum sheath of MC cable.
- B. Bundling Straps:
  - 1. Self-locking steel barb on one end, with tapered strap of self-extinguishing nylon, temperature rating minus 40F to plus 185F.
  - 2. For outdoor use: Ultraviolet-resistant.
- C. Insulating Tape:
  - 1. Plastic tape: Vinyl plastic tape with rubber-based pressure-sensitive adhesive, pliable at zero degree F with the following minimum properties when tested in accordance with ASTM D1000-99:
    - a. Thickness: 8.5 mils.
    - b. Breaking strength: 20 pounds per inch width.
    - c. Elongation: 200 percent.
    - d. Dielectric breakdown: 10,000 volts.
    - e. Insulation resistance, indirect method of electrolytic corrosion: 1,000,000 megohms.
  - 2. Rubber tape: Silicone-rubber tape with silicone pressure-sensitive adhesive, with the following minimum properties when tested in accordance with ASTM D1000-99:
    - a. Thickness: 12 mils.
    - b. Breaking strength: 13 pounds per inch width.
    - c. Elongation: 525 percent.
    - d. Dielectric breakdown: 13,000 volts.
    - e. Insulation resistance, indirect method of electrolytic corrosion: 1,000,000 megohms.
  - 3. Arcproof tape: Flexible, coated one side with flame-retardant flexible elastomer, self-extinguishing, non-combustible, with the following minimum properties:
    - a. Thickness, ASTM D1000: 30 mils.
    - b. Breaking strength, ASTM D5034-95 and D5035-95: 50 pounds per inch width.

- c. Thermal conductivity, ASTM D1518-85: 0.0478 BTU per hour per square foot per degree F.
    - d. Electrical arc resistance: Withstand 200 amperes arc for 30 seconds.
  - 4. Glass tape: Woven-glass fabric tape with pressure-sensitive thermosetting adhesive, with the following minimum properties when tested in accordance with ASTM D1000-99:
    - a. Nominal width: 3/4 inch.
    - b. Thickness: Seven mils.
    - c. Breaking strength: 170 pounds per inch width.
    - d. Elongation: Five percent.
    - e. Dielectric breakdown: 2,500 volts.
    - f. Insulation resistance, indirect method of electrolytic corrosion: 5,000 megohms.
- D. Epoxy Resin: Suitable for insulating and moisture sealing cable splices, with the following minimum properties:
  - 1. Dielectric strength, ASTM D149-97a: 400 volts per mil.
  - 2. Volume resistance, ASTM D257-99:  $2.8 \times 10^{15}$  ohm per centimeter cube at 30C.
  - 3. Water absorption, ASTM D570-98:
    - a. 0.193 percent in 24 hours at 23C.
    - b. 0.62 percent in 24 hours at 53C.
  - 4. Tensile strength, ASTM D638-00: 8,000 psi.
  - 5. Elongation, ASTM D638-00: 2.4 percent.
  - 6. Coefficient of expansion, ASTM D696-98:  $6.8 \times 10^{-5}$  inch per inch per degree C.
- E. Cable splice and tap-insulation/sealing kit: Suitable for use on 600-volt, 90C cables, material compatible with cable insulation and jacket, meeting the seal test requirements of ANSI C119.1.
  - 1. Heat-shrinkable tubing or wraparound heat-shrinkable sleeve: approved per referenced UL or ITS directory, flame-retardant, corrosion-resistant thick-wall tubing with factory-applied sealant for field insulation on in-line splices and taps or wraparound-type sleeve for retrofit installation on existing splices and taps to provide a watertight seal and insulating encapsulation, with the following additional requirements:
    - a. Material: Cross-linked polyolefin.
    - b. Shrink ratio: 3 to 1 minimum.
    - c. Physical properties:
      - 1) Ultimate tensile strength: 2,350 psi, ASTM D412-98a.
      - 2) Ultimate elongation: 350 percent, ASTM D412-98a.
      - 3) Hardness, Shore D: 42, ASTM D2240-00.
      - 4) Water absorption: 0.050 percent, ASTM D570-98, Method 6.1.
      - 5) Specific gravity: 1.28, ASTM D792-00.
    - d. Electrical properties:
      - 1) Dielectric strength: 450 volts per mil, ASTM D412-98a.
      - 2) Volume resistivity:  $1 \times 10^{14}$  ohm cm, ASTM D257-99.
    - e. Thermal properties:
      - 1) Continuous operating temp.: -55C to +135C.
      - 2) Air oven aging (14 days at 175C):
        - a) Tensile strength: 2,680 psi.
        - b) Elongation: 375 percent.
      - 3) Low temp. flexibility (4 hours at -55C): No cracking when flexed.
      - 4) Heat shock (4 hours at 250C): No cracking, flowing or dripping.
    - f. Chemical properties:
      - 1) Corrosivity: Non-corrosive.
      - 2) Fungus resistance: Non-nutrient, ASTM G21-96.
      - 3) Flammability: Self-extinguishing.

## **PART 3 - EXECUTION**

### **3.01 SPLICES AND TERMINATIONS:**

- A. Make wire and cable splices in outlet, junction or pull boxes, in cable troughs or in equipment cabinets. Splices in conduit are prohibited.
- B. Secure connectors or terminal lugs to conductor so as to engage all strands equally.
- C. Do not rupture insulation nor expose bare conductors.
- D. Install compression connectors and terminal lugs using tools and pressure recommended by manufacturer. Indent mark connectors and terminal lugs with number of die used for installation.
- E. Apply anti-corrosion joint compound to connectors, terminal lugs and bolting pads before installation.
- F. Wrap ½-lapped layer of arcproof tape, glass tape overall on cable splices installed in air tunnels, ducts and shafts.
- G. Install terminal fittings on multiple-conductor cable in accordance with manufacturer's recommendation. Completely seal cable from moisture.
- H. On cable splices, taps and terminations in manhole handhole and outdoor junction and pull boxes, cover connectors with electrical putty, wrapped with three layers of plastic tape or final layer of rubber tape and then install watertight encapsulation as follows and under the supervision of kit manufacturer's representative or using a factory-certified installation technician, proficient in field installation of heat-shrinkable sealing kits.
  - 1. Use heat-shrinkable tubing for encapsulation of new splices, taps and terminations.
  - 2. Use wraparound-type heat-shrinkable sleeve for encapsulation of existing splices, taps and terminations.

### **3.02 CATHODIC PROTECTION SPLICES AND TERMINATIONS:**

- A. For splices made in aboveground cable, use compression connectors covered with electrical putty, wrapped with three layers of plastic tape and final layer of rubber tape.
- B. Install compression terminal lugs using tools and pressure recommended by manufacturer. Indent mark terminal lugs with number of die used for installation.
- C. For splices made in direct-burial cable, use thermit weld sealed with cast epoxy-resin encapsulation.

### **3.03 INSPECTION:**

- A. Have splices in direct-burial cable for stray current and cathodic protection inspected by the Engineer before backfilling.
- B. Have splices and taps in manholes, handholes and outdoor junction and pull boxes inspected by the Engineer or the manufacturer's representative, when available.

**END OF SECTION**

## SECTION 16126

### CONTACT RAIL ANCHOR ASSEMBLY FOR TRACTION POWER

#### PART 1 - GENERAL

##### 1.01 SUMMARY

- A. This section specified fabricating, testing and furnishing contact rail cable connector assemblies as shown and specified.
- B. Related Sections:
  - 1. Section 16122 - Contact Rail Cable Connector Assemblies For Traction Power
  - 2. Section 16123 - Contact Rail Insulator Assembly For Traction Power
  - 3. Section 16124 - Contact Rail Protection Cover Assembly For Traction Power
  - 4. Section 16126 - Contact Rail System Installation For Traction Power
  - 5. Section 16128 - Wire and Cable For Traction Power
- C. Payment and Measurement Basis:
  - 1. Compensation for work specified in this section
    - a. Contact Rail Anchor Assemblies, Furnish, Fabricate and Deliver: Lump Sum.

##### 1.02 REFERENCES

- A. Codes, Regulations, Standards and Specifications:
  - 1. Society of Automotive Engineers (SAE):
    - a. SAE G18.
  - 2. American Society for Testing and Materials (ASTM):
    - a. ASTM A27.
    - b. ASTM A36.
    - c. ASTM A47.
    - d. ASTM A48.
    - e. ASTM A123.
    - f. ASTM A153.
    - g. ASTM A283.
    - h. ASTM A325.
    - i. ASTM A489.
    - j. ASTM A681.
    - k. ASTM B134.
    - l. ASTM B633.
    - m. ASTM D570.
    - n. ASTM D638.
  - 3. American National Standards Institutes (ANSI):
    - a. ANSI B4.1.
    - b. ANSI B46.1.
    - c. ANSI B18.8.1.
    - d. ANSI B18.21.1.
  - 4. Steel Structures Painting Council (SSPC):
    - a. SSPC-SP-6.

##### 1.03 SUBMITTALS

- A. Submit the following for approval in accordance with the Division 1 and with additional requirements as specified for each:

1. Shop Drawings
  - a. The Contractor shall submit shop drawings to be used for fabrication of the components and assemblies of the contact rail anchors.
2. Certification
  - a. Certification that contact rail anchor assemblies furnished meet or exceed specified requirements and are compatible with the contact rail.
  - b. Certified test reports for specified factory testing.

#### 1.04 QUALITY ASSURANCE

- A. Testing
  1. Production Testing
    - a. Prior to delivery two anchor assemblies of each production lot shall be randomly selected to be used as test specimens.
    - b. Perform the tests in the following sequence in accordance with the referenced codes and standards.
      - 1) Tension test:
        - a) Tension test shall be in accordance with ASTM D638 using a temperature range of plus 40C to minus 17C.
        - b) The minimum acceptable tensile strength shall be 60,000 psi.
      - 2) The impact-resistance test:
        - a) The impact-resistance test shall be conducted within the temperature range of plus 21C to minus 17C.
        - b) The strain insulator rod shall be mounted as a simple beam with 21 inches between supports.
        - c) A 50-pound weight shall be dropped from a height of 12 inches so that it impacts at a midpoint on the rod. Repeat the test three times. No fractures shall occur on the rod.
      - 3) Water-absorption test:
        - a) Water-absorption test shall be performed in accordance with ASTM D570 over a 48-hour period using a temperature range of 20C to 40C.
        - b) Weight gain shall not exceed 0.15 percent of the original weight.
      - 4) DC-resistance test:
        - a) Following the specified water-absorption test, one eight-inch length of 5/8-inch diameter strain insulator rod shall undergo a dc-resistance test. The rod shall show a resistance of not less than eight megohms measured between the end surfaces of the rod.
      - 5) Dielectric test:
        - a) A dielectric test shall be performed on the same rod used in the resistance test.
        - b) The strain insulator rod shall be capable of withstanding an ac potential of 15,000 volts, 60 Hertz applied to the rod surface for three minutes without insulation breakdown or damage.
        - c) If one test specimen of a lot fails to meet specified test requirements, the entire production lot shall be rejected.
      - 6) Strain Insulator Rod Testing
        - a) After the rods are assembled to the clevis ends using a resin compound or similar approved adhesive and allowed to cure for 24 hours, proof load test each assembly to 15,000 pounds. No physical damage shall be allowed at the conclusion of testing.

- B. For Codes, Regulation, References, Standards and Specifications, refer to Article 1.02.

## **PART 2 - PRODUCTS**

### **2.01 COMPONENTS**

- A. Contact Rail Anchors
1. Cast Parts
    - a. The contact rail anchor cast parts shall be free of cracks, blemishes, scale, machining flaws, excessive shrinkage or other defects rendering them unsuitable for their intended service. They shall be finished to a true and homogeneous surface and if necessary ground to ensure accurate fit with contiguous parts.
    - b. Steel used in the fabrication shall be medium steel manufactured by the open-hearth, basic-oxygen or electric furnace process, ASTM A27, Grade 65-35, fully annealed and tempered. Malleable iron shall be ASTM-A47, Grade 32510 and gray iron shall be ASTM A48 Class 40C.
  2. Rolled Steel Parts
    - a. Rolled steel parts shall be manufactured by the open-hearth, basic-oxygen or electric-furnace process and shall be in accordance with ASTM A36, ASTM A681 and ASTM A283, Grade C.
    - b. Parts shall be free from cracks, flaws, seams, blisters, imperfect edges and other defects rendering them unsuitable for their intended service. The surface roughness shall not exceed 125 micro inches as prescribed by ANSI B46.1
  3. Tolerances
    - a. All tolerances shall be in accordance with ANSI B4.1.
  4. Galvanizing
    - a. Parts to be galvanized shall be prepared by first pickeling in diluted sulfuric acid and cleaning in cold running water. The parts shall then be shot blasted in accordance with SSPC - SP6, maximum grit size SAE G18, followed by immersion in a solution of zinc chloride or hydrochloric acid. After drying, hot-dip galvanize the parts in accordance with ASTM A123, unless otherwise specified. Nuts, bolts, washers, clevis pins and eye bolts shall be galvanized in accordance with ASTM A153 or ASTM B633 Type I SC-2.
  5. Strain Insulator Rods
    - a. The strain insulator rods shall be fabricated from 5/8-inch diameter reinforced plastic consisting of 60 to 65-percent glass fiber uniformly impregnated with 35 to 40-percent thermosetting p
  6. Miscellaneous Hardware
    - a. Nuts, bolts and miscellaneous hardware shall be of the type, material and dimensions as shown. The parts shall be galvanized as specified and manufactured as follow:
    - b. Nuts, bolts and flat washers: ASTM A325.
      - 1) Spring washers: ANSI B18.21.1.
      - 2) Cotter pins: ASTM B134 and ANSI B18.8.1.
      - 3) Eye bolts: ASTM A489.

## **PART 3 - EXECUTION - Not Used.**

**END OF SECTION**

## SECTION 16127

### CONTACT RAIL SYSTEM INSTALLATION FOR TRACTION POWER

#### PART 1: GENERAL

##### 1.01 SUMMARY

- A. This section specifies the requirements for installation of an operable contact rail system consisting of composite contact rail and all appurtenances including protection equipment and furnishing of ancillary material as specified.
- B. Related Sections:
1. Section 05661 - Contact Rail and Appurtenances For Traction Power
  2. Section 16122 - Contact Rail Cable Connector Assemblies For Traction Power
  3. Section 16123 - Contact Rail Insulator Assemblies For Traction Power
  4. Section 16124 - Contact Rail Protection Cover Assemblies For Traction Power
  5. Section 16126 - Contact Rail Anchor Assemblies For Traction Power
  6. Section 16128 - Wire and Cable For Traction Power
  7. Section 16294 - Contact Rail Heating System For Traction Power
- C. Payment and Measurement
1. Compensation for work specified in this section will be made in the following manner and in accordance with the unit price schedule:
    - a. Contact rail system, install: linear foot.
  2. Measurement of work specified in this section will be made in the following manner:
    - a. Contact rail system, install: linear foot measured to nearest 0.5 foot along center line of contact rail including end approaches, excluding gaps to include:
      - 1) Insulators, ballasted, install: includes furnishing and installing insulators, shims and drive spikes.
      - 2) Insulators, direct fixation, install: includes furnishing and installing insulators, shims, anchor bolts and group pads.
      - 3) Composite contact rail, install: includes furnishing and installing of composite contact rail, bending rail, attachment of splice joints and installation of anchors, expansion joints and end approaches.
      - 4) Cable connector assembly, install: includes preparation and installation of 1,000 KCMIL power cable as required and installation of compression connectors and insulating covers.
      - 5) Composite contact rail terminal lugs, install: includes preparation and installation of extra-flexible, 427-strand, power cable as required and installation of the terminal lugs on the composite contact rail.
      - 6) Protection cover, install: includes furnishing and installation of protection cover, support brackets, expansion joint protection cover assemblies and hardware.

##### 1.02 REFERENCES

- A. Code, regulations, references standards and specifications
1. ASTM - D1248
  2. UL
  3. AREMA

### 1.03 SUBMITTALS

- A. Submit the following for approval in accordance with the Division 1 and with additional requirements specified for each:
  - 1. Shop drawings: shims for contact rail height adjustment.
  - 2. Documentation:
    - a. The method of bending and tolerances to be allowed for contact rail.
    - b. The method of brushing, cleaning, and grinding for removing local surface irregularities
  - 3. Certification:
    - a. Wire pulling lubricants to be non-injurious to insulation of wire.

### 1.04 QUALITY ASSURANCE

- A. Testing
  - 1. Electrical resistance of the installed composite rail not to be greater than 0.002 ohms per 1,000 feet at 20 degree centigrade.
  - 2. Sample compression cable connector assemblies will be tested to sustain tension of 5,000 psi for three hours. At the end of three hours, there shall be no slipping of the cable in the connector, deforming or loosening of the connection or increase in the electrical resistance beyond that is specified.
  - 3. Terminal lugs for composite contact rail shall be tested as specified for cable connector assembly compression connections.
- B. For codes, regulations, reference standards and specifications, refer to Article 1.02 above.

## PART 2: PRODUCTS

- A. The components furnished under this section shall be as follows:
  - 1. The top surface of each insulator rail clip shall be thoroughly coated with a non-conductive lubricant, Dow-Corning 44 (heavy) grease, or equal, to reduce strain on the insulators caused by the movement of the contact rail.
  - 2. Timber drive spikes to secure insulator to contact rail for ballasted track installment shall be ½ inch in diameter and 6-1/2 inches long. Two spikes will be required for each insulator. Timber drive spikes shall be in accordance with Area Plan.
  - 3. Anchor bolts for securing insulators to contact rail for direct fixation installation shall be galvanized threaded studs ½ inch in diameter.
  - 4. Group pads each 12 inches wide and 12 inches long shall be as specified for Direct Fixation Track Construction (DFTC). Grout pads of varying thickness will be required for adjusting required relative height of contact rail with respect to the top of running rail.
  - 5. Shims as required, up to 1/4 inch shall be used under the insulator for further height adjustment. Shims shall be supplied by the Contractor at no additional cost to the Authority.
  - 6. Shims for contact rail height adjustment shall be 1/8 inches thick high density polyethylene, ASTM D1248, Type III, Class C, Cat. 5, and shall provide full bearing of the insulator on the grout pad in all positions of adjustment. Shims shall be designed to stay in place even if bolts are loose.
  - 7. Shim material may be manufactured without carbon black but shall meet all other requirements.
  - 8. The contact rail anchors installed as shown shall be secured to the trackbed with 3/4 inch diameter by 7-3/4-inch long threaded studs in direct fixation track, and with 11/16-inch by 6-inch washer-head drive spikes in ballasted track. Drive spikes shall be in accordance with AREMA Plan.
  - 9. Expansion joint jumper cable shall be extra flexible, 427-strand, power cable. Its

- length and points of connection to the contact rail shall be as shown.
10. All jumper cable installed in conduit at crossovers, transitions and other special track work shall be standard duty, 127-strand, or extra flexible 427-strand power cable.
  11. Contact rail connection cable shall be extra flexible 427-strand, power cable. Its length and points of connection to the contact rail shall be as shown, in accordance with expansion and contraction requirements of the contact rail.

### 3.0 EXECUTION

#### A. Insulator Assemblies

1. Insulators shall be installed as shown and specified.
  - a. The insulators shall be centered and secured in place and shimmed if necessary.
  - b. Insulators shall be installed on the direct fixation invert or on contact rail ties and shown. The distance between insulators shall not exceed ten feet.
  - c. All injurious substances falling on the insulators shall be immediately removed to prevent damage. Upon completion of the work, all insulators shall be inspected and thoroughly cleaned. All insulators chipped, broken or otherwise defective after installation shall be replaced before final acceptance at no additional cost to the Authority.
2. Ballasted Track Installation
  - a. The insulator shall be located to permit positioning the contact rail with respect to the gauge line of the near running rail within the specified tolerances.
  - b. The insulators shall be secured to the contact rail ties by two 1/2-inch diameter by 6-1/2-inch long timber drive spikes per insulator. The ends of ties under insulators shall be adzed or shimmed as necessary to compensate for warped ties. Contact rail ties shall be bored in the field to receive the drive spikes. Position holes to ensure that each insulator is centered across width of tie. The holes shall be 3/8-inch in diameter and six inches deep and treated with pentachlorophenol oil or creosote immediately after boring. The drive spikes shall be started vertically and driven straight. Drive spikes bent during installation shall be withdrawn and new drive spikes driven. Drive spikes shall be driven firmly to the top of the insulator base. Uneven tightening of spikes to adjust rail locating is prohibited
3. Direct Fixation Installation
  - a. The insulators shall be located to permit positioning the contact rail with respect to the gauge line of the near running rail within the specified tolerances. Anchor bolts shall be 1/2-inch diameter galvanized threaded studs. Anchor bolt holes for the insulators shall be located as shown and drilled as specified for DFTC. The diameter of the holes shall be as recommended by the manufacturer of the anchoring device, to a maximum of 1-3/4 inches.
  - b. Anchor bolts shall be installed in accordance with the approved procedure as specified for DFTC, the minimum upward vertical load shall be 6,000 pounds tension.

#### B. Contact Rail:

1. The centerline of the contact rail shall be located as shown on drawings. The contact rail shall be installed to rest evenly and uniformly on all insulator assemblies.
2. No length of contact rail less than 25 feet in length shall be used, except at locations shown, unless otherwise approved. Cuts shall be made only as required to ensure that the end of a run of contact rail falls within the specified tolerances. Cuts shall be made straight and perpendicular to the longitudinal axis of the contact rail. Contact rail for curve radii of less than 400 feet shall be bent to the appropriate curve

prior to installation. Contact rail for curve radii greater than 400 feet may also be bent prior to installation to facilitate handling. The method of bending and tolerances to be allowed shall be submitted for approval.

- a. Ballasted Track Installation: The required relative height of contact rail with respect to the top of running rail for timber ties shall be obtained by using shims under the insulator if necessary. Shims necessary for height adjustment shall be supplied by the Contractor at no additional cost to the Authority.
  - b. Direct Fixation Installation: The required relative height of contact rail with respect to the top of running rail shall be obtained by varying the thickness of grout pads which will support the insulators as shown. The grout pads shall be as specified for DFTC, except that the dimensions shall be 12 inches wide and 12 inches long.
  - c. If further height adjustment is required, additional shims as required up to 1/4 inch shall be used under the insulator.
  - d. Shims shall be installed with tabs facing the direction of train traffic and a 3 inch finish nail tacked into the timber tie directly adjacent to the insulator base to prevent shims from vibrating out.
3. End Approaches: The end of contact rail sections shall be terminated with end approaches, installed as shown on drawings. They shall be assembled to the contact rail to ensure a smooth running surface. The allowable longitudinal location tolerance shall be plus or minus six inches except at special track work locations where the distance measured from the nearest point of switch shall be as calculated from dimensions shown with a tolerance of minus zero and plus one foot. An 11-foot long end approach shall be used for all main track unless otherwise shown.
  4. Splice Joints for Composite Contact Rail: Composite contact rail splice joint shall be installed as specified by the manufacturer of the composite contact rail and approved. Splice joints shall be installed to provide one foot clearance from contact rail insulators. The contractor shall demonstrate that the installed composite rail has an electrical resistance not greater than 0.002 ohms per 1,000 feet at 20 degrees C.
  5. Splice joints may be installed over insulators if the manufacturer demonstrates to the satisfaction of the Engineer that designed and furnished joint bars will not come in contact with insulator ears.
- C. Contact Rail Surface Preparation: After installation of the contact rail to the specified tolerances, but prior to its final acceptance, the Contact rail shall be brushed or otherwise cleaned to remove rust and scale from the head of the contact rail. Such brushing or cleaning shall not remove in excess of 0.002 inch from any surface of the rails, except that additional brushing, cleaning or grinding shall be performed as necessary to remove local surface irregularities. The method of brushing, cleaning and grinding shall be submitted for approval prior to use.
- D. Expansion Joints: Expansion joints shall be installed in the contact rails as specified at the locations shown with an allowable tolerance of plus or minus five feet centered between insulators. The expansion joint shall be installed to provide a flat surface uniform with the rails, ensuring that the top surfaces of the two sections are in line within 1/32 inch for a distance of three feet in either direction. Expansion joint gaps shall be established depending on the rail temperature at the time of installation as shown on the Expansion Data Table. After installation the top surfaces of the expansion joint bars shall be ground so that they are flat and do not project above the top surface of the contact rail.
- E. Protection Cover Assembly: The protection cover assembly shall be installed entirely within the clearance envelope shown and in accordance with the manufacturer's recommendations:
1. At end approaches the protection cover shall be maintained at the uniform height above the top of the contact rail and shall not drop with the end approach.
  2. On curve radii under 500 feet, the protection cover may be cut into lengths a

minimum of five feet long to conform as closely as possible to the arc of the curve. The protection cover shall lie within the clearance envelope at all times.

3. For underground installation, protection cover support brackets shall be installed at five-foot intervals maximum; one bracket joining ends of protection cover sections and one at the midpoint of each 10-foot section.
4. For at-grade installation, protection cover support brackets shall be installed at three foot, four inch intervals maximum; one bracket joining ends of protection cover sections and one at each third point of a 10-foot section.
5. Additional protection cover brackets shall be installed where necessary. The maximum middle ordinate of a length shall be  $\frac{1}{2}$  inch. At contact rail expansion joints, an expansion joint protection cover assembly shall be installed as shown. Contractor shall fabricate expansion joint protection covers from the protection covers as shown. Contractor shall install protection cover support brackets so as to avoid compression fasteners and splice joints in the composite contact rail.

F. Electric Cabling and Connections

1. Feeder cables from substations and tie breaker stations will be furnished and installed by the Contractor, including the cable connector assemblies, extra-flex 1,000 KCMIL, cables and connections to the contact rail.
  - a. All other contact rail cabling and connections shall be installed by the Contractor. All cabling shall be continuous without splices between terminations.
  - b. Cables shall not be bent, either permanently or during installation, to radii less than 10 times the outer diameters, except where shorter radii are approved for conditions making the specified radius impractical. The Contractor shall provide suitable installation equipment to prevent cutting and abrasions of conduit and cable during installation. Any conduit stub-ups broken or damaged shall be repaired as shown. Rod and swab conduits so as to remove water, cement and other foreign matter. Wire pulling lubricants, if used, shall conform to applicable UL requirements. The lubricant shall be certified by the manufacturer to be non-injurious to such insulation. Pull-lines shall be made of nylon, polyester, polyethylene or other suitable nonmetallic material. Pull-lines shall be attached to cables by means of either woven basket grips or pulling eyes attached directly to the conductors. Only one cable shall be installed per conduit. Pulling tensions on both the conductors and their insulations and jackets shall not exceed the maximum tensions recommended by the cable manufacturer
2. Cable Installed in Conduit: All jumper cable installed in conduit at crossovers, transitions and other special track work shall be standard duty, 127-strand, or extra flexible 427-strand power cable. After installation, all cables shall be tested in accordance with Section 16128. Conduit ends shall be sealed using existing conduit sealing bushings, OZ Gedney Type CSBE-400p-1 or equal, as shown.

G. Cable Connector Assemblies

1. Qualifications for Performing Compression Connections: Prior to installation, the Contractor shall have prepared, under the direction of each foreman who will supervise a crew performing compression connections, two compression assemblies. The test compression assemblies shall be made using the methods and equipment the Contractor proposes to use for the installation. The electrical resistance of the completed connection, when measured between the distal end of cable and the connector tongue, shall not be greater than the resistance of an equivalent length of uncut cable.
2. Installation of Compression Connectors: Compression connectors shall be attached to the cable with the manufacturer's recommended tooling. When bolting tongues together, a lockwasher shall be installed under the head of each bolt and under each nut. All bolted connections shall be tightened with torque wrenches to a uniform

- torque of 450 inch pounds.
3. Installation of Terminal Lugs for Composite Contact Rail: Cable connections to the composite contact rail shall be one-hole, tin-plated, copper compression connectors. Prior to assembly of the terminal lugs to the composite contact rail, mating surfaces shall receive a liberal coating of oxide-inhibiting paste, NO-OX-ID, Dearborn Chemical, or equal. The oxide-inhibiting paste shall also be applied to all interfaces of the compression fasteners. The methods and equipment used to fasten the terminal lugs to the composite contact rail shall be as recommended by the manufacturer of the rail. Compression fasteners bent or improperly installed shall be replaced. Compression fasteners shall be installed in existing compression fastener holes used to hold the aluminum extrusion in place. Existing steel compression fasteners shall be removed and new fasteners installed to hold the terminal lugs.

**END OF SECTION**

## SECTION 16128

### WIRE AND CABLE FOR TRACTION POWER

#### PART 1. GENERAL

##### 1.01 SUMMARY

- A. This section specifies furnishing, installing and testing wire and cable.
- B. Compensation for work specified in this section will be made in the following manner and in accordance with the Unit Price Schedule:
  - 1. Wire and Cable Materials: Lump Sum.
  - 2. Installation: Lump Sum.
- C. Related sections include:
  - 1. Section 16051 - Scope of Work For Traction Power
  - 2. Section 16052 - Basic Materials and Methods For Traction Power
  - 3. Section 16260 - Uninterruptible Power System (Static)
  - 4. Section 16261 - Transformer-Rectifier Units For Traction Power
  - 5. Section 16291 - Local Annunciator Panel For Traction Power
  - 6. Section 16292 - Remote Terminal Unites (AEMS RTU) For Traction Power
  - 7. Section 16294 - Contact Rail Heating System For Traction Power
  - 8. Section 16321 - High Voltage AC Switchgear (13.8kV) For Traction Power
  - 9. Section 16322 - High Voltage AC Switchgear (34.5kV) For Traction Power
  - 10. Section 16341 - Metal-Enclosed DC Switchgear For Traction Power
  - 11. Section 16441 - Drainage and Negative Switchboard For Traction Power
  - 12. Section 16451 - Substation Busways For Traction Power

##### 1.02 REFERENCES

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Codes and regulations of the jurisdictional authorities.
  - 2. NEC.
  - 3. ICEA: S-66-524, S-68-516, S-19-81, T-33 - 655.
  - 4. IEEE: 383.
  - 5. NEMA: WC7, WC8.
  - 6. ASTM: B3, B8, D471, B173, E662.
  - 7. UL: 44, 224, 1581, 1569, 1685

##### 1.03 SUBMITTALS

- A. Submit the following for approval in accordance with the Special Conditions and with the additional requirements as specified for each:
  - 1. Shop Drawings: Submit shop drawings for each type of cable in accordance with Section 16051.
  - 2. Samples: Specified smoke-density test sample will become property of the Authority.
  - 3. Certification:

- a. Certified flame retardancy test reports and data for tests performed not more than 12 months prior to submittal, for materials which are identical to those of cable furnished.
- b. Submit smoke-density test reports and data from tests performed not more than 12 months prior to the submittal for materials which are identical to those of the furnished cable.
- c. Certified test reports demonstrating that cable complies with specified requirements and those of referenced ICEA and NEMA Standards.
- d. Certificates from manufacturers verifying that products conform to specified requirements. Include certificate with submittal of shop drawings and with each cable shipment.

#### **1.04 QUALITY ASSURANCE**

- A. Qualifications: Select a manufacturer who is regularly engaged in production of similar wire and cable, particularly to Railway or Transit industry in USA.
- B. For Codes, Regulations, Reference Standards and Specifications, refer to Article 1.02.

#### **1.05 DELIVERY, STORAGE, AND HANDLING**

- A. Mark each single-conductor cable and each multiple-conductor cable to show UL label, size, voltage, manufacturer and number of conductors or phases in accordance with NEC requirements.
- B. Ship each unit securely packaged and labeled for safe handling and shipment.
- C. Store products in a dry and secure facility.

### **PART 2 PRODUCTS**

#### **2.01 MATERIALS**

- A. General Requirements for Single-Conductor and Multiple-Conductor Cable:
  1. Type and size: Type I cable having low smoke - generating characteristics as shown on contract drawings.
  2. Conductors: Type I cable having low smoke generating characteristics.
    - a. ASTM B3 or ASTM B8 annealed copper.
    - b. Size 10 AWG and smaller: Solid or Class B or Class C stranded.
    - c. Size 8 AWG and larger: Class B stranded, unless otherwise specified.
    - d. Other constructions as specified.
  3. Standards: Except as modified, wires and cable complying with the following standards:
    - a. Cross-linked polyethylene (XLPE) insulated cable: ICEA S-66-524, NEMA WC7.
    - b. Other cable: ICEA S-68-516, NEMA WC8.

4. Conductor insulation: Low smoke, halogen free, low toxicity Ethylene-Propylene Rubber (EPR), ICEA Type II, and have the following properties:
  - a. The low smoke, halogen free, low toxicity EPR insulation shall be capable of withstanding operating copper conductor temperature of 90 degrees C continuous, 130 degrees C emergency overload for standard prescribed periods and 250 degrees C for short circuits. The insulation shall be highly moisture resistant, shall be free-stripping and leave the surface of the conductor clean. An opaque mylar separator may be used between the conductor and the insulation to ease stripping. Any additional tapes (e.g., flame-retardant fiberglass over the tinned copper tape, etc.) deemed necessary by the manufacturer shall be clearly noted.
  - b. Insulation thickness:
    - 1) Minimum average thickness of the EPR insulation wall over the conductor: 90 mils (0.090 inches).
    - 2) Minimum average thickness of the supplemental EPR insulation wall over the shield: 80 mils (0.080 inches).

The minimum point thickness for both layers of insulation shall not be less than 90% of the minimum average thickness.
  - c. The EPR insulation will have the following physical and electrical characteristics when tested in strict accordance with Article 1.02 standards:
    - 1) Tensile strength (minimum): 1200 PSI .
    - 2) Elongation (minimum): 150 percent.
    - 3) Tensile stress at 100 percent elongation (minimum): 500 PSI.
    - 4) When air oven tested for 168 hours at 121 degrees C  $\pm$  1 degree C:
      - a) Tensile strength: 75 percent
      - b) Elongation: 75 percent.
    - 5) When Hot Creep tested after conditioning at 150 degrees C  $\pm$  2 degrees C:
      - a) Elongation (maximum): 50 percent
      - b) Set (maximum): 5 percent.
    - 6) Electrical properties after water immersion at 75 degrees C  $\pm$  1 degree C:
      - a) Permittivity after 24 hours (maximum): 6.0
      - b) One to 14 days immersion (maximum increase in capacitance): 5 percent
      - c) Seven to 14 days immersion (maximum increase in capacitance): 3 percent
      - d) Stability factor after 4 days (maximum): 1.0,  
- OR -  
Stability factor difference (maximum) 1 - 14 days: 0.5
    - 7) Insulation resistance constant at 15.6 degrees C (minimum): 10,000 meg/1000 feet.
5. Nonmetallic jacket for single-conductor cable and individual conductors of multiple-conductor cable and as overall covering on multiple-conductor cable:
  - a. Cross-linked polyethylene (XPLE) or cross-linked polyolefin unless otherwise specified.
6. Cross-linked polyolefin complying with the following physical requirements. Properties tested in accordance with Part 6 of ICEA S-68-516, NEMA WC8 if

ethylene-propylene-rubber (EPR) insulation is used, or with Part 6 of ICEA S-66-524, NEMA WC7 if cross-linked polyethylene insulation is used. Jacket material free of PVC and PVC-based compounds.

- 1) Tensile strength, minimum pounds per square inch: 1,800.
  - 2) Elongation at rupture, minimum percent: 150.
  - 3) Aging requirement: After 168 hours in air oven test at 100C, plus or minus 1 degree C:
    - a) Tensile strength, minimum percentage of unaged value: 100.
    - b) Elongation at rupture, minimum percentage of unaged value: 80.
  - 4) Oil immersion: 18 hours at 121degree C, plus or minus one degree C, ASTM D471, Table 1, No. 2 oil:
    - a) Tensile strength, minimum percentage of unaged value: 80.
    - b) Elongation at rupture, minimum percentage of unaged value: 80.
  - 5) Jacket materials other than cross-linked polyolefin complying with ICEAS-68-516, NEMA WC8. Jacket material free of PVC and PVC-based compounds.
7. Flame retardancy: Single-conductor and multiple-conductor cable demonstrating flame retardancy in accordance with IEEE-383. Not required for medium voltage cable.
- a. Single-conductor cable and individual conductors of multiple-conductor cable passing vertical flame test. Cable size for testing: 14 AWG.
  - b. Single-conductor cable, Size 1/0 AWG and larger, passing vertical tray flame test, using ribbon gas burner in accordance with UL 44. Cable size for testing: 1/0 AWG.
  - c. Multiple-conductor cable passing vertical tray flame test, using ribbon gas burner. Cable size for testing: 7/C or 9/C with 12 AWG or 14 AWG conductors.
8. Applied Voltage testing:
- a. Single-conductor cable and individual conductors of multiple-conductor cable to be given applied ac voltage dielectric strength test, i.e., six-hour water immersion test.
  - b. For single conductors of multiple-conductor cable, conduct tests prior to assembly as multiple-conductor cable
  - c. Test procedures:
    - 1) Polyethylene-insulated conductors: In accordance with paragraphs 6.14.1, 6.14.2, 6.14.5, and 3.5.2 of ICEA S-66-524.
    - 2) Other conductors: In accordance with paragraphs 3.5.2, 6.27.1 and 6.27.2 of ICEA S068-516.
- B. Smoke generation: Single-and-multiple-conductor cable jacket materials demonstrating low-smoke generation when tested in accordance with ASTM E662 by independent, nationally recognized testing agency.
1. Conduct tests on specimens of overall jacket material for multiple-conductor cable and of jacket material for single-conductor cable.
  2. Prepare slab specimens for each material .100 inch, plus-or-minus .005-inch thick, identical to those of finished cables and meeting minimum physical requirements specified.
  3. Prior to testing, submit six-inch square portion of each specimen.Tag sample with manufacture's jacket or insulation identification code or number.
  4. Test values for cross-linked polyolefin not to exceed the following:
    - a. Flaming mode:

- 1) Uncorrected maximum specific optical density during first four minutes of test: 150.
  - 2) Uncorrected maximum specific optical density for entire 20-minute test: 300.
  - b. Nonflaming mode:
    - 1) Uncorrected maximum specific optical density during first four minutes of test: 150.
    - 2) Uncorrected maximum specific optical density for entire 20-minute test: 300.
    - 3) Other conductors: In accordance with paragraphs 3.5.2, 6.27.1 and 6.27.2 of ICEA S-68-516.
- C. 15-kV Single-Conductor Cable:
1. Rated voltage: 15-kV.
  2. Conductor: As specified and with an extruded semi-conducting strand screen.
  3. Insulation: Ethylene-propylene rubber, 133 percent insulation level, with an extruded semi-conducting insulation screen.
  4. Shield: Copper tape, minimum thickness 2.5 mils.
  5. Jacket: Overall nonmetallic jacket of chlorosulfonated polyethylene or cross-linked polyolefin.
- D. 2000-Volt Single-Conductor Cable:
1. Rated voltage: 2000 volts.
  2. Conductor:
    - a. Extra-flexible, 1000 KCMIL cable, Class G stranded for power feeder between cable connector assembly and contact rail.
    - b. Standard 1000 KCMIL cable, Class D stranded for traction power feeder installed in conduit and cable tray.
    - c. 6 AWG cable for connecting DC surge arrester to ground.
  3. Insulation: Ethylene-propylene rubber, ICEA Type II, 90 degree C, suitable for dry and wet locations.
  4. Jacket: Overall nonmetallic jacket of T-33-655 thermoset type II or cross-linked polyolefin.
  5. UL labeling: Type RHW-2.
  6. Additional requirements:
    - a. Insulation power factor: Two percent maximum.
    - b. Bond jacketed to insulation to prevent moisture pockets. Minimum peel strength of the jacket from insulation: Four pounds per inch width for cross-linked polyolefin, and 10 pound per inch for heavy-duty neoprene.
- E. 2000-Volt, Aluminum-Sheathed Multiple-Conductor Cable for Polarity Reference for Tie Breaker Stations:
1. Individual conductors:
    - a. Rated voltage: 2000 volts.
    - b. Conductor Size: 6 AWG, Class B stranded.
    - c. Number of conductors: As shown.
    - d. Insulated with ethylene-propylene-rubber, with nonmetallic jacket.
    - e. UL-listed as Type RHW-2 or XHHW-2.
    - f. Insulation power factor: Two percent maximum.
    - g. Bond jacket to insulation to prevent moisture pockets. Minimum peel strength of the jacket from insulation: Four pounds per inch width for chlorosulfonated polyethylene or cross-linked polyolefin and 10 pound per inch for heavy-duty neoprene.
  2. Conductors assembled with non-wicking, flame-retardant filler to form cable of circular cross section.

3. Metallic-sheath:
    - a. Continuous corrugated sheath in accordance with ICEA S-19-81, Table 4-26A or UL 1569.
  4. Jacket: Overall nonmetallic jacket of T-33-655 thermoset type II or cross-linked polyolefin.
  5. Cable UL-listed: Type MC, suitable for wet and dry locations.
  6. Color coding:
    - a. Individual conductors shall be black.
- F. 600-Volt, Single-Conductor Cable:
1. Rated voltage: 600 volts.
  2. Insulated with jacketed ethylene-propylene-rubber with nonmetallic jacket UL-labeled Type RHW or unjacketed filled cross-linked polyethylene, UL-labeled Type XHHW-2 or RHW-2.
  3. Color coding: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.
- G. 600-Volt, Nonmetallic Sheathed Multiple-Conductor Cable:
1. Individual conductors:
    - a. Rated voltage: 600 volts.
    - b. Number of conductors: As shown.
    - c. Construction: Complying with one of the following:
      - 1) Insulated with ethylene-propylene-rubber, with nonmetallic jacket.
      - 2) Insulated with composite compound of ethylene-propylene-rubber and polyethylene, UL Class EPCV, without outer jacket.
      - 3) Insulated with filled cross-linked polyethylene without outer jacket.
    - d. Phase and neutral conductors: Individually insulated.
    - e. Neutral conductors: Same size as phase conductors.
    - f. Insulated ground conductors: Sized in accordance with the NEC, unless otherwise shown.
    - g. UL-listed as Type RHW-2 or XHHW-2.
  2. Conductors assembled with non-wicking, flame-retardant filler to form cable of circular cross section.
  3. Multiple-conductor cable provided with overall nonmetallic jacket of T-33-655 thermoset type II or cross-linked polyolefin.
  4. Cable UL-listed as follows:
    - a. Nonmetallic-sheathed cable: Type TC, suitable for wet and dry locations.
  5. Color coding:
    - a. Power cables: In accordance with paragraph 200-6, 200-7 and 210-5 of the NEC.
    - b. Control cables: In accordance with ICEA S-66-524, Table K-2.
- H. 600-Volt, Aluminum-Sheathed Multiple-Conductor Cable (ALS) for connection between ETS and between Junction Box and Type 9 Light Fixture Cabinet and ETS in Tunnels:
1. Individual conductors:
    - a. Rated voltage: 600 volts.
    - b. Number of conductors: As shown.
    - c. Construction: Complying with one of the following:
      - 1) Insulated with ethylene-propylene-rubber, with nonmetallic jacket.
      - 2) Insulated with composite compound of ethylene-propylene-rubber and polyethylene, UL Class EPCV, without outer jacket.
      - 3) Insulated with filled cross-linked polyethylene without outer jacket.
    - d. Phase and neutral conductors: Individually insulated.
    - e. Neutral conductors: Same size as phase conductors.
    - f. Insulated ground conductors: Sized in accordance with the NEC, unless otherwise shown.

- g. UL-listed as Type RHW-2 or XHHW-2.
  - 2. Conductors assembled with non-wicking, flame-retardant filler to form cable of circular cross section.
    - a. Metallic-sheath:
    - b. Provide continuous corrugated sheath in accordance with ICEA S-19-81, Table 4-26A.
  - 3. Multiple-conductor cables provided with overall non-metallic jacket of T-33-655 thermostat type II or cross-linked polyolefin.
  - 4. Cable UL-listed as follows:
    - a. Metallic-sheathed cable: Type MC, suitable for wet and dry locations.
  - 5. Color coding:
    - a. In accordance with ICEA S-66-524, Table K-2.
    - b. Power cables: In accordance with ICEA S-66-524, Table K-1.
- I. Instrumentation Cable: 2/C, twisted pairs:
  - 1. Individual conductors:
    - a. Rated voltage: 600 volts.
    - b. Number of conductors: As shown.
    - c. Construction: Insulated with polyethylene insulation.
  - 2. Conductors twisted and covered with a tinned copper braided shield; Class B stranded.
  - 3. Provided with overall jacket.
- J. Bare Conductor: ASTM B3, annealed copper conductor; 8 AWG and larger, Class B stranded.
- K. Medium Voltage Cable Terminations:
  - 1. Except as otherwise specified, heat shrinkable tubing kit type, with grounding accessory kits, in accordance with the characteristics of the medium voltage cable shall be furnished.
    - a. Shrinkable tubing kits to be pre-stretched shrinkable tubing and shall contain all necessary components to reinstate cable insulation, metallic shielding/grounding system and overall jacket.
- L. Cable Pulling Calculations:
  - 1. The Contractor shall perform pulling calculations in accordance with the cable manufacturer's recommendations, and these specifications. The calculations shall be made by an Electrical Engineer registered in the State of Maryland, or State of Virginia (depending on the location), and District of Columbia, depending on the location and bear the seal and signature of the engineer who is responsible for the calculations. Calculations shall be made for all conductors including DC power cable, 15kV cable, and multiconductor control cable when installed in conduit under the following conditions:
    - a. The conduit run exceeds 100 feet vertically;
    - b. The conduit run exceeds 300 feet horizontally; and
    - c. The conduit run contains a total of over 180 degrees of bend.
  - 2. The Contractor shall also provide calculations for any additional run under any condition when requested by the Engineer. The calculations shall establish that the Contractor's cable installation can be implemented without damage to any wire or cable.
  - 3. For pulling calculations, consideration shall be given to the following parameters - fill, coefficient of friction, clearance configuration, jam ratio of the cables and conduit, weight correction factor, bend radii, training of cables on entering and existing the conduits, maximum allowable tension, sidewall load, the method of attaching the conductors to the pulling equipment, and weight of the cables. These factors shall

be calculated for each pull as required. The contractor shall not exceed the maximum allowable values of sidewall pressure, pulling strain on conductors or sheath, limits of pulling device, and pulling tension.

4. In general, the Contractor shall not exceed the following guidelines:
  - a. The maximum pulling strain on the cable with a pulling eye attached to the conductors is a function of the conductor area as follows:  $TM = 0.008 \times n \times CM.$ , where TM = Maximum tension (lbs), n = number of conductors, CM = area of each conductor circular miles.
  - b. When a basket-weave grip is used in lieu of a pulling eye, the maximum tension shall not exceed the value calculated for the pulling eye method or 1000 lbs per grip, whichever is less.
  - c. The sidewall pressure loads shall not exceed 300 lb/ft of bend radius, or the Wire and Cable Manufacturer's recommendation, whichever is less.
  - d. The jam ratio shall not fall between 2.8 and 3.2.
  - e. The coefficient of the friction for the cables with lubrication shall be taken to be 0.5.
5. Cable pulling calculations shall be submitted to the Engineer for approval. Cable shall not be installed until the contractor receives approval from the Engineer for the pulling calculations and cable installation.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install all wiring continuous, without splices, between terminations, except as otherwise noted.
- B. Install single-conductor cable in conduit or cable tray as shown. Install UL Type TC multiple-conductor cable in cable trays. Install UL Type MC multiple-conductor cable and ground cable on channel inserts, cable trays or racks, using straps and fasteners as specified in Section 16052 (Basic Materials and Methods). Install UL Type MC multiple-conductor cable in conduit where shown or required. On walls or ceilings, fasten cable directly to channel inserts, or use expansion bolt anchors to attach to concrete and toggle bolts to attach to concrete masonry walls.
- C. Use nylon straps to bundle and secure wire and cable located in panelboards, cabinets, switchboards, switchgear and control panels.
- D. Minimum bending radius 12 times outer diameter of cable. Where shown, use shorter bending radius as permitted by NEC, Appendix H of ICEA S-66-524, NEMA WC7 and cable manufacturer.
- E. To facilitate pulling cable, use UL-listed lubricant recommended by cable manufacturer.
- F. Use polyethylene or other suitable nonmetallic rope for pulling cable. Attach to cable by means of either woven basket grips or pulling eyes attached directly to the conductors.
- G. In damp and dusty indoor locations, manholes and outdoor locations, seal cable at conduit termination using duct sealing compound.
- H. Support cable installed in manholes at each invert location with cable brackets, racks and insulators specified in Section 16052 (Basic Materials and Methods). Provide brackets of suitable length with one insulator for each cable.
- I. Support traction power cable installed in vertical risers with nonmetallic cable grip support at

top of riser and with nonmetallic or aluminum multiple segment wedging plug type cable support at intermediate pull box provided as specified in Section 16052 (Basic Materials and Methods)

- J. Where shown or necessary, install cable seal fitting specified in Section 16052 to prevent entry of water into electrical facilities. Where approved, use seal compound specified in Section 16052 (Basic Materials and Methods).
- K. Terminate medium voltage cable, using the specified termination kits, in accordance with the manufacturer's recommendations.
- L. The splicing of power and control cables is not permitted in ductbanks, cable troughs or cable trenches. However, if permitted by the Engineer, make watertight splices as approved.
- M. The Contractor shall hook up 1000 KCMIL traction power cables at switchgear end and trackside (negative and positive rails) when directed by the Engineer.
- N. All 1000 KCMIL cables shall be secured at every rung on the cable tray with tie wraps.
- O. Identify cable terminations, feeders, power and control circuits using the following:
  - 1. Cable Tags: Stainless steel tags punched with conduit or cable number as shown.
  - 2. Wire Labels: Sleeve-type, heat shrinkable, flame retardant Raychem TMS product line, Type XPE or equal and conforming to UL 224. Wire identification same as corresponding terminal block identification unless otherwise shown. The labels on 1000 KCMIL cable shall be clear, heat shrinkable with 1/2" height yellow lettering stamped on inside. The labels shall have reference of substation or tie breaker station breaker Supervisory control ID number and cable sequence in the branch of the feeder (e.g. BRK. 32-A) at both ends.
  - 3. Attach tags to cable with slip-free plastic lacing or nylon bundling straps. Use designation shown.

### **3.02 FIELD QUALITY CONTROL**

- A. Furnish equipment required to perform tests. Prior to insulation and high potential tests, disconnect instruments and equipment which might be damaged during such tests. Conduct tests in presence of the Engineer. Schedule all tests through the Engineer and provide a minimum 48 hours notice.
- B. Submit test procedure for approval and perform approved tests. Do not perform tests without approved test procedure. Schedule all tests through the Engineer. Tests include but not limited to the following:
  - 1. 600-volt non-metallic sheathed multiple-conductor cable:
    - a. Test continuity of cable conductors using ohmmeter.
    - b. Proof-test insulation resistance to ground and between insulated conductors for minimum of one minute using 1000-volt megger. Insulation resistance: one megohm minimum, corrected to 15.6 C. Testing procedures shall be as follows:
      - 1) Disconnect all wires of the cable under test at both ends and tape the far end of the wire under test with insulating tape of 600-volt class. Connect the bare end of the wire under test to the positive terminal of 1000-volt megger.
      - 2) Connect the negative terminal of 1000-volt megger to the nearest available ground terminal.
      - 3) Measure the insulation resistance of the wire under test by cranking the megger.
    - c. When cable shows insulation resistance of less than one megohm, perform

- high potential test at 80 percent of factory dc test voltage or as recommended by cable manufacturer. A gradual decrease of leakage current with time indicates an acceptable cable installation.
2. 600-volt aluminum sheathed multiple-conductor cable:
    - a. Test continuity of each conductor using ohmmeter.
    - b. Disconnect the cable under test at both ends. Proof-test insulation resistance between each conductor and the metal sheath. While conducting the test, all conductors of the cable and the metallic sheath other than that under test shall be grounded. Insulation resistance shall be measured with a 1000-volt megger for minimum of one minute between the wire under test and ground. Insulation resistance: one megohm minimum, corrected to 15.6 degree C.
    - c. When cable shows insulation resistance of less than one megohm, perform high potential test at 80 percent of factory dc test voltage or as recommended by cable manufacturer. A gradual decrease of leakage current with time indicates an acceptable cable installation.
  3. 600-volt single-conductor cable:
    - a. Test continuity of conductors using ohmmeter.
    - b. Disconnect cable under test at both ends. Proof-test insulation resistance between each cable and the conduit in which the cable runs. While conducting the test, all other cables installed in the same conduit with the cable under test shall be connected to ground at one end. Insulation resistance shall be measured with a 1000-volt megger for minimum of one minute between the cable under test and the ground. Insulation resistance: One megohm minimum corrected to 15.6 degree C.
    - c. When cable shows insulation resistance of less than one megohm, perform high potential test at 80 percent of factory dc test voltage or as recommended by cable manufacturer. A gradual decrease of leakage current with time indicates an acceptable cable installation.
  4. 2000-volt single-conductor cable:
    - a. Test continuity of conductors using ohmmeter.
    - b. Proof-test insulation resistance to ground of the cable under test for a minimum of one minute using a 2500-volt three-terminal megger. Insulation resistance: 500 megohms, minimum, corrected to 15.6 degree C. Testing shall be done prior to termination of the cables at the two ends. Terminal lugs shall be installed prior to cable testing. Testing procedure shall be as follows:
      - 1) Proof-test the system insulation resistance to ground of the cable under test using step-voltage testing method.
      - 2) Insulation resistance: 500 megohms, corrected to 15.6 degree C. Testing shall be done after all cables have been installed and lugged.
      - 3) Isolate all cables at trackside and in the switchgear.
      - 4) Secure each cable under test and connect the positive test lead of the megger to one end of the cable under test. Connect the megger ground lead to the station ground busbar.
      - 5) Apply a 1000-volt dc test voltage to the cable for one minute and record the end test reading on the data sheet.
      - 6) If the megger reading is greater than or equal to 500 megohms, proceed with testing the next cable in the test plan. If the test value is lower than 500 megohms, proceed with the step-voltage test as described below.
      - 7) Step-voltage test:
        - a) Examine and clean cable termination for presence of moisture or contamination.

- b) Make a second megger test at 1000 volts dc for one minute and record end test reading on data sheet. If reading is less than 500 megohms, proceed with step (c) below, otherwise record new test reading on data sheet with comments depicting corrective action and proceed with testing next cable in the test plan.
    - c) Increase the megger test voltage in increments of 500 volts starting at 1500 volts dc up to 2500 volts dc and perform one minute insulation resistance measurement tests. Record end test readings on data sheet for each incremental test.
    - d) Compare insulation test readings at all levels of test voltage. A decrease of insulation resistance from the 1000 volts dc test voltage to the 2500 volts dc test voltage indicates the cable insulation has incipient weakness and the cable shall be replaced at no cost to the Authority.
  - 8) Repeat the above procedures for all the positive and negative traction power cables.
- 5. 2000-volt aluminum-sheathed multiple-conductor cable:
  - a. Test continuity of each conductor using ohmmeter.
  - b. Disconnect the cable under test at both ends. Proof test insulation resistance between each conductor and the metal sheath. While conducting the test, all conductors of the cable and the metallic sheath other than that under test shall be grounded. Insulation resistance shall be measured with a 2500-volt megger for minimum of one minute. Insulation resistance: 500 megohms minimum corrected to 15.6 degree C.
  - c. When cable shows insulation resistance less than 500 megohms, perform high potential test at 80 percent of factory test voltage or as recommended by cable manufacturer. A gradual decrease of leakage current with time indicates an acceptable cable installation.
- 6. 15-kV single-conductor cable:
  - a. Test continuity of conductors using ohmmeter.
  - b. Proof-test insulation resistance between conductor and the metallic shield. While conducting the test, the metal shield shall be tied to ground. Insulation resistance shall be measured with a 2500-volt megger for minimum of one minute. Insulation resistance: 500 megohm minimum corrected to 15.6 degree C.
  - c. Submit certified test reports within 10 days after completion of test.

**END OF SECTION**

## SECTION 16129

### 2000 VOLT SHIELDED CABLE FOR TRACTION POWER

#### PART 1. GENERAL

##### 1.01 SUMMARY

- A. This section specifies furnishing, installing and testing shielded, low-smoke, halogen-free, low toxicity, single conductor 2000V cable, with standard and "extra-flexible" stranding. Size as shown on the contract drawings.
- B. Compensation for work specified in this section will be made in accordance with the Unit Price Schedule.
- C. Related sections include:
  - 1. Section 16051 - Scope of Work For Traction Power
  - 2. Section 16052 - Basic Materials and Methods For Traction Power
  - 3. Section 16128 - Wire and Cable For Traction Power
  - 4. Section 16341 - Metal-Enclosed DC Switchgear For Traction Power

##### 1.02 REFERENCES

- A. Pertinent provisions of the current edition of the following listed Codes, Regulations, Reference Standards and Specifications shall apply to the work of this Section, except as they may be modified herein, and are hereby made a part of this Specification to the extent required. In instances of conflict, the more stringent requirement will take precedence.
  - 1. Latest codes and regulations of the jurisdictional authorities.
  - 2. NEC, NESC.C2.
  - 3. ICEA: S-95-658, S-96-659, S-93-639, T-26-465, T-27-581, T-28-562, T-33-655.
  - 4. IEEE: 383.
  - 5. NEMA: WC53, WC54, WC70, WC71, WC74.
  - 6. ASTM: B3, B8, B173, D412, D471, D572, D573, E662.
  - 7. UL: 1072, 1581, 1685
  - 8. MIL: C-24643

##### 1.03 SUBMITTALS

Submit the following for approval in accordance with the Special Conditions and with the additional requirements as specified for each:

- A. Shop Drawings: Submit shop drawings for each type of cable in accordance with Section 16051.
- B. Samples: Specified smoke-density test sample will become property of the Authority.
- C. Certification
  - 1. Certified flame retardancy test reports and data for tests performed not more than 36 months prior to submittal, for materials which are identical to those of the furnished cable.
  - 2. Submit smoke-density test reports and data from tests performed not more than

36 months prior to the submittal for materials that are identical to those of the furnished cable.

3. Certified test reports demonstrating that cable complies with specified requirements and those of referenced ICEA and NEMA Standards.
4. Certificates from manufacturer and the Underwriters Laboratories Inc.(UL Listing) verifying that products conform to specified requirements. Include certificates with submittal of shop drawings and with each cable shipment.

#### **1.04 QUALITY ASSURANCE**

- A. Qualifications: Select a manufacturer who is regularly engaged in production of similar wire and cable, particularly to Railway or Transit industry in USA. The manufacturer must have in place a quality system in accordance with ISO 9001 or 9002 and be registered by an independent registration organization.
- B. For Codes, Regulations, Reference Standards and Specifications, refer to Article 1.02.

#### **1.05 DELIVERY, STORAGE, AND HANDLING**

- A. Mark each single-conductor cable to show UL Listing, size, voltage, manufacturer, etc. in accordance with NEC, ICEA/NEMA and UL requirements.
- B. Ship each unit securely packaged and labeled for safe handling and shipment.
- C. Store products in a dry and secure facility.

### **PART 2 PRODUCTS**

#### **2.01 MATERIALS**

- A. General Requirements for Single-Conductor Shielded Cable:
  1. Type and rating: Type II shielded, low smoke, halogen free, low toxicity 2000 Volt jacketed cable.
  2. Conductors:
    - a. ASTM and ICEA standards.
    - b. Standard 1000kcmil, 127 strand Class D tinned copper.
    - c. Other constructions, as specified or shown on the contract drawings.
    - d. Cable suitable for dry and wet locations and hostile environmental conditions associated with underground heavy rail transit systems.
  3. Standards: Except as modified, cable shall comply with the Article 1.02.
  4. Conductor insulation: Low smoke, halogen free, low toxicity Ethylene-Propylene Rubber (EPR), ICEA Type II, and have the following properties:
    - a. The low smoke, halogen free, low toxicity EPR insulation shall be capable of withstanding operating copper conductor temperature of 90 degrees C continuous, 130 degrees C emergency overload for standard prescribed periods and 250 degrees C for short circuits. The insulation shall be highly moisture resistant, shall be free-stripping and leave the surface of the conductor clean. An opaque mylar separator may be used between the conductor and the insulation to ease stripping. Any additional tapes (e.g., flame-retardant fiberglass over the tinned copper tape, etc.) deemed necessary by the manufacturer shall be clearly noted.
    - b. Insulation thickness:

- 1) Minimum average thickness of the EPR insulation wall over the conductor: 90 mils (0.090 inches).
- 2) Minimum average thickness of the supplemental EPR insulation wall over the shield: 80 mils (0.080 inches).

The minimum point thickness for both layers of insulation shall not be less than 90% of the minimum average thickness.

c. The EPR insulation will have the following physical and electrical characteristics when tested in strict accordance with Article 1.02 standards:

- 1) Tensile strength (minimum): 1200 PSI .
- 2) Elongation (minimum): 150 percent.
- 3) Tensile stress at 100 percent elongation (minimum): 500 PSI.
- 4) When air oven tested for 168 hours at 121 degrees C  $\pm$  1 degree C:
  - a) Tensile strength: 75 percent
  - b) Elongation: 75 percent.
- 5) When Hot Creep tested after conditioning at 150 degrees C  $\pm$  2 degrees C:
  - a) Elongation (maximum): 50 percent
  - b) Set (maximum): 5 percent.
- 6) Electrical properties after water immersion at 75 degrees C  $\pm$  1 degree C:
  - a) Permittivity after 24 hours (maximum): 6.0
  - b) One to 14 days immersion (maximum increase in capacitance): 5 percent
  - c) Seven to 14 days immersion (maximum increase in capacitance): 3 percent
  - d) Stability factor after 4 days (maximum): 1.0,  
 - OR -  
 Stability factor difference (maximum) 1 - 14 days: 0.5
- 7) Insulation resistance constant at 15.6 degrees C (minimum): 10,000 meg/1000 feet.

5. Shield:

- a. The shield shall consist of a continuous layer of tin-coated copper tape at least 5 mils (0.005 inches) thick. The tape shall be a minimum width of 0.75 inches and be applied with an overlap of at least 0.25 inches or 25 % of its width.
- b. The tape shall be free from burrs and shall be applied in such a manner that electrical continuity or contiguity will not be distorted or disrupted during normal installation bending. Joints in tapes shall be made electrically continuous by welding, soldering or brazing. Butted tapes shall not be permitted.

Note: Reminder: Apply supplemental EPR over shield before non metallic jacket. See 2.01 A.4.b.2), above.

6. Nonmetallic jacket for single-conductor cable:

- a. Cross-linked polyolefin (XLPO) Thermoset Type II complying with the following physical requirements. Minimum average wall thickness shall be 0.095 inches, minimum thickness at any point 0.080 inches. Properties tested in accordance with ASTM, ICEA, UL, IEEE and MIL specifications, refer to Article 1.02. Jacket material shall be low-smoke,

halogen-free, low toxicity, fire retardant. Bond jacket to insulation to prevent moisture pockets between the jacket and insulation. The minimum peel strength of the jacket from insulation shall be four pounds per inch width.

- 1) Tensile strength, minimum pounds per square inch: 1,600.
  - 2) Elongation at rupture, minimum percent: 150.
  - 3) Aging requirement: After 168 hours in air oven test at 121degrees C  $\pm$  1 degree C:
    - a) Tensile strength, minimum percentage of unaged value: 85.
    - b) Elongation at rupture, minimum percentage of unaged value: 75.
  - 4) When Hot Creep tested after conditioning at 150 degrees C  $\pm$  2 degrees C:
    - a) Elongation (maximum): 100 percent
    - b) Set (maximum): 10 percent.
  - 5) Cold Bend Temperature: minus 25 degrees C.
  - 6) Gravimetric Method - Water Absorption (maximum): 50 mg/in<sup>2</sup>.
  - 7) When oil immersion tested for 18 hours at 121 degrees C  $\pm$  1 degree C:
    - a) Tensile strength: 50 percent
    - b) Elongation: 50 percent.
  - 8) Smoke density, 100 mil slab:
    - a) Flaming mode:  
Uncorrected maximum specific optical density during first four minutes of test Ds4: 50  
Uncorrected maximum specific optical density for entire 20-minute test, Dm: 250
    - b) Non-flaming mode:  
Uncorrected maximum specific optical density during first four minutes of test, Ds4: 50  
Uncorrected maximum specific optical density for entire 20-minute test, Dm: 350
7. The completed cable (including insulation and jacket) will be tested in accordance with ASTM, UL and MIL standards by an independent, nationally recognized testing agency. The combustion requirements and characteristics are:
- a. Acid gas equivalent (maximum): 2 percent
  - b. Halogen content: 0.2 percent
  - c. Smoke density, 100 mil slab:  
Prepare 100 mil (0.100 inches), plus-or-minus 0.005 inches, thick slab specimens for each material identical to those of finished cables and meeting minimum physical requirements specified. Prior to testing, submit six-inch square portion of each specimen. Tag sample with manufacture's jacket or insulation identification code or number.
    - 1) Flaming mode:  
Uncorrected maximum specific optical density during first four minutes of test Ds4: 50  
Uncorrected maximum specific optical density for entire 20-minute test, Dm: 250
    - 2) Non-flaming mode:  
Uncorrected maximum specific optical density during first four minutes of test, Ds4: 50  
Uncorrected maximum specific optical density for entire 20-minute test, Dm: 350

- d. Flame retardancy: All 2000-volt shielded power cables shall be flame-retardant and shall pass the vertical tray flame test as described in the IEEE - 383, ICEA S-95-658, T-30-520 and UL-1581, 1685. Cable size for testing shall be a minimum 250 kcmil.

8. Applied Voltage testing:

- a. All 2000-volt shielded cable to be given applied AC voltage dielectric strength test, i.e., six-hour water-immersion test.
- b. Test procedures:  
Conductor shall be immersed in water for a minimum of six hours before test. Shielded cables shall be tested from conductor to shield, and tested from shield to water at 11.0 kV AC. Test in accordance with methods outlined in appropriate sections of ICEA, NEMA and UL standards.

B. Cable Pulling Calculations

The Contractor shall perform pulling calculations in accordance with the cable manufacturer's recommendations, and these specifications. The calculations shall be made by an Electrical Engineer registered in the State of Maryland, or the State of Virginia, and District of Columbia, depending on the installation location and bear the seal and signature of the engineer who is responsible for the calculations. Calculations shall be made for all conductors including DC power cable, 15kV cable, and multiconductor control cable when installed in conduit under the following conditions:

1. The conduit run exceeds 100 feet vertically;
2. The conduit run exceeds 300 feet horizontally; and
3. The conduit run contains a total of over 180 degrees of bend.

The Contractor shall also provide calculations for any additional run under any condition when requested by the Engineer. The calculations shall establish that the Contractor's cable installation can be implemented without damage to any wire or cable.

For pulling calculations, consideration shall be given to the following parameters - fill, coefficient of friction, clearance configuration, jam ratio of the cables and conduit, weight correction factor, bend radii, training of cables on entering and existing the conduits, maximum allowable tension, sidewall load, the method of attaching the conductors to the pulling equipment, and weight of the cables. These factors shall be calculated for each pull as required. The contractor shall not exceed the maximum allowable values of sidewall pressure, pulling strain on conductors or sheath, limits of pulling device, and pulling tension.

In general, the Contractor shall not exceed the following guidelines:

1. The maximum pulling strain on the cable with a pulling eye attached to the conductors is a function of the conductor area as follows:  $TM = 0.008 \times n \times CM$ ., where TM = Maximum tension (lbs), n = number of conductors, CM = area of each conductor circular mils.
2. When a basket-weave grip is used in lieu of a pulling eye, the maximum tension shall not exceed the value calculated for the pulling eye method or 1000 lbs per grip, whichever is less.
3. The sidewall pressure loads shall not exceed 300 lb/ft of bend radius, or the Wire and Cable Manufacturer's recommendation, which ever is less.
4. The jam ratio shall not fall between 2.8 and 3.2.
5. The coefficient of the friction for the cables with lubrication shall be taken to be 0.5

Cable pulling calculations shall be submitted to the Engineer for approval. Cable shall not be installed until the contractor receives approval from the Engineer for the pulling calculations and cable installation.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install all cable continuous, without splices, between terminations, except as otherwise noted.
- B. Install single-conductor cable in conduit or cable tray as shown. On walls or ceilings, fasten cable directly to channel inserts, or use expansion bolt anchors to attach to concrete and toggle bolts to attach to concrete masonry walls.
- C. Minimum bending radius 12 times outer diameter of cable. Where shown, use shorter bending radius as permitted by NEC, and/or appropriate sections of ICEA/NEMA standards and cable manufacturer.
- D. To facilitate pulling cable, use UL-listed lubricant recommended by cable manufacturer.
- E. Use polyethylene or other suitable nonmetallic material for the line to pull the cable. The pulling line should be adequately sized to safely pull the cable into the raceway. The pulling line should be high strength, low stretch and abrasion resistant. Attach to cable by means of either woven basket grips or pulling eyes attached directly to the conductors.
- F. In damp and dusty indoor locations, manholes and outdoor locations, seal cable at conduit termination using duct sealing compound prior to cable pulling.
- G. Support cable installed in manholes at each invert location with cable brackets, racks and insulators specified in Section 16052 (Basic Materials and Methods). Provide brackets of suitable length with one insulator for each cable.
- H. Support traction power cable installed in vertical risers with nonmetallic cable grip support at top of riser and with nonmetallic or aluminum multiple segment wedging plug type cable support at intermediate pull box provided as specified in Section 16052 (Basic Materials and Methods).
- I. Install cable seal fitting specified in Section 16052 to prevent entry of water into electrical facilities. Where approved, use seal compound specified in Section 16052 (Basic Materials and Methods).
- J. The splicing of power cables is not permitted in ductbanks, cable troughs or cable trenches. However, if permitted by the Engineer, make watertight splices as approved and note on as-built drawings.
- K. The Contractor shall hook up 1000 KCMIL traction power cables at switchgear end and track side (negative and positive rails) when directed by the Engineer.
- L. All 1000 KCMIL cables shall be secured at every rung on the cable tray with tie wraps.
- M. Identify cable terminations, feeders, power and control circuits using the following:
  - 1. Cable Tags: Non-ferrous tags or pressure sensitive labels, stamped or printed with cable number as shown.
  - 2. Labels: The labels on 1000 KCMIL cable shall be clear, heat shrinkable with ½" height yellow lettering stamped on inside. The labels shall have reference of substation or tie breaker station breaker Supervisory control ID number and cable sequence in the branch of the feeder (e.g. BRK. 32-A) at both ends, as well as at each entry and exit point or stub up, from concealed raceways.
  - 3. Attach tags to cable with slip-free plastic lacing or nylon bundling straps. Use designation shown.
- N. Refer to WMATA's procedure for shielded cable terminations.
- O. Refer to WMATA's procedure for shielded cable monitoring system.

- P. Provide fire proofing on exposed cables.

### 3.02 FIELD QUALITY CONTROL

- A. Furnish equipment required to perform tests. Prior to insulation and high potential tests, disconnect instruments and equipment that might be damaged during such tests. Conduct tests in presence of the Engineer. Schedule all tests through the Engineer and provide a minimum 48 hours notice.
- B. Submit test procedure for approval and perform approved tests. Do not perform tests without approved test procedure. Schedule all tests through the Engineer. Tests include but not limited to the following:
  - 1. 2000-volt single-conductor shielded cable:
    - a. Test continuity of conductors using ohmmeter.
    - b. Proof-test insulation resistance to shield or to ground of the cable under test for a minimum of one minute using a 2500-volt three-terminal megger. Insulation resistance: 10,000 megohms, minimum, corrected to 15.6 degrees C. Testing shall be done prior to termination of the cables at the two ends. Terminal lugs shall be installed prior to cable testing. Testing procedure shall be as follows:
      - 1) For shielded cables, proof-test insulation resistance between conductor and the metallic shield. While conducting the test, the metal shield shall be tied to ground. For unshielded cables, proof-test the system insulation resistance to ground of the cable. The step-voltage testing method shall be used.
      - 2) Testing shall be done after all cables have been installed and lugged. Isolate all cables at track side and in the switchgear.
      - 3) Secure each cable under test and connect the positive test lead of the megger to one end of the cable under test. Connect the megger ground lead to the station ground busbar and/or cable shield, as appropriate.
      - 4) Apply a 1000-volt dc test voltage to the cable for one minute and record the end test reading on the data sheet.
      - 5) If the megger reading is greater than or equal to 10,000 megohms, proceed with testing the next cable in the test plan. If the test value is lower than 10,000 megohms, proceed with the step-voltage test as described below.
      - 6) Step-voltage test:
        - a) Examine and clean cable termination for presence of moisture or contamination.
        - b) Make a second megger test at 1000 volts dc for one minute and record end test reading on data sheet. If reading is less than 10,000 megohms, proceed with step (c) below, otherwise record new test reading on data sheet with comments depicting corrective action and proceed with testing next cable in the test plan.
        - c) Increase the megger test voltage in increments of 500 volts starting at 1500 volts dc up to 2500 volts dc and perform one minute insulation resistance measurement

tests. Record end test readings on data sheet for each incremental test.

- d) Compare insulation test readings at all levels of test voltage. A decrease of insulation resistance from the 1000 volts dc test voltage to the 2500 volts dc test voltage indicates the cable insulation has incipient weakness and the cable shall be replaced at no cost to the Authority.
- 7) Repeat the above procedures for all the positive and negative traction power cables.

END OF SECTION

## SECTION 16130

### RACEWAYS, BOXES AND CABINETS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing conduit, raceways, cable trays, boxes and cabinets to form raceway and support system for power, communication and control cables.
- B. Related Work Specified Elsewhere:
  - 1. Underground electrical and communications distribution systems: Section 02585.
  - 2. Concrete formwork: Section 03100.
  - 3. Cast-in-place structural concrete: Section 03300.
  - 4. Structural precast concrete: Section 03400.
  - 5. Grounding and bonding: Section 16060.
  - 6. Firestopping: Section 07841.

##### 1.02 QUALITY ASSURANCE:

- A. Qualifications: Select a manufacturer who is engaged in production of similar raceways, boxes and cabinets.
- B. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. National Electrical Code (NEC).
  - 3. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum); VE 1, Metallic Cable Tray Systems; TC-2, Electrical Polyvinyl Chloride (PVC) Tubing and Conduit.
  - 4. American National Standards Institute (ANSI): C80.1, Rigid Steel Conduit - Zinc Coated; C80.5, Aluminum Rigid Conduit - (ARC); and Z55.1, Gray Finishes for Industrial Apparatus and Equipment.
  - 5. UL: 5, Surface Metal Raceways and Fittings; 6, Rigid Metal Conduit; 50, Enclosures for Electrical Equipment; 94, Test for Flammability of Plastic Materials for Parts in Devices and Appliances; 360, Liquid Tight Flexible Steel Conduit; 514A, Metallic Outlet Boxes; 514B, Fittings for Conduit and Outlet Boxes; 514C, Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers; 651, Schedule 40 and 80 Rigid PVC Conduit; 884, Underfloor Raceways and Fittings; and 1684, Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
  - 6. Federal Specifications (FS): FF-S-325C, FF-S-760, TT-S-227.
  - 7. American Standards of Testing and Materials (ASTM): A47/A47M-99, Standard Specification for Ferritic Malleable Iron Castings; A123/A123M-00, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; A185-97, Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement; A276-00a, Standard Specification for Stainless Steel Bars and Shapes; A507-00, Standard Specification for Drawing Alloy Steel, Sheet and Strip, Hot-Rolled and Cold-Rolled; A532/A532M-93a(1999)e1, Standard Specification for Abrasion-Resistant Cast Irons; A536-84(1999)e1, Standard Specification for Ductile Iron Castings; A615/A615M-00, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement; A653/A653M-00, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; B138-96, Standard Specification for Manganese Bronze Rod, Bar and Shapes; B455-96, Standard Specification for Copper-Zinc-Lead Alloy (Leaded-Brass) Extruded Shapes; B584-00, Standard Specification for Copper Alloy

Sand Castings for General Applications; B633-98, Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel; C109/C109M-99, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens); C173-94ae1, Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method; C231-97e1, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method; D149-97a, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies; D495-99, Standard Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation; D570-98, Standard Test Method for Water Absorption of Plastics; D638-00, Standard Test Method for Tensile Properties of Plastics; D648-00a, Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position; and D790-00, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

8. American Association of State Highway and Transportation Officials (AASHTO): Standard Specifications for Highway Bridges (SSHB).
9. ITS: Directory of ITS listed products.

- C. The following items to be listed or labeled per referenced UL or ITS directory:
1. Conduit and fittings.
  2. Surface raceways and fittings.
  3. Underfloor raceways and fittings.
  4. Boxes.
  5. Cabinets.

### **1.03 SUBMITTALS:**

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings.
  2. Certification.

### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Mark each item in accordance with applicable reference standard.
- B. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.
- C. Store products in secure and dry storage facility.

## **PART 2 - PRODUCTS**

### **2.01 PRODUCTS AND MATERIALS:**

- A. General Requirements for Conduit, Raceways, Cable Trays, Boxes, Cabinets and Fittings:
1. Size: As shown, minimum conduit size 3/4 inch.
  2. Materials:
    - a. Steel sheet: ASTM A507-00.
    - b. Zinc-coated steel sheet: ASTM A653/A653M-00.
    - c. Cast iron: ASTM A532/532M-93a(1999)e1.
    - d. Ductile iron: ASTM A536-84(1999)e1.
    - e. Malleable iron: ASTM A47/A47M-99.
    - f. Bronze extrusion: ASTM B455-96, Alloy C38500.

- g. Bronze casting: ASTM B584-00, Alloy C83600.
  - h. Rigid fiberglass reinforced epoxy: UL 1684.
  - i. Stainless steel: ASTM A276-00a, Type 304.
- 3. Zinc coating:
  - a. Hot-dip galvanizing: ASTM A123/A123M-00.
  - b. Electro galvanizing: ASTM B633-98.
- B. Galvanized-Steel Rigid Conduit and Fittings: UL 6 and ANSI C80.1, zinc coating tested in accordance with reference test in appendix.
- C. Plastic Conduit and Fittings:
  - 1. PVC, UL 651, NEMA TC-2, Schedule 40 and 80 heavy-wall, for use with 90C conductors.
  - 2. Solvent cement: Manufacturer's standard.
- D. Aluminum Rigid Conduit and Fittings:
  - 1. ANSI C80.5 and UL 6.
- E. Liquid-Tight Flexible Conduit and Fittings:
  - 1. Applicable requirements of UL 360.
  - 2. Flexible galvanized-steel core with extruded liquid-tight neoprene or PVC jacket overall.
  - 3. Sizes up to 1-1/4 inch provided with continuous copper bonding conductor, spiral wound between convolutions.
  - 4. Sizes 1-1/2 inch and above provided with separate grounding conductor.
- F. Conduit Expansion Fittings and Expansion and Deflection Fittings:
  - 1. Materials:
    - a. For galvanized-steel rigid conduit:
      - 1) Expansion fittings: Steel or malleable iron, hot-dip galvanized.
      - 2) Expansion/deflection fittings: Bronze or ductile iron end couplings, neoprene sleeve and stainless steel clamping bands.
    - b. For PVC conduit: Rigid metal expansion/deflection fitting with galvanized rigid steel to PVC conduit adapters at each end.
  - 2. Conduit expansion fitting: Weatherproof.
  - 3. Conduit expansion and deflection fitting: Watertight.
  - 4. Metallic fittings equipped with bonding jumper cable to provide electrical continuity.
- G. Conduit Connector Fittings:
  - 1. UL 514B, material and finish similar to that of conduit with which they are to be used.
  - 2. For enclosures, cabinets, boxes and gutters in electrical rooms and aboveground indoor locations: Threaded nylon-insulated bushing and locknuts.
  - 3. For enclosure, cabinets, boxes and gutters with hub in outdoor, tunnel and underground locations, except electrical rooms: Threaded watertight hub fitting with gasket.
  - 4. For enclosure having punched or formed knockout for conduit entry in outdoor and underground locations, except electrical rooms: Threaded watertight fitting with gasket, nylon-insulated throat and sealing locknut.
- H. Conduit and Cable-Seal Fittings:
  - 1. Conduit seal:
    - a. To provide watertight seal between concrete and conduit where it penetrates wall, floor or ceiling.
    - b. Size as shown or necessary.

- c. Materials: Body and pressure clamp of malleable or cast iron with a neoprene sealing grommet and PVC-coated or galvanized-steel pressure rings, oversized sleeve of FRE or galvanized steel.
    - d. Seal between conduit and concrete to withstand pressure from 50-foot head of water without leakage.
  - 2. Cable seal:
    - a. To provide watertight seal between cable and conduit for use with single-conductor or multiple-conductor cable as necessary.
    - b. Size as necessary, drilled to accommodate cable.
    - c. Pressure discs of PVC-coated steel and sealing ring of neoprene.
    - d. Seal between cable and conduit to withstand water pressure of 50 psi without leakage.
  - 3. Seal compound:
    - a. FS TT-S-227, two-component, fast-setting, polymeric sealing compound to provide watertight seal between concrete and conduit, between cable and conduit.
    - b. Pour-type for horizontal and gun-grade for vertical or overhead application.
    - c. When cured, sealant to have rubber-like flexibility allowing minimum movement of conduit and cable in temperature range of minus 40F to plus 150F without loss of watertight seal.
    - d. Pot life: 15 minutes.
    - e. Minimum ambient temperature for application: 35F.
    - f. Initial cure: 15 minutes.
    - g. Final cure: Seven days.
    - h. Hardness, Durometer A: 20-35.
    - i. Seal between conduit and concrete to withstand pressure from 50-foot head of water without leakage.
    - j. Seal between conduit and single-conductor or multiple-conductor cable to withstand water pressure of 70 psi without leakage.
    - k. Fox Industries, Type FX-571G or approved equal.
- I. Conduit and Cable Supports:
  - 1. Retaining straps and fasteners: FS FF-S-760, with the following additional requirements:
    - a. Type, style and size: As necessary.
    - b. Material and finish: Stainless steel, Type 304, or approved equal.
    - c. For separating conduit from masonry surface: Hot-dip galvanized malleable-iron spacer assembled with Style A strap.
    - d. For vertical run of metallic-sheath cable: Basket-weave cable support.
    - e. For fastening conduit or cable to channel inserts: Stainless steel, Type 304, or approved equal.
  - 2. Multiple pipe hangers (trapeze-type): Consisting of two or more hanger rods, horizontal member, U-bolt clamp and other attachment necessary for securing hanger rods and conduit, with the following additional requirements:
    - a. Material and finish: Stainless steel, Type 304, or approved equal.
    - b. Hanger rod: Not smaller than 3/8-inch diameter, threaded for sufficient distance at each end to permit at least 1-1/2 inches of adjustment.
    - c. Horizontal member: Channel, 1-1/2 inches square or 1-5/8 inches square by 12 gauge or heavier. Weld two or more channels together for greater strength if necessary.
    - d. Design: Capable of supporting load equal to sum of weights of conduit, cable and hanger plus 200 pounds. At design load, stress at root of thread on hanger rod 9,500-psi maximum; stress in horizontal member 12,500-psi maximum.
  - 3. Channel inserts:

- a. Size and shape as shown, 12 gauge or heavier stainless steel, Type 304, or approved equal, with 7/8-inch wide slot.
    - b. For surface mounting: Channel inserts with 9/16-inch base slot, eight inches on center with minimum pullout-load rating of 1,000 pounds per linear foot.
  - 4. Spot inserts: Rated 800 pounds with safety factor of five, fabricated from steel galvanized after fabrication, covered to prevent entrance of concrete during installation.
- J. Surface Raceways and Fittings: UL 5, fabricated from galvanized steel.
- K. Underfloor Raceways and Fittings:
  - 1. UL 884.
  - 2. Size: As shown.
  - 3. Fabricated from steel 14 gauge or heavier steel sheet.
  - 4. Finish: Corrosion-resistant coating listed per referenced UL or ITS directory.
- L. Boxes and Cabinets:
  - 1. Outlet boxes:
    - a. UL 514A, capable of accommodating conduit as shown.
    - b. Material and finish:
      - 1) Steel, malleable iron, cast iron or ductile iron.
      - 2) Hot-dip galvanized or electro galvanized after fabrication.
    - c. For aboveground indoor locations and electrical rooms: Punched or formed knockouts.
    - d. For outdoor and underground locations, except electrical rooms:
      - 1) Threaded-conduit entrance hub.
      - 2) Threaded watertight fitting with gasket, nylon-insulated throat and sealing locknuts for enclosures having punched or formed knockouts for conduit entry.
    - e. For wall receptacles and switches, single or double devices: Outlet boxes 4-11/16 inch square by 1-1/2 inch deep.
    - f. For floor receptacles: Watertight cast-iron outlet boxes, four inches diameter, of suitable depth and complete with the following:
      - 1) Adjustment screws for final leveling.
      - 2) Bronze floor plate with flush-mounted screw plug, without exposed fastener, M32 finish.
      - 3) Screw plug attached to outlet-box assembly by chain or other means, M32 finish.
      - 4) Bronze floor plate flange, five inches in diameter, extending beyond box 1/2-inch above finished floor, M32 finish.
      - 5) One special screw-plug removal tool with every 10 receptacles.
    - g. For recessed wall-mounted receptacles: Watertight cast-iron outlet box, three-inch diameter, of suitable depth and complete with the following:
      - 1) Bronze faceplate with flush-mounted screw plug, without exposed fasteners, M32 finish.
      - 2) Screw plug attached to outlet-box assembly by chain or other approved means, M32 finish.
      - 3) Bronze faceplate flange, five inches in diameter, extending beyond box, M32 finish.
      - 4) One special screw-plug removal tool with every 10 receptacles.
  - 2. Junction and pull boxes:
    - a. Internal volume up to 100 cubic inches, metallic boxes: UL 514A, non-metallic boxes: UL514C; internal volume above 100 cubic inches, UL 50.
    - b. Flush-mounted or surface-mounted as shown.

- c. Size: Suitable to accommodate conduit, raceways, ducts, number of cables and splices shown.
- d. Material and finish:
  - 1) Metallic boxes:
    - a) Steel, malleable iron, cast iron or ductile iron.
    - b) Hot-dip galvanized or electro galvanized after fabrication.
    - c) Stainless steel in tunnel areas.
  - 2) Non-metallic boxes:
    - a) Precast concrete: Compressive strength 3,500 psi; air entrainment six-percent minimum, ASTM C173-94ae1 or C231-97e1; Section 03300 and Section 03400 and in accordance with the following:
      - 1) Box: Concrete formed with closed bottom and sides and recess at top of box or at edge of cover to provide mating surfaces to prevent lateral movement of flush-mounted cover. Knockouts provided to accommodate conduits as shown.
      - 2) Cover:
        - (a) Material same as for box. Use of metallic cover and cover frame prohibited.
        - (b) Metro Type "B" logo with 3-1/8 inch by 4-inch envelope and service designation recessed in center of cover.
        - (c) Non-protruding provisions provided for lifting.
      - 3) Reinforcement:
        - (a) Sidewalk and landscape locations: Welded wire fabric, ASTM A185-97.
        - (b) Areas subject to vehicular traffic: Deformed steel bars, ASTM A615/A615M-00.
      - 4) Loading:
        - (a) Sidewalk and landscape locations: AASHTO 's SSHB H15-44.
        - (b) Areas subject to vehicular traffic: AASHTO's SSHB H20-44.
        - (c) Hardware: Stainless steel.
        - (d) Size: As shown or next available larger size.
    - b) Composite material: Sand and gravel bound together with a polymer and reinforced with continuous woven glass strands and in accordance with the following:

Physical Properties	Values	Method
Compressive strength	11,000 psi	ASTM C109
Tensile strength	1,700 psi	ASTM D638
Flexural strength	7,500 psi	ASTM D790
Water Absorption (24 hours)	0.5 percent	ASTM D570

- 1) Box: Gray-color material formed with closed bottom and sides and flange with recess at top of box to accommodate flush-mounted cover.

- 2) Cover:
    - (a) Material same as for box.
    - (b) Skid-resistant top surface with minimum 0.5 coefficient of friction.
    - (c) Metro Type "B" logo with 3-1/8 inch by 4-inch envelope and service designation recessed in center of cover.
    - (d) Secured to box with bolts.
    - (e) Non-protruding provisions provided for lifting.
  - 3) Loading:
    - (a) Sidewalk and landscape locations: AASHTO's SSHB H15-44.
    - (b) Areas subject to vehicular traffic: AASHTO's SSHB H20-44.
  - 4) Hardware: Stainless steel.
  - 5) Size: As shown or next available larger size.
- c) Molded fiberglass-reinforced polyester 1/8-inch thickness, minimum, and in accordance with the following requirements:

Physical Properties	Values	Method
Flexural strength	17,000 psi	ASTM D790
Deflection temperature	400F	ASTM D648
Water absorption (24 hours)	0.5 percent	ASTM D570
Tensile strength	6,500 psi	ASTM D638
Specific gravity	1.8	ASTM D794
Flammability	94-5V	UL 94
Dielectric strength	400 volts per mil	ASTM D149
Arc resistance	180 seconds	ASTM D495

- 1) Ultraviolet protection: Fiberglass material containing ultraviolet-inhibitor, or coated with polyurethane paint, 1.5 mils minimum dry-film thickness on both inside and outside surfaces.
  - 2) Color: Fiberglass material, gray inside and outside.
  - d) Molded polyvinyl chloride 1/8-inch thickness, minimum.
- e. For aboveground indoor locations and electrical rooms: Punched or formed knockouts.
- f. For outdoor and underground locations, except electrical rooms:
- 1) Threaded conduit entrance hub.
  - 2) Threaded watertight fitting with gasket, nylon-insulated throat and sealing locknuts for boxes having punched or formed knockouts for conduit entry.
3. Cabinets:

- a. UL 50, fabricated from galvanized steel.
  - b. Surface-mounted, unless otherwise shown.
  - c. Backplate of reinforced steel for mounting interior components and to ensure rigid support and accurate alignment.
  - d. Provision for cabinet grounding.
  - e. Provide latch and handle in accordance with UL 50; screw fastenings will not be accepted in lieu of latch.
  - f. Finish: Metallic surface thoroughly cleaned, degreased, primed with zinc primer and coated after fabrication with light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.
- M. Cable Trays:
- 1. NEMA VE1, ventilated-steel ladder-type.
  - 2. Dimensions: Three inches inside depth; nine inches rung spacing unless otherwise shown.
  - 3. Maximum load rating: 50 pounds per linear foot with safety factor of 1.5 at 12-foot support span.
  - 4. Bend radius:
    - a. For incoming service cable: As required by power company.
    - b. For all other cable: 24 inches or as necessary and approved.
  - 5. Finish: Cable trays, fittings and accessories hot-dip galvanized or electro galvanized after fabrication.
- N. Expansion Bolt Anchors: FS FF-S-325C Group II, stainless steel, Type 304, or approved equal.
- O. Data-Transmission System (DTS) Cabinet:
- 1. Wall-mounted, single-door, NEMA 250 Type 12, with panel, Hoffman Engineering Company, as shown, or approved equal.
  - 2. Enclosure: Formed of minimum 14-gauge steel, seams continuously welded and ground, without openings or knockouts, with threaded-conduit entrance hubs, lugs for mounting enclosure and collar studs for mounting panel. Rolled lip formed on all sides of door opening. Enclosure and door reinforced when size exceeds 30 inches square. Size as shown.
  - 3. Door: Formed of minimum 14-gauge steel, with rolled lip along top and sides to mate with enclosure. Fitted with removable print pocket. Closed-cell neoprene gasket attached with oil-resistant adhesive and steel retaining clips.
  - 4. Hardware: Corrosion-resistant steel continuous piano hinge with removable pin. Hasp and staple for padlocking.
  - 5. Panel: Formed of 12-gauge steel.
  - 6. Finish: Galvanized enclosure, door, panel and latch mechanism. Prepared for painting by manufacturer's standard method in accordance with the following:
    - a. Outside: Phosphatized, primed and finished with two coats of light-gray enamel or epoxy coating, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.
    - b. Inside including panel: Two coats of white enamel or epoxy coating.
  - 7. Breather drain: One 1/2-inch diameter, Crouse-Hinds Catalog No. ECD11, or approved equal.
  - 8. Grounding stud: Manganese bronze, ASTM B138-96, Alloy No. 675 hard, 3/8-inch high; Evedur GSI, American Brass Company or approved equal.
  - 9. Terminations: Assembly rail and modular terminals, Weidmuller Terminations, Incorporated or approved equal.
    - a. Terminal: Modular test terminal, Melamine plastic, screw-clamp connections, with socket screws; Type SAKC4, Catalog No. 3406.2 or approved equal, with the following additional requirements:
      - 1) Amperes: 25.

- 2) Volts: 300.
- 3) Wire-gauge range: 22AWG to 12AWG.
- 4) Thickness: 0.256 inch.
- 5) Listed per referenced UL or ITS directory.
- 6) Standard accessories; compatible with terminal, with the following additional requirements:
  - a) End section: Type AP, No. 1179.2 or approved equal.
  - b) End bracket: Type EWK1, No. 2061.6 or approved equal.
  - c) Test plug: Type PS, No. 1804.0 or approved equal.
  - d) Cross-connection combination: QB25, No. 91455.D or approved equal.
  - e) Disconnect plug for SAKC4 terminal: Type TST, No. 3399.0 or approved equal.
- b. Assembly rail: Type TS32 steel standard section compatible with terminals, with fixing slots, Catalog No. 1228.0 and standard rail-mounting screws or approved equal.
- c. Marking tags: Dekafix 6.5-FS or approved equal, consecutive vertical, Number 4682.6 or Number 5766.6 as approved. Consecutive numbering conforming to that of DTS box.
- d. Group marking carrier with paper marking strip and transparent cover.
  - 1) Type SCHAT5, Catalog No. 2924.6 or approved equal.
  - 2) Type ESO5, Catalog No. 2937.0 or approved equal.
  - 3) SST5, Catalog No. 2940.0 or approved equal.

P. Fiberglass Conduit and Fittings:

1. Rigid fiberglass reinforced epoxy conduit, UL 1684, IPS (Iron Pipe Size) based conduit.
2. Conduit shall be manufactured by using filament winding process with minimum fiberglass content of 65 percent by weight and no fillers.
3. IPS based conduit with nominal wall thickness of 0.09 inches for five-inch nominal conduit size.
4. Conduits, elbows and fittings manufactured from the same material and using the same manufacturing process.
5. Conduit sections formed with integral bell and spigot type couplings. Rubber sealing gasket at bell end is prohibited.
6. Conduits, elbows and fittings provided with protection from exposure to sunlight by pigmentation uniformly dispersed through resin material.
7. Adhesive as recommended by conduit manufacturer.
8. Conduits, elbows and fittings are specified for use throughout a temperature range of -40°F to 230°F, and they are to be protected from exposure to sunlight by pigmentation uniformly dispersed through the resin material.
9. Conduits, elbows and fittings shall be suitable for encasement in concrete below grade and conform to UL 1684, and listed and labeled by UL meeting the requirements of NEC Article 347 for Rigid Nonmetallic Conduit and its use.
10. Each piece of the straight length conduit and each piece of the elbow and other bend made from and for use with such conduit is to be labeled with the following information, mark clearly legible and durable every 10 feet or as recommended by the manufacturer.
  - a. "Reinforced Thermosetting Resin Conduit", "RTRC"; "Fiberglass Reinforced Epoxy Conduit", "FRECE"; or equivalent, as applicable.
  - b. Normal Size: (IPS)
  - c. Manufacturer's name and trademark.
  - d. Temperature range for conduit application.
  - e. "Above Ground", "AG", "Below Ground", "BG", or equivalent wording, as applicable.

## PART 3 - EXECUTION

### 3.01 INSTALLATION:

- A. General:
1. Use size, type, general routing, location of conduit, raceways, boxes and cabinets as shown and specified.
  2. Install metallic raceway, fittings, boxes and cabinets free from contact with reinforcing steel.
  3. Where aluminum is placed in contact with dissimilar metal or with concrete, separate contact surfaces by means of gasket, nonabsorptive tape or coating to prevent corrosion.
  4. Make metallic conduit, raceways, ducts and cable trays, electrically and mechanically continuous and ground them in accordance with Section 16060.
  5. Install FRE conduit where conduit runs are embedded in concrete and where conduit is shown as direct-burial.
- B. Conduit:
1. Run exposed conduit parallel to building lines.
  2. Install exposed conduit to avoid interference with other work.
  3. Traction-power substations, tie-breaker stations, ac-switchboard, electrical, train-control, communication and mechanical rooms: Where shown or where necessary to prevent seepage of subsoil or water into such areas, seal where conduits in contact with concrete and seal cable inside conduit using cable seal or sealing compound in accordance with the following requirements:
    - a. Where shown and as necessary, install cable seal and conduit seal in accordance with the manufacturer's recommendations.
    - b. Use sealing compound where approved and in accordance with manufacturer's recommendations, with the following additional requirements:
      - 1) Before applying sealing compound, prime concrete, conduit and cable surface using primer recommended by manufacturer.
      - 2) Pour or inject compound to prevent voids inside seal and to keep cable centered in conduit.
      - 3) Use FRE sleeve for conduit seal installed on traction-power, train-control and communication conduit.
    - c. For 34.5 kv incoming-service cable with concentric neutral, install cable seal in traction-power substations, ac-switchboard rooms and 34.5 kv utility company manholes adjacent to WMATA facilities in accordance with the following requirements:
      - 1) Do all work in coordination with a utility company representative.
      - 2) Install O-Z CSBI cable seal at each end of the conduit for the service entrance cables ( one at the last utility company manhole and one at the WMATA facility entrance). Use torque recommended by manufacturer for this type of cable seal, do not over-torque.
    - d. For 13.8 kv incoming-service cable, install cable seal in traction-power substation, ac-switchboard rooms and utility company manholes adjacent to WMATA facilities. Coordinate the work with utility company representative.
    - e. In empty conduit installed for future use, install blank cable seal inside conduit to prevent seepage of water.
    - f. All conduits free of water before conduit seals are installed.
  4. Apply lead-free conductive anti-seize compound to threaded-conduit joints.

5. In outdoor and underground locations, except electrical rooms, use threaded-conduit hub to attach conduit to equipment enclosure. Use watertight conduit fitting with gasket, nylon-insulated throat and sealing locknuts for attachment of conduit to enclosure having punched or formed knockout.
6. In aboveground indoor locations and electrical rooms, use locknut and nylon-insulated bushing to attach conduit to enclosure.
7. Install suitable caps or plugs in empty conduit for future extension. Leave approved nylon or polyester pull line in each conduit.
8. Thread and ream ends of field-cut conduit to remove rough edges. Use bushing at conduit entrance to boxes, cabinets and equipment enclosures.

9. Bends:

- a. Unless otherwise shown or specified, install conduit bends in accordance with reference codes.
- b. Install bends in buried conduit in accordance with the following:

Size of Conduit (in inches)	Minimum Radius of Factory-Bend (in inches)	Minimum Radius of Field-Bend (in inches)
3	18	24
4	24	30
5	48	48
6	48	48

- c. Total bends in each conduit run for traction-power cable: 225 degrees maximum.
- d. Bend conduit so that field-made bend is free from cuts, dents and other surface damage.
10. Support conduit during construction to prevent distortion and to ensure independent support.
11. Support horizontal conduit with one-hole pipe straps or individual pipe hangers.
12. Secure conduit supported on multiple-hangers (trapeze) or channel inserts by fasteners suitable for such purpose.
13. Where conduit is attached to masonry surface, use malleable-iron spacers with Style A pipe straps.
14. Support and secure vertical conduit spanning open areas at intervals not exceeding 10 feet.
15. Support conduit above suspended ceiling using applicable specified methods.
16. Install conduit so as to drain moisture to nearest outlet or pull box.
17. Use minimum of 18-inch long liquid-tight flexible-conduit connection for equipment enclosure subject to vibration.
18. Do not use wire for support of conduit and cable.
19. Install expansion fitting in exposed conduit runs longer than 300 feet and where shown. Install expansion/deflection fittings where embedded conduits cross structural expansion joints. Where embedded conduits cross a structural contraction joint, paint the external surface of conduit with linseed oil or other compatible bond breaker for two feet on each side of contraction joint.
20. Buried FRE conduit: Install in accordance with the following requirements in addition to those specified elsewhere:
  - a. Arrange conduit to cross each expansion joint at right angle to joint.
  - b. Prevent concrete and other materials from obstructing the conduit. Pack outlets, pull boxes and junction boxes and cap conduit ends prior to pouring concrete.
  - c. Use Tight Lock Joint method to join conduit sections for providing water tightness and pull out strength.

- d. Provide compatible conduit supports and spacers to maintain position of conduit during placement of concrete.
  - e. Install buried non-metallic conduit for cable over 600 volts in accordance with reference code.
  - f. Waterproof conduit connections.
  - g. Rod and swab conduit after installation so as to remove water, cement and other foreign matter; cap conduit ends. If obstructions cannot be removed or if condition exists which may result in damage to cable, replace conduit.
  - h. Leave approved nylon or polyester pull-line in each conduit.
  - 21. Use metallic conduit or above ground FRE conduit in exposed locations.
  - 22. Conduit installed in outdoor location: Waterproof conduit connection.
  - 23. Use IPS FRE conduit for all concrete-encased applications except as follows:
    - a. Use FRE conduit with minimum wall thickness of 0.95 inch for train control conduit direct buried without concrete encasement where shown.
    - b. Install conduits encased in concrete ductbanks, associated manholes and handholes outside the structural work in accordance with Section 02585.
- C. Channel Inserts and Spot Inserts:
- 1. Surface-mount channel inserts as shown.
- D. Surface Raceways:
- 1. Install as shown.
- E. Underfloor Raceways:
- 1. Install underfloor raceways as specified in Section 03100. Align and level raceways accurately. Hold raceways in place during placing of concrete.
- F. Outlet, Junction and Pull Boxes:
- 1. Mount outlet boxes as shown.
  - 2. Arrange front of box or attached plaster cover flush with finished wall or ceiling.
  - 3. Keep number of knock-outs to minimum.
  - 4. Clean boxes thoroughly after installation and correct damage to boxes and to finish.
  - 5. Install covers on boxes mounted on walls and ceilings.
  - 6. Measure height of wall-mounted outlet box from finished floor to horizontal centerline of cover plate.
  - 7. Fasten floor boxes securely in place.
  - 8. Install junction and pull boxes so that covers are readily accessible.
  - 9. Do not install boxes above suspended ceilings except where ceilings are removable or definite provision is made for access to boxes.
  - 10. Use stainless steel (Type 304) mounting channels, retaining straps and fasteners, pipe hangers for conduits and cables; expansion bolt anchors, junction boxes, outlet boxes, cover plates for receptacles, enclosures for load centers in tunnel environment which includes vent and fan shafts and underplatform areas.
  - 11. Use non-metallic boxes as follows:
    - a. Buried with cover flush-mounted with finish grade: Precast concrete or composite material junction and pull boxes within AASHTO load designations as specified.
    - b. For indoor and outdoor locations not subject to pedestrian or vehicular traffic: Molded fiberglass-reinforced polyester junction and pull boxes.
    - c. For outdoor locations but not for burial: Molded polyvinyl chloride junction and pull boxes.
- G. Cabinets:
- 1. Fasten cabinet securely using expansion bolts, toggle bolts or mounting ears.
  - 2. Touch-up damaged painted finish.

- H. Cable Trays:
  - 1. Install cable trays neatly, adequately supported and as shown.
  - 2. For incoming-service cable from power company, install cable tray as approved by the power company.
- I. Use expansion-bolt anchors to secure equipment to concrete surfaces.
- J. Attachments to Prestressed-Concrete Girders:
  - 1. Attach pipes, conduits, boxes or similar items to prestressed girders by welding to embedded plates or bolting to embedded fittings. Drilling into prestressed girders is prohibited, except for track fasteners and appurtenances as shown.
- K. DTS Cabinet and Terminals:
  - 1. Install as shown.
- L. Car Wash Areas:
  - 1. Use PVC-coated galvanized steel conduit.

### **3.02 FILLING OF OPENINGS:**

- A. Where conduit and raceway pass through fire-rated walls, ceilings or floors, provide seals to prevent passage of fire and fumes and to maintain integrity of fire-rated structure in accordance with Section 07481.
- B. Where openings are provided for passage of conduit and raceways in walls, ceilings or floors, use fire-resistant fibrous-glass safing or similar material to seal unused openings to prevent passage of fire and fumes in accordance with Section 07841.
- C. Close unused openings or spaces in floors, walls and ceilings. Plug or cap unused conduit and sleeves.

### **3.03 IDENTIFICATION:**

- A. At end of each run, use stainless steel or aluminum tags, minimum 1-1/2 inch diameter, with stamped markings, minimum 1/4-inch high lettering, and tag holders attached to conduit using a stainless steel band with worm screw clamping device to establish identification of conduits and raceways in accordance with designations shown. Where conduits are terminated flush with concrete structure, install three-ply laminated phenolic plate, engraved through black face to white core and attached adjacent to conduits' entrance by means of non-metallic screws. Engrave conduits' designations within circles arranged in pattern similar to that of conduits.
- B. Identify by red painted color code and by marking EMERGENCY SYSTEM on all boxes and enclosures for emergency circuits to identify them as part of an emergency system in accordance with the NEC.

### **3.04 FIELD QUALITY CONTROL:**

- A. Arrange with the Engineer for inspection and approval of embedded conduit and boxes prior to concrete placement.
- B. Arrange with the Engineer for inspection by electrical utility company representative of incoming-service conduit prior to placing concrete.

- C. Test metallic conduit and boxes for electrical continuity. Conduct tests in presence of Engineer.
- D. Test not less than 0.5 percent of total installed channel inserts and spot inserts as directed for compliance with specified pullout-load rating. Replace and retest inserts which fail. Conduct tests in presence of Engineer.
- E. Arrange with the Engineer for inspection and approval of direct-buried conduits for future train control circuits prior to backfilling.

**END OF SECTION**

## SECTION 16145

### WIRING AND CONTROL DEVICES

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing switches, cover plates, limit switches, occupancy sensors, receptacles, plugs, magnetic contactors, automatic transfer switches, photoelectric controls and time switches.
- B. Related Work Specified Elsewhere:
  - 1. Ornamental metal: Section 05700.
  - 2. Wire connection accessories: Section 16125.
  - 3. Grounding and bonding: Section 16060.
  - 4. Raceways, boxes and cabinets: Section 16130.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. National Electrical Code (NEC).
  - 3. National Electrical Manufacturers Association (NEMA):WD1, General Color Requirements for Wiring Devices; KS1, Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum); ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC; ICS 12, Profiles of Networked Industrial Devices--Part 1: General Rules; NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
  - 4. American National Standards Institute (ANSI): Z55.1, Gray Finishes for Industrial Apparatus and Equipment.
  - 5. UL: 98, Enclosed and Dead-Front Switches; 198D, Class K Fuses; 198E, Class R Fuses; 508, Industrial Control Equipment; 773, Plug-In Locking-Type Photocontrols for Use With Area Lighting; 1008, Transfer Switch Equipment.
  - 6. American Standards of Testing and Materials (ASTM): A47/A47M-99, Standard Specification for Ferritic Malleable Iron Castings; A276-00a, Standard Specification for Stainless Steel Bars and Shapes; and A507-00, Standard Specification for Drawing Alloy Steel, Sheet and Strip, Hot-Rolled and Cold-Rolled.
  - 7. ITS: Directory of ITS Listed Products
- B. Source Quality Control:
  - 1. Following items listed per referenced UL or ITS directory:
    - a. Snap switches.
    - b. Disconnect switches.
    - c. Receptacles and plugs.
    - d. Automatic transfer switch.
    - e. Lighting contactor.
    - f. Photoelectric control.
    - g. Time switch.
    - h. Occupancy sensor.
- C. Qualifications: Select a manufacturer who is regularly engaged in the production of automatic transfer switches.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings.
  - 2. Certification:
    - a. Certified test reports of factory tests performed on each automatic transfer-switch unit in accordance with reference standards.
    - b. Furnish certificate from manufacturer verifying that automatic transfer switches conform to specified requirements. Include certificate with submittal of shop drawings.
  - 3. Documentation for Automatic Transfer Switch:
    - a. Submit field test plan within 60 days after award with accompanying documentation in the form of test data recording sheets and list of proposed test equipment for approval prior to testing.
    - b. Submit certified copies of test data, dated and clearly identified within two weeks after completion of testing.
  - 4. Operation and Maintenance Manuals for Automatic Transfer Switch.

#### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Mark each item in accordance with applicable reference standard.
- B. Ship each unit securely packaged and labeled for safe handling and to avoid damage
- C. Store products in secure and dry storage facility.

### **PART 2 - PRODUCTS**

#### **2.01 PRODUCTS AND MATERIALS:**

- A. Snap Switches:
  - 1. NEMA WD1, specification grade.
  - 2. Rating:
    - a. Twenty amperes at 120-277 volts ac.
    - b. Horsepower-rated when used as disconnecting device for motor circuit.
  - 3. Body and base: Fully enclosed, brown, fire-resistant, non-absorptive thermosetting urea or nylon.
  - 4. Contacts: Silver alloy.
  - 5. Mounting yoke: Corrosion-resistant metal with plaster ears.
  - 6. Poles: Single-pole, double-pole, three-way or four-way as shown.
- B. Disconnect (Safety) Switches:
  - 1. UL 98, NEMA KS1, heavy-duty, fusible or non-fusible as shown.
  - 2. Voltage rating: 240 volts ac, 480 volts ac or 250 volts dc as shown and as necessary.
  - 3. Number of poles and current rating: As shown and as necessary.
  - 4. Fuses:
    - a. UL 198D.
    - b. For fused disconnect switch associated with motor load: UL Class RK5 with time delay or as shown.
    - c. For fused disconnect switch associated with other loads: UL Class RK1 or as shown.
    - d. Current rating: As shown.
  - 5. Enclosure: (NEMA 250)

- a. Type:
    - 1) For aboveground indoor locations and electrical rooms: Type 1.
    - 2) For tunnel and underground locations, except electrical rooms: Type 4.
    - 3) For outdoor locations: Type 3R.
  - b. Materials:
    - 1) Steel sheet: ASTM A507-00.
    - 2) Malleable iron: ASTM A47/A47M-99.
  - c. Finish: Metallic surface cleaned, degreased, primed with zinc primer and finished with light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.
6. Quick-make/quick-break switching mechanism with operating handle external to enclosure with positions labeled ON/OFF and capable of being padlocked in OFF position, defeatable interlock to prevent opening of enclosure door when switch is closed.

C. Receptacles and Plugs:

- 1. NEMA WD1, specification grade.
- 2. Rating: 20 amperes at 125 or 250 volts as shown.
- 3. Base and body: Brown, fire-resistant, non-absorptive thermosetting urea or nylon.
- 4. Receptacles:
  - a. Outlet: Single or duplex as shown.
  - b. Mounting yoke: Corrosion-resistant metal with plaster ears.
  - c. Configuration:

Rating	NEMA Configuration
Two-pole, three-wire, 20 amps, 125 volts	5-20 R
Two-pole, three-wire, 20 amps, 250 volts	6-20 R

- d. For use in restroom; water service room; locker room; wash rooms; elevator machine room, pit and hoistway; and outdoor locations: Equipped with solid-state ground-fault circuit interrupter with five-milliampere trip level.
5. Plugs:
- a. Configuration and design: As follows unless otherwise shown:

Rating		NEMA Configuration
Two-pole, three-wire, 20 amps, 125 volts	Urea or neoprene with cord grip	5-20 P
Two-pole, three-wire, 20 amps, 250 volts	Armored cap with cord grip	6-20 P

D. Cover Plates:

- 1. Wall plates:
  - a. NEMA WD1, suitable for specified receptacles and switches, size suitable for recess-mounted or surface-mounted associated outlet box, stainless steel, ASTM A276-00a, Type 304, or approved equal.

- b. For use in indoor public areas: Bronze, with M32 medium satin finish as specified in Section 05700.
  - c. For above ground indoor service areas and electrical rooms: Steel, stainless steel or aluminum plate, as standard with the manufacturer.
  - d. For receptacles in outdoor and underground locations, except electrical rooms: Stainless steel, ASTM A276-00a, Type 304, wall plate with gasketed spring-loaded hinged cover.
2. Floor plates: Section 16130.
- E. Automatic transfer switch: UL-1008, electromechanical, in surface-mounted enclosure as shown, with the following additional requirements:
- 1. Operating and electrical characteristics:
    - a. Capable of transferring load automatically from normal source to alternate source when the voltage drops to 85 percent of rated voltage on any phase for set time. Operating point adjustable over range of 80 to 90 percent of rated voltage and time-delay adjustable over range from zero to five minutes in increments of at least eight steps.
    - b. Capable of transferring load automatically from alternate source to normal source when normal source returns to 90 percent of rated voltage for set time. Operating point adjustable over range of 85 to 100 percent of rated voltage and time-delay adjustable over range from zero to five minutes in increments of at least eight steps.
    - c. Capable of transferring load automatically from normal source to alternate source when normal source failure is simulated by integral test switch.
    - d. Rating:
      - 1) Number of poles: Three or four as shown.
      - 2) Voltage rating: 480-volt, three-phase, three-wire or 480Y/277-volt, three-phase, four-wire, 60 Hertz system as shown.
      - 3) Current rating: As shown and rated 100 percent.
      - 4) Transfer time: Ten cycles maximum on 60-Hertz base after initiation signal.
      - 5) Short-circuit current rating, rms symmetrical amperes: 14,000; 22,000; 25,000; 30,000; 35,000; or 50,000 as required and shown.
      - 6) Capacity to close into available short-circuit current or let-through current of fuses without functional degrading.
    - e. Solid-state control panel for sensing and control logic with accuracy of plus-or-minus two percent on voltage and frequency settings over a temperature range of minus 20 degrees to plus 70 degrees.
  - 2. Design and construction features:
    - a. Mechanically held, electrically operated, double-throw switch.
    - b. Electrical and mechanical interlock to prevent maintained neutral position.
    - c. Designed to break-before-make on transfer and retransfer.
    - d. Equipped with renewable silver-alloy contact.
    - e. Neutral bus or terminal provided on 480Y/277-volt, three-phase, four-wire unit to allow interconnection of neutral conductors.
    - f. Pilot lights on door to indicate switch position as follows:
      - 1) On normal source: Green light.
      - 2) On alternate source: Red light.
    - g. Pilot lights on door to indicate:
      - 1) Normal source available: Green or white light.
      - 2) Alternate source available: Red or white light.
    - h. Contacts opened by single solenoid, motor operator or stored energy mechanism.
    - i. Handle provided to permit manual operation of automatic transfer switch for maintenance purposes.
    - j. Power conductors made of silver-plated copper bus.

- k. Equipment ground lug provided.
      - 3. Enclosure:
        - a. Type:
          - 1) For aboveground indoor locations and electrical rooms: NEMA Type 1.
          - 2) For tunnel and underground locations, except electrical rooms: NEMA Type 12.
        - b. Door: Hinged with handle and latch.
        - c. Material: Steel.
        - d. Finish: Metallic surface thoroughly cleaned, degreased, primed with zinc primer and finished with gray enamel, ANSI Z55.1, Color No. 61; two mils minimum DFT.
- F. Lighting Contactors:
  - 1. NEMA ICS 2, UL 508, electrically held, equipped with silver-alloy contacts, designed to control incandescent, tungsten, halogen, fluorescent, high-intensity discharge lamp load.
  - 2. Number of poles: As shown.
  - 3. Continuous current rating: As shown.
  - 4. Line and load voltage: 480-volt or 208-volt three-phase or 277-volt or 120-volt single-phase as shown.
  - 5. Control coil rated 120 volts.
  - 6. 480-volt or 277-volt to 120-volt control transformer fused on secondary and primary as required.
  - 7. Control:
    - a. Heavy-duty, three-position selector switch with positions labeled HAND/OFF/AUTO for lights controlled by photo-electric cell.
    - b. ON-OFF push button for indoor lights.
  - 8. Enclosure: NEMA 250, Type 1; fabricated from steel, cleaned, degreased, primed with zinc primer and finished with light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.
- G. Photoelectric Control:
  - 1. UL 773, designed to respond to natural daylight with 15-second inherent delay to prevent functioning due to sudden bright light such as vehicle lights or lightning and to operate in ambient temperature from minus 50C to plus 60C.
  - 2. Adjust to turn lights ON at two plus-or-minus one foot-candles, unless otherwise specified. ON to OFF ratio: One to three.
  - 3. Rating: 1,800VA at 120 volts or 277 volts, 60 Hertz, as shown.
  - 4. Contacts:
    - a. For control of outdoor lights: SPST, NC contact.
    - b. For control of tunnel lights at portals: SPST, NO contact
  - 5. Cells: Hermetically sealed.
  - 6. Enclosure: Weatherproof and tamper proof aluminum or non-metallic enclosure equipped with locking receptacles when mounted on fixture or designed for mounting on outlet box as shown and as necessary.
  - 7. At tunnel portal, set photoelectric control to turn on selected lights at dawn and turn off lights at dusk, as shown.
- H. Limit Switches:
  - 1. NEMA ICS 2, industrial-control.
  - 2. Suitable for mounting in folding-gate cabinet. Switch contacts closed when cabinet door is fully closed and latched. Switch contacts opened when respective cabinet door is not fully closed.
  - 3. Voltage rating: 120 volts ac.
  - 4. Current rating: 10-amperes continuous.

5. Enclosure: NEMA 250, Type 13.
  6. Actuator: Lever-operated and adjustable, with spring return.
  7. Mounting: Plug-in type with receptacle tapped for conduit size as shown.
  8. Contacts: Single-pole double-throw; one NO, one NC; snap action.
- I. Time Switch:
1. Seven-day and 24-hour calibration for each day time switch, listed per referenced UL or ITS directory, heavy-duty type suitable for controlling type of lighting fixtures shown.
  2. Type: As shown, with contacts capable of switching continuous load of 20 or 40 amperes per pole at 277 volts as necessary.
  3. Seven-day, 24-hour dial with day and night zones and 24-hour calibration for each hour clearly marked.
  4. Providing up to four automatic ON/OFF operations each day.
  5. Removable ON/OFF trippers designed for minimum ON period of one hour and minimum two-hour period between one OFF operation and next ON operation.
  6. Provision for manual ON and OFF operation of switch by hand without disturbing weekly preset schedule.
  7. Provision for omitting operation of switch on selected days.
  8. Spring-driven reserve power suitable for operation of switch for 16 hours minimum after failure of power. On restoration of power, switch transfers to synchronous motor drive and automatically rewinds spring.
  9. Terminals designed to accommodate up to 8AWG conductor cable.
  10. Operation at 480/277Y or 208Y/120 volts, 60 Hertz as shown and within temperature range of zero degree F to plus 140F.
  11. Enclosure:
    - a. NEMA 250, Type 1, steel, surface-mounted.
    - b. Hinged flush front door with catches and spring-loaded door pull.
    - c. Finish: Metallic surfaces cleaned and degreased, primed with zinc primer and finished with one coat of light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.
- J. Occupancy Sensor:
1. UL 508, passive infra-red motion detector designed for wall mounting over single-gang outlet box, minimum radio frequency interference and use with incandescent and fluorescent lighting fixtures and electronic ballasts.
  2. Voltage rating: 120-277 volts ac.
  3. Switching capacity:
    - a. 120-volt operation: 800 watts minimum.
    - b. 277-volt operation: 1,500 watts minimum.
  4. Coverage area: 1,000 square feet.
  5. Detection zone:
    - a. Horizontal: 180 degrees.
    - b. Vertical: 5 degrees.
  6. Ambient light sensing: Photocell for preventing operation of lights at ambient light levels above an adjustable setting.
  7. Adjustments: Adjustable settings for time delay, sensitivity and light level concealed by tamper proof cover. Time delay adjustable from 10 seconds to 15 minutes after motion stops.
  8. Operating mode: OFF/AUTO.
  9. Detection indicator: LED.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION:**

- A. Install switches, limit switches, occupancy sensors, receptacles, automatic transfer switches, lighting contactor, photoelectric controls and time switches as shown and in accordance with referenced codes and standards in Article 1.2, and manufacturer's instructions.
- B. Install cover plate on switch and receptacle.
- C. Install cover plate with gasketed spring-loaded cover, on each receptacle in outdoor and underground locations except electrical rooms.
- D. Ground disconnect switch, time switches, automatic transfer switches, receptacles, snap switches, photoelectric controls and lighting-contactor enclosures in accordance with Section 16060.
- E. Make power cable connections to snap switches, plugs, time switches, occupancy sensors, photoelectric controls, receptacles, automatic transfer switches and lighting contactors by means of integral mechanical connectors. If such items are not furnished with integral mechanical connectors, make connections using compression connectors in accordance with Section 16125.
- F. Make power cable connections to snap switches and receptacles using their side screw wiring connection terminals.
- G. Apply matching touch-up paint as necessary.

### **3.02 FIELD QUALITY CONTROL:**

- A. Furnish necessary test equipment and perform the following in the presence of the Engineer, in accordance with approved procedures:
  - 1. Test time switches, receptacles and contactors for connection in accordance with wiring diagram.
  - 2. Test equipment enclosure for continuity to grounding system.
  - 3. Check tightness of cable connections of snap switches, receptacles, time switches, occupancy sensors, disconnect switches, automatic transfer switches, lighting contactors, photoelectric controls and limit switches.
  - 4. Test operations of circuits and controls of switches, occupancy sensors, receptacles and contactors.
  - 5. Automatic transfer switches:
    - a. Test switches for connection in accordance with wiring diagrams.
    - b. Calibrate and set voltage-sensing device for each source and time delay for transfer and retransfer as follows and as approved:
      - 1) Automatic transfer switches for fan shafts and drainage pumping stations: Time delay setting for transfer equal to total of 30 seconds for each connected motor or additional time as required.
      - 2) Time delay setting for retransfer equal to or greater than time delay setting for transfer.
    - c. Perform automatic transfer of load in accordance with the following requirements:
      - 1) With power available on both the normal and alternate sources, initiate automatic transfer from the normal source to the alternate source by opening the disconnect switch or circuit breaker on the line side of the automatic transfer switch for the normal source. Check that the switch position changes to the alternate source and remains connected to the alternate source.
      - 2) With power available on the alternate source and the switch connected to the alternate source, initiate automatic transfer to the normal source by closing the disconnect switch or circuit breaker on the line side of the automatic transfer switch for the normal source.

Check that the switch position changes to the normal source and remains connected to the normal source.

- 3) If testing indicates failure to comply with specified requirements, modify settings for the automatic transfer switch so that the specified requirements are met. Conduct additional tests witnessed by the Engineer to prove compliance with specified requirements.

- B. Submit certified test reports for compliance with field quality control requirements.

**END OF SECTION**

## SECTION 16220

### EMERGENCY STANDBY GENERATOR SYSTEM

#### PART1 - GENERAL

##### 1.01 DESCRIPTION

- A. This Section includes the following:
  - 1. A diesel engine-driven electric generator package, complete with weatherproof walk-in housing and skid mounted fuel tank and rupture basin kit.
  - 2. A engine start-stop control system mounted on the generating set.
  - 3. An automatic load transfer control to provide automatic starting and stopping of the engine and switching of the load.
- B. This system shall be built, tested and shipped by the manufacturer of the engine-generator so there is one source of supply and responsibility. The performance of the generating set shall be certified by an independent testing laboratory.

##### 1.02 SUBMITTALS:

- A. Product Data: Submit manufacturer's data on engine-driven electric generator systems and components. Include manufacturer's standard product warranty (for not less than one-year period) for replacement of materials and equipment used in standby engine-driven system.
- B. Shop Drawings: Submit dimensioned drawings of engine-driven generator unit, walk-in housing and accessories including, but not limited to, automatic transfer switch, fuel line piping, remote start-stop stations, and instruments, showing accurately scaled generator set layout within the housing enclosure and its special relationship to associated equipment, and connections to remote equipment.
- C. Submit certified final factory test reports certifying unit's full power rating, stability, voltage and frequency regulation.
- D. Submit Operation and Maintenance Manual in accordance with General Requirements.
- E. Submit Operation and Training program plan in accordance with General Requirements.

##### 1.03 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Maintain a service center capable of emergency maintenance and repairs of the Project with eight hours' maximum response time.
- B. Source Limitations: Obtain packaged engine generator and auxiliary components specified in this Section through one source from a single manufacturer.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

- D. Comply with NFPA 70.
- E. Comply with NFPA 110 requirements for Level 2 emergency power system.
- F. Noise Emission: Comply with applicable state and local government requirements.
- G. Comply with MG1.

## **PART 2 - PRODUCTS**

### **2.01 MANUFACTURERS**

- A. Generator Manufacturer: Subject to compliance with requirements, provide standby generator system and transfer switch from one of the following (for each type of electric generator unit):
  - 1. Onan/Cummins Engine Company
  - 2. Caterpillar Tractor Company
  - 3. Kohler Company
  - 4. Or approved equal
- B. Transfer Switch
  - 1. Onan
  - 2. Russell Electric
  - 3. Automatic Switch Company
  - 4. Or approved equal

### **2.02 ENGINE-GENERATOR UNITS**

- A. Diesel Engine-Driven Generator: Provide an alternating-current standby diesel engine-driven generator unit as indicated and rated in the drawing for continuous standby operation, 460/265 -volt, 3-phase, 4-wire, 60 Hz; equipped with 4-cycle, 6 -cylinder, 1800 RPM,(BHP as indicated in the drawing), liquid-cooled, with unit mounted radiator, diesel engine; connected directly to 4-pole revolving-field type single-bearing generator through semi-flexible steel disk coupling. Equip set with associated control equipment to automatically start engine, transfer load to standby power upon failure of normal power source, transfer load back to normal power upon its restoration, and stop engine. Cushion-mount engine-generator on heavy steel base with vibration isolators to reduce possibility of torsional vibration. Equip engine with low-oil pressure, high-water temperature, and automatic overspeed safety shutdown devices. Equip generator with exciter and voltage regulator to maintain voltage within 2% of rated value. Generator shall be brushless type. Generator shall be connected directly to fly wheel by semi-flexible steel disk coupling. Provide unit capable of voltage recovery, within regulated range, of 7 seconds following a sudden load increase from 0 percent to 100 percent of rated load, and with voltage dip not to exceed 5% upon application of rated load at rated power factor. Construct unit in compliance with applicable standards; and with additional construction features as indicated. Frequency regulation shall not exceed 3-hertz from no load to rated load. The insulation system of the generator shall be class F as defined by NEMA MG1-1.65 and the temperature shall be within MG1-22.40 definition.
  - 1. Starter: Provide engine with 24-volt starting system including batteries, starting motor, and charging generator with automatic charging rate regulator. Provide SCR

type battery float charger 24-volt, 10-amp, fully automatic, constant voltage Le Marche A46 or approved equal

2. Instrument Control Panel: Provide standby generator unit with engine oil-pressure and water-temperature indicators, battery charge-rate ammeter, START and STOP button for manual operation of unit, reset circuit breaker, (static) voltage regulator, voltage-adjusting rheostat, voltmeter, ammeter with phase selector switch with OFF position, and with running time and frequency meters. Provide NFPA 110 light monitor panel with common alarm contact.

### **2.03 ENGINE-GENERATOR UNIT ACCESSORIES**

- A. Provide two auxiliary contacts for emergency elevator operations. Both contacts shall close on emergency power. One contact time controlled upon return to normal power. This timed contact shall open approximately one minute before normal power is restored to the elevator feeder.
- B. Provide skid mounted diesel oil transfer tank (capacity of the tank as per manufacturer) with positive displacement fuel pump and control switch for maintaining supply of fuel in tank at predetermined levels. Also provide rupture basin kit complete with rupture basin alarm switch for collection of fuel due to overflow or fuel tank rupture. Rupture basin to be sized for 150% of fuel tank capacity. Provide low voltage transformer as required for controls.
- C. Provide annunciator panel with visual and audible alarm to warn of emergency operating conditions affecting auxiliary power source. Locate in communications room or as directed by the Authority representative.
- D. Provide critical grade exhaust silencer and tubing.
- E. Provide anchor Bolts of galvanized steel, of types and sizes indicated.
- F. Provide molded case circuit breaker on or adjacent to engine generator set to serve as on site generator service disconnect.
- G. Fill engine and radiator with premium grade anti-freeze/coolant solution of a type recommended by the manufacturer.
- H. Provide jacket heaters on engine generator set to prevent freezing. Manifold and jacket heaters shall be sized as recommended by engine manufacturer.
- I. Make connections to high level and low level switches in oil storage tank. Provide and make connection to low level alarm bell located in communications room or as directed by the Authority representative. Provide and make connections to high level alarm bell with name plate adjacent oil fill pipe.

### **2.04 WEATHERPROOF WALK-IN HOUSING**

- A. The factory fabricated housing shall be designed to provide adequate cooling air in ambient as high as 122°F.

- B. Base Frame: Structural Steel Wide Flange beams shall be utilized as side rails with crossmembers designed to support genset. Concrete floor pad for enclosure will be provided by others.
- C. Side and End Walls: Construct from high strength aluminum with pre-painted and baked urethane finish. Wall panels shall be pre-painted gloss white on inside and out, and attached to wall posts by hard rivets.
- D. Walls shall be framed by extruded aluminum rails and corner posts. The rails and corner posts shall be heavy duty extruded high tensile aluminum.
  - 1. Roof: Provide a single sheet aluminum cover over the formed galvanized steel cambered roof bows.
  - 2. Personnel Access: Provide a single personnel door at the end of the enclosure for easy access to the genset control. The door shall be equipped with a heavy duty industrial grade bar lock with top and bottom cams for positive two (2) point locking. The hardware shall include provision for padlock for security. Additional service access shall be provided by hinged inlet air louvers.
  - 3. Cooling/Combustion Air Intake: Provide fixed blade inlet louvers with hinging and internal latch to open for service access. Louvers shall incorporate special drainable blade design to inhibit water penetration. Provide expanded aluminum bird/rodent screen on inside of louver. Louver assembly and mounting frame shall be of all aluminum construction utilizing high tensile strength extrusions.
  - 4. Radiator Discharge: Design to permit cooling air to exit the enclosure via expanded aluminum screen, sized appropriately.
  - 5. Exhaust Provisions: Roof mounting brackets shall be provided for standard silencers. Rainshields shall be included to eliminate water entry through roof penetrations for exhaust. Bracketry for silencers shall be aluminum construction, mill finish. All hardware for installation of exhaust shall be included.
  - 6. Provide electrical distribution panel to include enclosure lights and wiring of coolant heaters and battery charger.
  - 7. Provide housing insulation and interior lining.

## **2.05 FUEL SUPPLY SYSTEM**

- A. Comply with NFPA 30 and NFPA 37.
- B. Tank: Capacity shall supply adequate fuel to engine for uninterrupted period of eight hours' continuous operation at 100 percent of rated power output without being refilled.

## **2.06 AUTOMATIC TRANSFER SWITCH**

- A. The load transfer controls shall be rated for continuous duty and for all classes of load. The ampere rating of the automatic transfer switch (ATS) shall be sufficient to handle the capacity of the loads being transferred. The control components shall be compatible with the electrical requirements of the standby genset. The ATS shall be capable of performing the following functions:
  - 1. Automatically start standby generator unit when power line voltage drops to 70% of normal value, transfer load to generator, and transfer load back to normal source when voltage is restored to 90% normal. Equip electrically operated, mechanically

- held, transfer switch with limiter to open starting circuit after 45 seconds if engine fails to start.
2. Provide time-delay features for engine starting to override momentary power dips, load retransfer and engine shutdown.
  3. Provide adjustable time delay and co-ordinate with elevator contractor. Provide all necessary components to prevent more than one elevator from operating simultaneously. Time delay shall be adjustable from 1 to 30 seconds.
  4. Equip unit with test switch for manual simulation of power outage including standby unit operation and load transfer, and time-clock exerciser circuit for automatic periodic exercise of engine-generator unit.
  5. Install the ATS in NEMA 1 enclosure
- B. The transfer switch shall be 480/277V, 4-pole, UL listed, Onan,OTIII series or approved equal, complete with battery charger, programmed transition, exerciser, and all auxiliary contacts for starting and stopping generator from fire alarm annunciator panel.

## **2.07 AUTOMATED ENERGY MANAGEMENT SYSTEM (AEMS) INTERFACE**

- A. The supplier of the emergency generator shall provide interface to the AEMS per point list in Table 2 of Section 16601 for generator status points and generator control points. Provide raceways and wiring from the generator to the AEMS interface box per Section 16601.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION OF ENGINE-GENERATOR SYSTEMS**

- A. Install standby engine-generator set complete with walk-in housing as indicated, in accordance with the equipment manufacturer's written instructions, and with recognized industry practices, to ensure that engine-generator set fulfills requirements. Comply with NFPA and NEMA standards pertaining to installation of standby engine-generator systems and accessories.
- B. Coordinate with other work as necessary to interface installation of standby generator system work with other work.
- C. Install units on spring vibration isolators and comply with manufacturer's indicated installation method if any.
- D. Align shafts of engine and generator within tolerances recommended by equipment manufacturer
- E. The manufacturer shall provide Operation and Maintenance manuals and provide WMATA maintenance personnel a 4 - hour instruction period for maintenance and general service of the generator in accordance with the General Requirements.

### **3.02 TESTING**

- A. Upon completion of installation of engine-generator system and after parking structure electrical circuitry has been energized with normal power source, test engine-generator under full load conditions to demonstrate standby capability and compliance with

requirements. Where possible, field correct malfunctioning units, then retest to demonstrate compliance.

**END OF SECTION**

## SECTION 16225

### MOTORS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTIONS:

- A. This section specifies providing motors.
- B. Related Work Specified Elsewhere:
  - 1. Grounding and bonding: Section 16060.
  - 2. Wire connection accessories: Section 16125.
  - 3. Raceways, boxes and cabinets: Section 16130.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of jurisdictional authorities.
  - 2. NEC.
  - 3. IEEE: 85, 112.
  - 4. NEMA: MG1.
  - 5. ANSI: Z55.1.
  - 6. ASTM: A582.
  - 7. OSHA: 1910.95.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Outline dimensions.
    - b. Cross section showing internal construction and weight.
    - c. Connection diagram.
  - 2. Certification.
  - 3. Operation and Maintenance Manuals.

##### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Ship each motor securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.
- B. Store motors in secure and dry storage facility.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. Motors:
  - 1. NEMA MG1, squirrel-cage, induction-type, unless otherwise shown.
  - 2. Rating:
    - a. Horsepower: As shown.
    - b. Voltage and frequency:
      - 1) Motors, 1/2 HP and smaller: 115-volt, single-phase, 60 Hertz.

- 2) Above 1/2 HP: 460-volt, three-phase, 60 Hertz, unless otherwise specified or shown.
- 3) For motors in air-conditioning units:
  - a) For units up to and including 10,000 BTUH: 115-volt, single-phase, 60 Hertz.
  - b) For units from over 10,000 BTUH up to and including 36,000 BTUH: 208-volt, single-phase, 60 Hertz.
  - c) For units over 36,000 BTUH: 460-volt, three-phase, 60 Hertz.
- c. RPM: As shown.
- d. Time rating: Continuous, unless otherwise shown.
- e. Nominal full-load efficiency: Premium Efficiency when tested in accordance with NEMA MG1 and IEEE 112.
3. Design:
  - a. Single-phase motors: Design N, suitable for full-voltage across-the-line starting.
  - b. Three-phase motors: Design B, unless otherwise shown, with the following additional requirements:
    - 1) Up to and including 50-HP motors: Suitable for full-voltage across-the-line starting.
    - 2) Above 50-HP motors: Suitable for reduced-voltage starting.
4. Service factor:
  - a. Motors, one HP and smaller: In accordance with NEMA MG1.
  - b. Above one-HP up to and including 200-HP motors: 1.15.
  - c. Above 200-HP motors: 1.00.
5. Insulation: Class and allowable temperature rise above average ambient temperature of 30C and maximum ambient temperature of 40C as follows:
  - a. Integral-horsepower motors:
    - 1) Dripproof motors: Class B insulation with Class B temperature rise.
    - 2) Totally enclosed motors: Class F insulation with Class B temperature rise, unless otherwise shown or specified.
  - b. Fractional-horsepower motors: In accordance with NEMA MG1.
6. Noise level: NEMA MG1-12.49 but not to exceed requirements of OSHA 1910.95 when measured in accordance with IEEE 85.
7. Enclosure:
  - a. Dripproof, fully guarded; totally enclosed fan-cooled guarded; or totally enclosed air-over as specified.
  - b. Heavy-duty steel or cast-iron frame.
  - c. End bell:
    - 1) Up to 10HP: With cast-iron or aluminum end bells.
    - 2) 10HP and above: With cast-iron end bells.
  - d. Mounting: Foot-mounted on pad or adjustable pad, if necessary or as otherwise shown.
  - e. Provision for grounding.
  - f. Finish: Red-oxide zinc-chromate primer with finish coat of light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.
  - g. Totally enclosed air-over:
    - 1) Variation to totally enclosed fan-cooled machines with air flow for cooling supplied by fan specified elsewhere.
    - 2) Fan/motor application factory-engineered for air flow shown or specified.
8. Conduit box:
  - a. Diagonally split, suitably gasketed.
  - b. Type:
    - 1) Up to 10HP: Steel, cast iron or aluminum with threaded or punched conduit holes.

- 2) 10HP and above: Cast iron with threaded conduit holes.
  - c. Size suitable to accommodate motor and line leads including taping.
  - d. Capable of rotation in each 90-degree position.
- 9. Bearings:
  - a. Unless otherwise specified, average life 15 years, but not less than three years at continuous operation, with double shields.
  - b. Integral-horsepower motors:
    - 1) Five HP and smaller: Sealed ball bearings or roller bearings.
    - 2) Above five HP: Ball bearings or roller bearings with grease fittings and pressure-relief fittings for in-service lubrication.
  - c. Fractional-horsepower motors:
    - 1) 1/6 HP and larger: Sealed ball bearings.
    - 2) Below 1/6 HP: Sealed ball bearings or sleeve.
- 10. Motors for hermetically sealed and semi-hermetically sealed compressors: NEMA MG1, 18.076 through 18.093.
- 11. Motors for close-coupled pumps: Stainless-steel shaft in accordance with ASTM A582, Type 303.
- 12. Provide nameplate on each motor in accordance with NEMA MG1-10.37.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION:**

- A. Install motors where shown and in accordance with the NEC.
- B. Install conduit in accordance with Section 16130.
- C. Connect power cable as shown and in accordance with Section 16125.
- D. Ground motor enclosure in accordance with Section 16060.

#### **3.02 FIELD QUALITY CONTROL:**

- A. Furnish necessary equipment and perform the following tests:
  - 1. Check and test wiring connections in accordance with wiring diagram.
  - 2. Test to ensure that insulation resistance of motor winding is 10 megohms minimum.
  - 3. Test motor enclosure for continuity to grounding system.
  - 4. Test motors for proper operation with their associated controls.
- B. Submit certified test reports.

**END OF SECTION**

## SECTION 16260

### UNINTERRUPTIBLE POWER SYSTEM

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing uninterruptible power system (UPS) consisting of rectifier/charger, storage battery, battery-disconnect circuit breaker, inverter, power transfer switch, main emergency panelboard, and floor mat.
- B. Related Work Specified Elsewhere:
  - 1. Raceways, boxes and cabinets: Section 16130.
  - 2. Wire, cable and busways: Section 16120.
  - 3. Grounding and bonding: Section 16060.
  - 4. Circuit breakers, panelboards and load centers: Section 16440.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of jurisdictional authorities.
  - 2. National Electrical Code (NEC).
  - 3. National Electrical Manufacturers Association (NEMA): PE1, Uninterruptible Power Systems
  - 4. American National Standards Institute (ANSI): C39.1, Requirements, Electrical Analog Indicating Instrum; and Z55.1, Gray Finishes for Industrial Apparatus and Equipment.
  - 5. ANSI/NEMA: PB1, Panelboards, and 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
  - 6. ANSI/IEEE: C57.12.90, Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers; 450, IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead- Acid Batteries for Stationary Applications, and 484, IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications.
  - 7. UL: 50, Enclosures for Electrical Equipment; 67, Panelboards; 94, Tests for Flammability of Plastic Materials for Parts in Devices and Appliances; and 198C, High-Interrupting-Capacity Fuses, Current Limiting Type.
  - 8. American Standards of Testing and Materials (ASTM):B187-00 Standard Specification for Copper Bar, Bus Bar, Rod, and Shapes; and D635-98 Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.
  - 9. ANSI/American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE): 52.1, Gravimetric and Dust Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.
  - 10. ANSI/American Hardboard Association (AHA): 135.4, Basic Hardboard.
  - 11. The equipment manufacturer shall maintain ISO 9001 or ISO 9002 certification
- B. Source Quality Control:
  - 1. Design and production tests: Perform and submit, in accordance with the General Requirements certified test results for the following tests on the uninterruptible power

system or provide certified test reports on identical unit. Furnish certified test reports showing test data and results as well as manufacturer's comments on oscillograph traces obtained during in-rush test and short-circuit coordination tests.

- a. Storage battery: Perform tests to determine the following:
  - 1) Ampere-hour rating of battery during three-hour discharge period.
  - 2) Charge rate starting from fully discharged state based on 105-volt terminal voltage, to 90-percent of fully charged state within 12 hours.
  - 3) Maximum short-circuit current available at battery terminals at full charge.
- b. Rectifier/Charger: Perform tests to ensure that:
  - 1) Unit has capacity to feed specified load including overload capacity of static inverter.
  - 2) Output voltage regulation is within specified tolerance.
  - 3) Unit has specified efficiency at rated output.
  - 4) Unit is current limiting when activated by an external contact closure from an engine driven generator.
- c. Static inverter: Perform tests to ensure that:
  - 1) Unit has capacity to feed rated kVA into load which has power factor of 0.8 lagging.
  - 2) Unit has capacity to deliver specified overload.
  - 3) Output voltage has sine wave with maximum of five-percent total harmonic distortion.
  - 4) Output voltage and frequency regulation are within specified limits.
  - 5) Efficiency at rated output at unity power factor of load is within specified limits.
- d. Power transfer switch: Perform tests as recommended by the manufacturer and verify compliance with specified requirements.
- e. Uninterruptible power system: Perform following tests with UPS in normal operating mode and alternate power available on transfer switch:
  - 1) In-rush test: Test to verify that power transfer switch and inverter power circuits remain operative without reset or replacement of protective devices while the following test is performed:
    - a) 480-208Y/120-volt transformer with primary protection and full-load on secondary side as specified below connected to load side of power transfer switch, close transformer primary switch 10 times to provide maximum magnetizing in-rush. Record calibrated oscillograph traces of three-phase output voltages and line currents on load side of power transfer switch. Include oscillograph traces with the submittals.
      - 1) Inverter below 25 kVA: Nine-kVA transformer with disconnect switch fused at 20 amperes on primary side.
      - 2) Inverter 25 kVA or larger: 15-kVA transformer with disconnect switch fused at 30 amperes on primary side.
  - 2) Short-circuit coordination test: Test to verify that distribution-panel fuses clear fault and that protective devices in inverter and power transfer switch continue to function without reset and equipment remains fully operable while the following test is performed:

- a) With main emergency panelboard connected to load side of power transfer switch using 10 feet of 1/0-AWG three-conductor cable, with UL Class J or RK1 fuses sized as follows, in one panelboard feeder, with specified short-circuit current available at input terminals of rectifier/charger and at bypass-circuit terminals of power transfer switch, close fuse switch on bolted three-phase fault at load terminals of branch circuit. Repeat test three times and record calibrated oscillograph traces of three-phase voltages of inverter output and bypass source, and fault current from power transfer switch.
    - 1) In panelboard fed by inverter below 25 kVA: 20-ampere fuses.
    - 2) In panelboard fed by inverter 25 kVA and larger: 30-ampere fuses.
  - 3) Input power factor: Test to determine input power factor at rated inverter output.
- C. Furnish products of a manufacturer regularly engaged in the manufacture of uninterruptible power systems.
- D. Qualifications of Instructor for Operation and Maintenance Training: Qualifications will be considered adequate when the following is demonstrated:
- 1. Instructor has in-depth knowledge of the design, packaging, operations, maintenance and trouble-shooting of the systems to be taught.
  - 2. Instructor has been trained in teaching methods or has previous satisfactory experience in teaching with emphasis on the subject matter to be covered in the course of instruction.

### **1.03 SUBMITTALS:**

- A. General: Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
- 1. Shop Drawings: In accordance with Table 16260-1.
  - 2. Certification.
  - 3. Documentation:
    - a. Submit field-test plan and documentation within 60 days after award with accompanying documentation in the form of test-data recording sheets and list of proposed test equipment.
    - b. Do not proceed with testing until plan and documentation are approved.
    - c. Indicate in scope of test plan method of testing equipment in order to ensure safe and orderly transition from installation, through initial energizing, to specified field testing.
    - d. Accompanying documentation to include data-recording sheets as used by manufacturer for in-plant testing of equipment and devices or as used by large industrial users of specified equipment.
    - e. Submit certified copies of test data, dated and clearly identified within two weeks after completion of testing.
  - 4. Certified test data for specified enclosure intake filter performances.

5. Instructor qualifications: Five copies of resume which outlines each instructor's qualifications and skills not later than 180 calendar days prior to commencement of training.
6. Operations and maintenance training material: Five copies not later than 180 calendar days prior to commencement of training.
7. Operations and Maintenance Manuals:
  - a. Include in manuals general theory of operation of the Uninterruptible Power System including description, purpose and function of:
    - 1) Battery.
    - 2) Rectifier/Charger.
    - 3) Inverter.
    - 4) Transfer switch.
    - 5) Maintenance bypass arrangement.
    - 6) Logic power supplies.
    - 7) All logic boards.
  - b. Describe and include in manuals procedures for:
    - 1) Battery testing and for optimizing:
      - a) Float voltages.
      - b) Equalizing voltages.
      - c) Equalizing time adjustments.
    - 2) Operational checks of:
      - a) Transfer to bypass source.
      - b) Retransfer from bypass to inverter.
    - 3) Alignment and adjustment of operating, detector and alarm circuits including rectifier, inverter and power transfer switch logic boards.
    - 4) Troubleshooting to include test procedures and system logic in identifying malfunctions.
  - c. Include in manual the shop drawings listed in Table 16260-1. Print shop drawings on folded pages in accordance with the General Requirements.

**1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.
- B. Ship battery cells assembled and filled to proper level with electrolyte and fully charged.
- C. Temporary Bracing: Where necessary, brace each unit for hoisting, lowering and skidding into position. Temporary internal bracing of the equipment labeled as follows: TEMPORARY-REMOVE BEFORE OPERATION.
- D. Protection Against Concealed Damage: Include within shipping container mechanical impact recorder of rating recommended by manufacturer for shipment by railroad and submit in accordance with the General Requirements impact chart with manufacturer's recommendations for disposition of damaged materials.
- E. Store equipment in secure and dry storage facility.

**1.05 WARRANTY FOR STORAGE BATTERY:**

- A. In addition to warranty requirements of the General Provisions, furnish a four-year warranty for a total of five years against defective parts and workmanship and a 19-year warranty for intended operation for a total of 20 years.

**1.06 OPERATION AND MAINTENANCE TRAINING:**

- A. Perform operation and maintenance training in accordance with the General Requirements and the following additional requirements for development and performance of operation and maintenance training for uninterruptible power system:.
- B. Use only instructors who are fully qualified for their presentations as required above under Quality Assurance.
- C. Concept of Training:
  - 1. Design classroom and field instruction to cover in detail the functions of each item of equipment. Cover fault isolation and troubleshooting technique to the extent necessary to permit a technician to diagnose and repair faulty modules. Design instruction to provide Authority maintenance personnel with practical experience in the performance of preventive and corrective maintenance. Provide troubleshooting and fault isolation of simulated faults for each item of equipment in the unit substation.
  - 2. Develop and provide all operation and maintenance training necessary for Authority-designated personnel to support the power equipment. Have classroom instruction include not only the anatomy and functioning of the parts under discussion, but the essentials of their routine care, including lubrication schedules, adjustments, limits, test frequency, inspection frequency, troubleshooting, removal and replacement. Have instruction cover theory of operation of the power systems, individual modules and special protective circuits. Use flow diagrams to show sequence of events and time required to complete each event.
  - 3. Have the course include performance of preventive maintenance operations on the equipment and hands-on troubleshooting of each subsystem.
  - 4. In training, assume the Authority's employees have no knowledge of the features of the new equipment. The Authority is permitted to videotape all class presentations.
- D. Training materials:
  - 1. Develop first-generation reproducible training material.
  - 2. Conduct training using final manuals approved by the Authority and certified by the Contractor as being correct, as-built and reproducible. These materials become the property of the Authority at the end of program.
  - 3. Develop the following training materials for each course:
    - a. Instructor material for each course.
    - b. Course outline: Course outline with learning objectives. Include a topic outline for each item of equipment. Include in maintenance training a section devoted to system-fault analysis and troubleshooting. State the learning objectives for each topic.
    - c. Lesson plans: A set of lesson plans for each item of equipment, corresponding to the topic outline, and containing the following information:
      - 1) Lesson title.
      - 2) Instruction time.
      - 3) Objectives.
      - 4) Training aids required.

- 5) Instruction sequence (outline).
  - 6) Tests.
  - 7) Summary.
- d. Training aids: For each topic, develop optimum use of visual aids, including transparencies size eight-inch by 10-inch, 35-mm slides, films, and mockups. Provide approved shop drawings in transparency.
  - e. Instructional material: Use the applicable equipment operation and maintenance manuals as the primary source of instructional material. In addition, develop notebooks for each course containing such additional drawings, descriptive information and procedures necessary to ensure that the learning objectives are met in an orderly and timely manner. Arrange notebook material by each item of equipment and sequence according to the topic outline.
  - f. Course topic outlines and schedules: Have the topic outline and schedules for each course contain the following:
    - 1) Description of course including course objectives and training program level.
    - 2) Course length and recommended numbers of students per course.
    - 3) List of training materials required including documentation and equipment.
    - 4) For each topic outline for the course, a topic objective and the time allotted to the topic.
    - 5) Schedules listing the major topics and subtopics on a time allocation for each topic.
  - g. Instructor guides and training aids: Have the instructor guide for each course include:
    - 1) Table of contents listing each topic and the time allotted.
    - 2) List of applicable documents.
    - 3) List of training materials.
    - 4) Course learning objectives, course length and recommended number of students.
    - 5) Provide each topic with a cover sheet listing topic, objective, time allotted and training aids required.
    - 6) Include training aids with the instructor guides.
  - h. Student workbook: Reproduce diagrams, drawings and procedures from engineering data and manuals and include them in student handout.
- E. Instructional Equipment: Conduct training utilizing installed equipment in normal operating conditions, permitting the trainees to perform hands-on work.
- F. Course of Instruction:
1. Conduct this course for Authority-designated individuals; providing in-depth instruction on the fundamentals involved in the design of the complete system combined with practical aspects of operation and maintenance. Include also the following:
    - a. Practical exercises that require the trainees to make use of the operation and maintenance manuals.
    - b. Familiarization with the assembly, subassembly and components that make up a total system. Include instruction and practical exercises in troubleshooting at a level higher than that performed by equipment operators.

- c. Use and replacement of original assemblies, subassemblies and components with compatible assemblies, subassemblies and components manufactured by others.
  - d. Handouts to each trainee that include information drawings, shop drawings, catalog cuts, manufacturer's literature, equipment maintenance check lists and other literature describing the total system.
  - e. Video and color slide presentations showing system installation, operation, troubleshooting, maintenance, module removal and replacement.
  - f. Tools and test equipment necessary to conduct operation and equipment maintenance troubleshooting.
2. Supplemental Training: In the event Contractor changes or performs modifications to equipment subsequent to the training that impact form, fit or function; provide supplementary training to the Authority's training instructor on a one-time basis.

G. Scope: The training program consists of the following:

Course Title	Length of Course Hours	Number of Persons Per Course	Number of Courses	Total Number of Course Hours
Operation and Maintenance Training	80	10	2	160

- 1. Provide practical training on equipment for not less than 60-percent of the course duration.
  - a. Location: Conduct training classes at facilities provided by the Authority.
  - b. Times: Set class times at the convenience of the Authority.
- 2. Contractor may propose four courses at 40 hours each in lieu of two courses at 80 hours each subject to approval.

H. Equipment:

- 1. Training equipment: Supply and deliver to the Engineer after completion of the course special tools required for maintenance training.
- 2. Test equipment: Supply and deliver to the Engineer after completion of the course test equipment required for maintenance training.

**PART 2 - PRODUCTS**

**2.01 PRODUCTS AND MATERIALS:**

- A. General: Comply with NEMA PE1.
  - 1. Interchangeability: Components of same type, size, rating, functional characteristics and make are to be interchangeable.
  - 2. Enclosure:
    - a. Rectifier/charger, inverter, and power transfer switch provided with common ANSI/NEMA 250, Type 1-EFVF enclosure (Evacuated forced ventilation with

- inlet air filters), or ANSI/NEMA 250, Type 1-FVFF enclosure (Forced ventilation with inlet air filter and outlet air filter), with gasketed dust-tight doors.
- b. Intake filter: Intake filter easily removable from front of unit, throw-away or washable, providing an average ANSI/ASHRAE 52.1 efficiency of 30-percent and an average ANSI/ASHRAE 52.1 arrestance of 95-percent.
  - c. Design: Panel-type, with hinged front door suitable for mounting meters and accessories, ventilated for satisfactory operation of equipment under ambient temperature up to 105F.
  - d. Fabricated from minimum 14-gauge steel sheet and reinforced with steel framework to form rigid structure with smooth outer surface free of burrs, ridges or other blemishes.
  - e. Equipped with latch and handle; screw fastenings will not be accepted in lieu of latch.
  - f. Provision for grounding enclosure.
  - g. Finish: Metallic surfaces cleaned, degreased, primed with zinc primer and finished with light-gray enamel, ANSI Z55.1 Color 61, two mils minimum DFT.
3. Control and instrument wiring:
- a. Factory-installed.
  - b. Wire: Type SIS tinned-copper wire, 22AWG minimum for control logic and printed circuit card and 18AWG minimum for other control circuits. Class C or D stranded wire used for wiring across hinged joints.
  - c. Wire terminals: Tinned-copper ring or spade-type compression terminals with insulated sleeve installed in accordance with manufacturer's recommendations.
  - d. Wire identification: Each wire identified with the circuit number corresponding to that shown on wiring diagrams adjacent to terminal connections.
4. Fuses: Current-limiting fuse installed in each control circuit and where necessary for protection and coordination in power circuits.
5. Nameplates:
- a. Provide nameplate on each UPS in accordance with reference standards.
  - b. Three-ply, laminated phenolic plates; engraved through black face to white core and attached by means of steel rivets or screws.
    - 1) Lettering to be vertical Gothic using a round or square cutter. V-shaped groove not acceptable.
    - 2) Each UPS enclosure labeled with nameplate 1-1/2 inches high with letters one-inch high: UNINTERRUPTIBLE POWER SYSTEM.
    - 3) Each main emergency panelboard labeled with nameplate one-inch high with letters 1/2-inch high: EMERGENCY POWER PANEL.
  - c. Provide nameplate on each charger, battery, inverter and power transfer switch showing manufacturer's name, brand designation, reference standard, type, class, rating, wiring diagram and serial number, as applicable.
  - d. In addition to other information normally displayed on the equipment, provide nameplates showing switch positions, meaning of indicator lamps and other pertinent information.
6. System controls and indicators: Located on the front of the UPS cabinet; and as per manufacturer standard product with the following minimum requirements:

- a. Monitoring and control: Provide a microprocessor based unit status display and controls section designed for convenient and reliable user operation. The monitoring functions such as metering status and alarms shall be displayed on a graphical LCD display. Additional feature of the monitoring and control system shall include graphical display of single line diagram of the UPS, menu-driven with pushbutton navigation, real time clock, alarm history with time and date, and battery back-up memory. All operation and parameters are firmware controlled, thus eliminating the need for manual adjustments or potentiometers.
  - b. Metering display:
    - 1) Input AC voltage, line to line, and line to neutral for each phase.
    - 2) Input AC current for each phase.
    - 3) Input frequency.
    - 4) DC bus voltage.
    - 5) Battery current and direction (charge/discharge).
    - 6) System output AC voltage, line to line and line to neutral for each phase.
    - 7) System output AC current for each phase.
    - 8) System output frequency.
    - 9) Bypass input voltage, line to line, line to neutral for each phase.
    - 10) Elapsed time-discharging battery.
7. Status displays, alarm messages and indication lights: Minimum requirement as specified for the rectifier/charger, inverter and power transfer switch units with the following additional requirements:
- a. Indication lights: Long-life LED.
  - b. Clear identification of each indication light.
  - c. All alarm messages and indications resettable with push-button.
  - d. Controls: A graphical LCD mimic screen to depict a single line diagram of the UPS with switch positions and power flow.
  - e. Operation Instructions: Display to provide all necessary instructions and step-by-step procedure for each sequence of operation
8. Accessibility of circuit boards and components:
- a. Front accessibility to rectifier/charger, inverter, and power transfer switch, including all cable connections.
  - b. Where a circuit-alignment procedure is required and adjustments require measurement of circuit points on circuit boards: Accessible test points on cards with appropriate designations and supplementary removable extender boards provided for making points accessible.
  - c. Sub-assemblies, parts and circuit boards that may require replacement: Arranged and mounted so that replacement requires no soldering or special tools.
  - d. All cable and conduit connections: Through top of cabinet.
9. Operational noise level: Not exceeding 70dB measured six feet from the equipment on the A weighting network of a general-purpose sound-level meter at slow response. Test conditions and correction factors in accordance with ANSI/IEEE C57.12.90.
10. Supervisory contacts: As specified for the rectifier/charger, inverter and power transfer switch units, with the following additional requirements:
- a. Dry-type sealed contacts rated to switch 500 milliamperes at 250 volts dc or three amperes at 24 volts dc.
  - b. Contact resistance: 0.10-ohm maximum.

- c. Contact bounce: Five milliseconds maximum.
- d. Wired to terminal block for remote connection to supervisory system.

B. Storage Battery:

- 1. Complete with accessories and battery racks.
- 2. Battery: UPS Cycle Duty, Industrial Flooded Lead Acid Cell.
  - a. Round cell or equal. Plate construction: Pure lead cylindrical cone-shaped. Positive grid minimum 0.2 inches thick.
  - b. Discharge capacity: Capable of providing dc inverter input to give rated inverter output at 0.8 power factor for three hours at 77F while simultaneously providing average load of 1.8 kW dc for switchgear operation and control, with peak demands of six kW for five seconds at each 30-minute interval during specified duration. Minimum battery-terminal voltage: 105 volts under full-load at end of three-hour discharge period.
  - c. Cycling duty: Capable of numerous cycling discharges at full load. Corresponding number of cycles for each discharge duration representing 100-percent of the available cycles: 30 seconds, up to 10,000 events; 30 seconds to 1.5 minutes, up to 2,000 events; 1.5 minutes to 4 minutes, up to 600 events and 3 hours, 50 events minimum.
  - d. Cell container:
    - 1) Extra-strength transparent plastic providing clear view of cell interior.
    - 2) Flammability rating: UL 94-V2, ASTM D635-98 self extinguishing, minimum Low Oxygen Index (LOI) 30-percent.
    - 3) Integral molded ribs for supporting internal elements without developing stresses caused by variation of temperature.
    - 4) Ample sediment space below cell plate to prevent premature battery failure.
    - 5) Mark indicating level of electrolyte to be maintained.
  - e. Post type: Two or four, square copper insert posts with dual bolt holes.
  - f. Container cover:
    - 1) Sealed to provide permanent leakproof seal. Sufficient clearance from plate grids to allow for expansion and contraction of plate without cracking or splitting. Replace cells determined to have a cover leak within the warranty period at no additional cost to the Authority.
    - 2) Insulating material: Free from circuit leakage and impurities detrimental to plates or separators and impervious to absorption of electrolyte.
    - 3) NEMA flame arrester vent plugs.
    - 4) Flammability Rating: UL 94-VO, ASTM D635-98, self extinguishing.
  - g. Post seal: Historically proven and demonstrated leak-proof design. Replace cells determined to have a post seal leak within the warranty period at no additional cost to the Authority.
  - h. Factory test and shipping capacity: 100-percent capacity at time of delivery from factory. Factory tested for similar float and end of discharge voltages. Batteries tested together with a maximum difference of plus and minus 0.03 volts from the average cell voltage.
- 3. Accessory equipment:
  - a. One syringe hydrometer with specific-gravity scale range no greater than 1.100 to 1.300.

- b. One thermometer.
  - c. One torque wrench for battery connection.
  - d. Two cell-lifting devices complete with strap and spreader.
  - e. Two sets of stainless steel connecting bolts, nuts and washers.
  - f. Two sets of intercell connectors.
  - g. One set of manufacturer-recommended interrack cable and load-terminal lugs.
  - h. Pegboard: Hard board, ANSI/AHA 135.4, tempered, one smooth side (S1S), 1/4-inch nominal thickness, perforated, sized to accommodate all products specified above. Framed with one-inch by one-inch hardwood. Paint frame and hardboard in color selected by the Engineer. Include hardware for wall-mounting and pegboard accessories suited to the products to be mounted. Provide one-inch high nameplates as specified, with accessory names inscribed in 1/2-inch-high letters.
  - i. One portable lifting jig for battery, as recommended by battery manufacturer, in each battery room.
  - j. Battery Cycle Monitor: C&D BCM1100 or equal, electronic logging and event recorder/monitor to provide summary information for validating battery manufacturer's warranty. Install monitor in accordance with manufacturer instructions and requirements. Provide signal wiring, power wiring and conduits to ensure correct operation. Provide power wiring and conduits from nearest available distribution panel as selected by the Engineer. Ensure that Monitor meets manufacturer's requirements for verifying load cycling warranty. As a minimum, make monitor able to:
    - 1) Measure battery room temperature, present, maximum and minimum values. Maintain a register of the dates and values of the minimum and maximum occurrences.
    - 2) Indicate float voltage with record retrieval of the maximum and minimum values.
    - 3) Monitor the following parameters during discharge:
      - a) Time of day the event started.
      - b) Battery voltage at start and end of discharge.
      - c) Battery load current during discharge.
      - d) Length of time of the discharge.
    - 4) Provide a summary read-out showing detailed information on number of cycles on the battery.
    - 5) Provide alarm contacts to signal an event is occurring on the battery.
    - 6) Indicate total Kilowatt hours taken out of the battery.
    - 7) Indicate total ampere-hours taken out of battery.
    - 8) Indicate percent of cycle life remaining in battery.
4. Battery rack:
- a. Round Cell Battery:
    - 1) Two-tier type fabricated from polyester-glass-composite that is acid resistant, flame retarding, maintenance-free, electrical insulator.
    - 2) Floor mat: Durable, 1/4-inch thick, electrolyte-resistant black rubber mat
5. Enclosed dc circuit breaker:
- a. Two-pole, 250-volt dc, molded-case circuit breaker as specified in Section 16440.

- b. Enclosure: ANSI/NEMA 250, Type 1, marked ON/OFF, capable of being padlocked in OFF position.
- c. Location: In battery room.

C. Rectifier/Charger:

1. Solid-state, three-phase: Continuous-duty rectifier including the following requirements:
  - a. Bridge rectifiers: Silicon-controlled or power transistor.
  - b. Six-pulse minimum, each pulse fully controlled.
  - c. Electronic current-limiting control for output.
  - d. Output voltage: Maximum six-percent rms ripple with battery not connected.
2. Electrical characteristics:
  - a. For converting 480-volt, three-phase, 60 Hertz alternating current to direct current with characteristics suitable for charging associated battery and for providing input to the associated inverter.
  - b. Float and equalizing charge rate: As necessary for proper charging of associated battery, with the following additional requirements:
    - 1) Float voltage adjustable between 125 and 135 volts.
    - 2) Equalizing voltage adjustable between 135 and 144 volts.
  - c. Output rating: To provide dc input to inverter for giving rated inverter output while simultaneously providing average load of 1.8-kW dc for switchgear loads as specified, with sufficient rating to simultaneously recharge the battery to 90-percent or more of fully charged condition in a 12-hour period from a discharged battery voltage of 105 volts.
  - d. Output voltage regulation: Within plus-or-minus one percent from zero to 100-percent of charger rated capacity for ac supply-voltage variation of plus-or-minus 10-percent at 480 volts and supply-frequency variation of plus-or-minus five-percent at 60 Hertz.
  - e. Efficiency: 95-percent minimum at nominal input voltage with rectifier/charger supplying 100-percent of rated load.
  - f. Power factor: Input power factor minimum 0.7 with rated input voltage, UPS supplying 100-percent load, and battery on minimum float voltage.
3. Accessory equipment:
  - a. Meters: As specified in Article 2.1.A.6.b
  - b. Indicating lights or status displays:
    - 1) One to monitor ac supply voltage (low voltage or loss on any phase).
    - 2) Status displays:
      - a) Input circuit breaker closed.
      - b) Rectifier/charger in float or equalizing mode.
      - c) Rectifier/charger failed.
      - d) For ungrounded dc system: Ground-fault indication lights.
  - c. Relay equipped with one NO contact and one NC contact for indicating normal and failure status of rectifier/charger output at remote location.
  - d. One 480-volt, three-pole, molded-case circuit breaker or one integrally fused circuit breaker in accordance with Section 16440 for incoming power to protect against available short-circuit current of rms symmetrical amperes at 0.15 power factor not less than the following based on substation-transformer capacity as shown:
    - 1) 750-kVA transformer: 17,500.
    - 2) 1,000-kVA transformer: 25,000.

- 3) 1,500-kVA transformer: 35,000.
  - 4) 2,000-kVA transformer: 42,000.
  - 4. Automatic control:
    - a. Current-limiting device or circuit capable of limiting output current to rating of charger without disconnecting charger from battery or ac power supply. Provide a current limit, 0% to 25%(adjustable) of nominal full load current to limit the battery recharge current when activated by a remote
    - b. Automatic recharging on equalizing cycle after return of input ac voltage following an outage. Input current rate of increase limited (ramped) to achieve full-load input capability in no more than 15 seconds after turn-on.
    - c. Adjustable equalizing timer with range from one-hour to 60 hours minimum. Timer-adjustment function identified.
    - d. Built-in overload protection including short circuit at output terminals.
  - 5. Manual control:
    - a. Manual momentary contact switch to initiate equalizing operation and timer.
    - b. Manual momentary contact switch to stop equalizing operation, restore float operation and reset timer.
    - c. Screwdriver slot or locking knob-operated devices for adjusting float voltage and equalizing voltage, with function identified.
- D. Static Inverter:
- 1. Solid-state design using Insulated Gate Bipolar Transistor (IGBT) with Pulse Width Modulation/Stepwave.
  - 2. Electrical characteristics:
    - a. Input voltage: Nominal input-voltage range from low voltage of 105 volt to highest equalizing voltage of 144 volts as specified for battery.
    - b. Output voltage: 480Y/277-volt, three-phase, four-wire, 60 Hertz.
    - c. Output rating:
      - 1) kVA rating: As shown.
      - 2) Capable of delivering rated three-phase KVA with any one phase 30-percent unbalanced from the other two phases within the dc input-voltage limits, and not exceeding three-percent voltage unbalance for any phase combination with no manual adjustment.
      - 3) Capable of delivering rated KVA into load which has power factor of 0.8 lagging.
    - d. Output-wave form: Sine wave, maximum of five-percent total harmonic distortion.
    - e. Output-voltage regulation: Zero to 100-percent rated load and dc input voltage within stated limits:
      - 1) Balanced load: Plus-or-minus one percent.
      - 2) Unbalanced load at 30-percent of rated load: Plus-or-minus 2.5 percent.
    - f. Output-voltage stability: With 100-percent step-load change, balanced load: Plus-or-minus 10-percent maximum deviation. Recovery to stated regulation band within six cycles.
    - g. Output-frequency control and synchronization:
      - 1) Inverter-output frequency phase locked to bypass source whenever source frequency is within plus-or-minus two-percent of standard 60 Hertz.
      - 2) Inverter-frequency control to shift to crystal- controlled oscillator in inverter whenever utility reference frequency goes outside limits.

- Whenever utility source returns within the frequency limits, frequency control to return to bypass source.
- 3) Crystal-controlled oscillator to maintain a stable, continuous, standard 60-Hertz frequency within plus-or-minus one-half percent.
  - 4) Phase-lock control to maintain output-voltage wave of each phase to within six electrical degrees of the utility voltage wave (bypass source).
- h. Overload rating: 125-percent of rated load for 15 minutes (without bypass source); 200-percent for 30 seconds (without bypass source).
  - i. Starting characteristics: Capacity to start at any load within overload rating with and without external ac power source.
  - j. Fault and surge override: Capacity to:
    - 1) Sustain fault at load terminals of main emergency panelboard until fault is cleared or load is transferred.
    - 2) Override magnetizing in-rush current of transformer as follows:
      - a) Inverter below 15 kVA: Nine-kVA transformer.
      - b) Inverter 25 kVA and larger: 15-kVA transformer.
  - k. Inverter automatic shutdown: To occur when battery voltage reaches lower limit of 105 volts. Battery to continue to supply the specified switchgear load.
  - l. Inverter to restart automatically when dc voltage reaches nominal value of 125 volts.
  - m. Efficiency: Not less than the following with load power factor of 0.8 lagging.
    - 1) 15 kVA or less: 80-percent.
    - 2) 20 kVA through 50 kVA: 84-percent.
3. Accessory equipment:
- a. Meters: As specified in Article 2.1A.6.b
  - b. Indicating lights or status displays:
    - 1) Inverter operating in normal mode.
    - 2) Inverter operating in standby mode or power transfer switch in bypass mode.
    - 3) Inverter operating and phase locked.
    - 4) DC voltage below minimum float voltage or above maximum equalizing voltage.
    - 5) Overtemperature.
    - 6) Low cooling air flow.
    - 7) Overload.
  - c. Relays and controls:
    - 1) Adjustable three-phase undervoltage relay or static circuitry to sense each phase of inverter output for initiating transfer to bypass power source. Initiation voltage adjustable over range of 80-percent to 90-percent of rated voltage.
    - 2) Voltage-sensing circuitry to prevent retransfer of load to the inverter unless voltage is within specified tolerance and frequency is phase locked within tolerance.
    - 3) Signals from the frequency and synchronization control to be used to inhibit retransfer from bypass to inverter if out-of-tolerance.
    - 4) Inverter control for restarting of a shutdown inverter.
    - 5) Manual ON/OFF control switch. ON position of switch to restart inverter for full-automatic operation.

- 6) Devices and circuitry to protect inverter from dc over/under voltage, overload, short-circuit, and overtemperature.
  - 7) Device and circuitry equipped with two supervisory contacts, one NC and one NO, for remote monitoring inverter-output status.
- E. Static Transfer Switch: An integral part of the UPS, silicon-controlled rectifier-type with the following requirements:
1. Automatic transfer of inverter load to bypass source: Transfer to be made under the following conditions provided transfer/retransfer selector switch is in automatic position:
    - a. Inverter-output failure occurs.
    - b. Overload is equal to or less than 25-percent for more than 15 minutes.
    - c. Overload greater than 25-percent occurs.
    - d. Inverter is shutdown with manual switch.
  2. Automatic retransfer of load to inverter: Retransfer to be made under following conditions provided transfer/retransfer selector switch is in automatic position:
    - a. The overload condition is removed.
    - b. Inverter-output voltage is within specified tolerance for magnitude and frequency and within six electrical degrees of the bypass-source voltage.
  3. Manual transfer and retransfer:
    - a. Transfer of inverter load to the bypass source initiated by a switch closure. Inverter to remain operating and ready to accept the load.
    - b. Retransfer initiated by automatic control when transfer/retransfer selector switch is in automatic position.
  4. Switch identified as a transfer/retransfer selector switch: Two-position selector switch with positions labeled as follows:
    - a. AUTOMATIC (TRANSFER AND RETRANSFER).
    - b. MANUAL TRANSFER (INHIBIT RETRANSFER).
  5. Electrical characteristics:
    - a. Rated voltage: 480/277-volt, three-phase, 60 Hertz with neutral bus for four-wire bypass-source service and UPS-output neutral connection.
    - b. Rated continuous current: 125% rated load continuously and 200% rated load for 30 seconds.
    - c. Withstand capability: Withstand short-circuit current available at bypass source. Vendor may provide current-limiting protection to provide required withstand. Current-limiting fuses to provide coordination with the bypass source and the branch-circuit protection in the main emergency panelboard.
    - d. Capacity to close into short-circuit or let-through of fuses without functional degrading other than fuse clearing.
  6. Indicating lights or status displays:
    - a. Bypass-source undervoltage, overvoltage, loss of a phase, or out-of-frequency tolerance.
    - b. Power transfer switch on bypass.
  7. Maintenance bypass capability:
    - a. A manually operated maintenance bypass switching arrangement to transfer the UPS output load to the bypass ac source without interruption of UPS output while electronically isolating or permitting the isolation of the static transfer switch and the inverter from the bypass source.
  8. Circuit and device with two supervisory contacts, one NO and one NC for monitoring status of power transfer switch feeding load from inverter output or from bypass source.

- F. Main Emergency Panelboard:
1. ANSI/NEMA PB1, UL 67 fused-switch panelboard.
  2. Enclosure:
    - a. ANSI/NEMA 250, Type 1, fabricated from galvanized steel, surface-mounted, unless otherwise shown.
    - b. Minimum of four-inch side gutter and six-inch top and bottom gutters.
    - c. Mounting channel drilled and tapped to accommodate any combination of fused switches.
    - d. Provide latch and handle in accordance with UL 50; screw fastenings will not be accepted in lieu of latch.
    - e. Provisions for enclosure grounding.
    - f. Finish: Metallic surfaces degreased, cleaned, primed with zinc primer and finished with light-gray enamel, ANSI Z55.1 Color 61; two mils minimum DFT.
  3. Busbar:
    - a. ASTM B187-00, 98-percent-conductivity copper with silver-plated or tin-plated contact surface, drilled and tapped to accommodate any combination of fused switch units.
    - b. Neutral and ground bus of the same rating as that of phase bus. Neutral bus mounted on insulated block.
    - c. Rated at minimum 150-percent of inverter rating and not less than power transfer switch bypass overcurrent protection.
  4. Type of service: 277/480 volts, three-phase, four-wire, 60 Hertz.
  5. Type of mains: Main lugs only, located at top or bottom as shown.
  6. Branch circuit: Equipped with fused switch unit, number of circuits as shown.
  7. Fused switch unit:
    - a. Individually enclosed, quick-make/quick-break switching mechanism with silver-alloy contacts, external operating handle with provision for padlocking in ON or OFF positions.
    - b. Mechanical defeatable door interlock to prevent opening door when the switch is in ON Position.
    - c. Pressure-type fuse clip, with Class J cartridge fuse conforming to UL 198C.
    - d. Number of poles: As shown.
    - e. Current rating: As shown. Maximum rating 30 amperes.
    - f. If single-pole fused switch unit is not available, use a two-pole or three-pole fused switch unit for each circuit shown with a single-pole fused switch unit. Two or more separate circuits are not to be fed from a two-pole or three-pole fused switch unit.
  8. Fuse time-current characteristic coordinated with upstream fuse time-current characteristic for providing selective overcurrent tripping.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION:**

- A. Install UPS where shown in accordance with the following requirements:
1. Storage battery: Anchor battery rack to floor, then mount and connect battery cells in accordance with manufacturer's recommendations, with the following additional requirements:
    - a. For connecting cells mounted on same rack, use lead-plated or tin-plated solid-copper conductor as recommended by battery manufacturer.

- b. For connecting cells mounted on different racks, use Class D stranded single-conductor insulated cable sized the same as the battery cable. Run cable in two-inch, galvanized-steel rigid conduit in accordance with Section 16130.
    - c. Use nylon-insulated bushing at each end of conduit where cable passes through conduit to protect cable insulation from damage.
    - d. Install conduit and cable to connect battery to UPS as shown.
    - e. Use two-tier battery racks as specified for battery type used. All batteries to be easily accessible from floor. Three-tier and three-step racks are prohibited.
  - 2. Anchor UPS enclosure to floor as shown and approved. Install input and output power and control wiring as shown and as approved in accordance with Section 16120. Ground enclosure in accordance with Section 16060.
  - 3. Main emergency panelboard: Install as shown and in accordance with Section 16440.
  - 4. Install pegboard at location approved by the Engineer. Mount accessories and associated nameplates on pegboard.
- B. Initial Energizing:
  - 1. Initial energizing of each UPS will be under the guidance of the manufacturer's engineering representative who will advise Contractor and Authority personnel on step-by-step procedures.
- C. Apply touch-up paint where necessary.
- D. Floor Mat for Battery Rack: Cover walking area with floor mat cut to fit entire room layout, six inches larger than the overall width and length of rack to protect floor from electrolyte.

### **3.02 FIELD QUALITY CONTROL:**

- A. Field Testing and Inspection:
  - 1. General:
    - a. Conduct field inspection and field testing at each ac switchboard room to ensure proper operation of devices and equipment provided.
    - b. Operation and protective-device setting: The Contractor is responsible for setting and calibration of protective devices for proper operation during field testing.
  - 2. Field inspection:
    - a. Prior to field testing, check equipment installation in accordance with manufacturer's recommendations and applicable IEEE and ANSI standards, including verification of the following:
      - 1) Connection of circuit in accordance with wiring diagram.
      - 2) Tightness of cable and busbar connections.
      - 3) Battery-intercell bus-link integrity.
  - 3. Field Testing:
    - a. Furnish equipment to perform tests.
    - b. Provide services of manufacturer's engineering representative and supporting field crew for a period not less than three man-days. Conduct tests in the presence of the Engineer. Perform approved tests including, but not limited to, those specified.

- c. Test grounding conductors and enclosures on equipment for continuity to room ground bus.
- d. Storage battery:
  - 1) Measure battery-charging voltage, electrolyte specific gravity and level.
  - 2) Compare measured value and correct to manufacturer's specified tolerances.
- e. Power transfer switch:
  - 1) Calibrate and set voltage-sensing device and transfer time-delay as specified and as approved.
  - 2) Perform automatic transfer by:
    - a) Simulating loss of inverter output.
    - b) Return to normal power.
- f. Uninterruptible power system:
  - 1) Perform load test at inverter rated output with UPS operating in normal mode. Provide equipment necessary to achieve rated capacity load.
  - 2) Under the following conditions, perform automatic-throwover operation and manual restoration of utility service in associated ac switchboard room and check for normal operation of UPS:
    - a) With UPS in normal mode and feeding connected load.
    - b) With battery fully charged, no ac power fed to rectifier/charger and alternate feeder to power transfer switch and UPS feeding connected load.
  - 3) In combined ac switchboard room: Check for normal operation of UPS when feeding rated load during simultaneous loss of both 13.8-kV or 34.5-kV, as applicable, feeders and subsequent manual restoration of both services.
  - 4) With no ac power available to UPS, stop and restart inverter five times.
  - 5) Acceptance testing:
    - a) Perform installation related measurement and acceptance testing in accordance with ANSI/IEEE 450 and ANSI/IEEE 484. In the event of a conflict between this procedure and the ANSI/IEEE documents, this procedure will take precedence.
    - b) Calibrate test equipment used during this procedure, calibration date not older than one year from the date of testing, calibrations traceable to NIST. Have calibration stickers visible on all applicable equipment. As a minimum, calibrate the following equipment with accuracy as stated:

<u>Equipment</u>	<u>Accuracy</u>
1) Multimeter	± 0.1%
2) Microhm meter	± 0.5%
3) Current measuring equipment	± 1 amp
4) Cell voltage monitor equipment	± 0.5%

c) Initial measurements:

- 1) Read and record individual cell voltages to two decimal places while the battery is on a normal float charge.
  - 2) Read and record the ac ripple voltage out of the rectifier utilizing an ungrounded oscilloscope. Read and record ac ripple current utilizing an ac clamp on meter.
  - 3) Read and record intercell connection resistance using a microhm meter . Remake and re-measure any connection that has a resistance measurement more than 10-percent or 5 microhms, whichever is greater, over the average for each type of connection.
  - 4) Read and record each cell's internal impedance or conductance. Note make and model of meter.
  - 5) Read and record the specific gravity of each cell.
  - 6) Read and record the temperature of each cell and the ambient temperature of the room.
- d) Rectifier test:
- 1) Apply ac load at inverter rated output with UPS operating in normal mode. Have battery connected and fully charged.
  - 2) Using infrared thermography, scan accessible UPS internal components. Also, scan UPS fuses, circuit breakers, associated circuit breakers, and UPS ac feed networks where accessible. Record abnormal heating and save these images for incorporation into the report.
  - 3) With full ac load still applied, attached dc load to UPS output. Slowly increase dc load until the point where the UPS rectifier is at current limit. This will occur when the voltage begins to sag to a pint where current will begin to flow from the battery. Reduce load slightly so that no current is being drawn from the battery. Record the total dc current out of the UPS rectifier at the current limit point. Leave the rectifier at this current limit point for 20 minutes. During the 20 minutes, utilize infrared thermography to scan components as outlined above. Record abnormal heating and save these images for incorporation into the report. Utilizing an ungrounded oscilloscope, read and record the ac ripple voltage out of the rectifier at the current limit point. Also, measure and record the ac ripple current using an ac clamp on meter.
  - 4) Remove the load from both the rectifier section and the UPS ac output.
- e) Full UPS test:
- 1) Attach a monitor to the battery to measure every individual cell voltage. Ensure that this monitor

can read and record every cell voltage not less than once per minute. Also use the monitor to measure and record overall battery voltage and total battery discharge current

- 2) Attach an automatic load bank to the battery. When initiated, have the load bank provide a constant 1.8 KW load to the battery until the end of the full UPS test. Every 30 minutes increase this load to 6.0 kW for five seconds and then return it to 1.8 KW. Program this to occur automatically until the end of the full UPS test.
  - 3) Apply ac load at inverter rated output with UPS operating in normal mode. Have battery connected and fully charged.
  - 4) Trip breaker feeding ac power to rectifier/charger. This will initiate the UPS to operate on battery. Simultaneously, initiate the dc load bank and the battery voltage/current monitor. While test is running, utilize infrared thermography to scan the battery, associated interconnects, and ups components where accessible. Record abnormal heating and save these images for incorporation into the report. Continue the test until the under-voltage device operates on the UPS. Record the time and the battery voltage when this occurs. Turn off the dc load bank and stop the battery voltage/current monitor.
  - 5) Attach a current monitor to the battery that can measure and record current into the battery every 10 minutes. Disconnect all other load equipment and monitors. Re-energize circuit breaker to UPS. Start monitoring current. Check monitor after 12 hours. Record ampere hours that have been returned to the battery.
  - 6) Remove all equipment from UPS area. Read and record float voltages.
- f) Pass-fail criteria:
- 1) The UPS battery is acceptable only if the battery operates for a minimum of three hours and the battery capacity is a least 90-percent. No individual cell capacity may be less than 80-percent. Base capacity on a temperature correction to 77F.
  - 2) Specific gravities are to be within the manufacturer's specified values.
  - 3) Intercell connection resistances are to be within 10-percent or five microhms, whichever is greater, over the average for each type of connection.
  - 4) Have the battery 90-percent charged within 12 hours after returning normal power to the UPS. This can be determined by the ampere hours

returned to the battery after the 12-hour period. At least 100-percent of the ampere hours removed from the battery must be returned to the battery in order to be 90-percent charged.

- g) Report: Include the following items:
  - 1) Abnormal heating detected by the infrared thermography.
  - 2) Time of battery operation under full load. Include final overall battery voltage at time of UPS under-voltage device operation.
  - 3) Battery capacity percentage corrected to 77F. Base this on the battery manufacturer's's constant power data.
  - 4) Graph of overall battery voltage versus time. Supply this data also in tabular form.
  - 5) Graph of individual cell voltages at the three-hour point, at the final reading, and at the 80-percent, 90-percent and 100-percent capacity points. Supply this data also in tabular form.
  - 6) Graphical display of cell float voltages before and after test, with the required minimum and maximum values annotated. Supply this data also in tabular form.
  - 7) Graphical display of temperature-corrected cell specific gravities with the required minimum and maximum values annotated. Supply this data also in tabular form.
  - 8) Graphical display of impedance/conductance values. Supply this data also in tabular form.
  - 9) Current limit value of rectifier section of UPS.
  - 10) Print-out of ac ripple voltage wave form during full-load and no-load conditions. Include ac ripple current values.
- 6) After battery is discharged to level of 105 volts, initiate equalizing mode. After 12 hours, measure ampere hours to determine that 90-percent of recharge condition remains; then recharge to 100-percent level.
- 7) Simulate operations of rectifier/charger, inverter and power transfer switch operations for verifying equipment-status indication at DTS cabinet.
- 8) Set UPS to normal mode with rectifier/charger on automatic control.
- g. Compliance:
  - 1) If testing indicates failure to comply with specified requirements, replace, correct or modify equipment so that it does comply.
  - 2) Conduct additional tests witnessed by the Engineer to prove compliance with specified requirements.

B. Field-Testing Personnel:

- 1. Provide services of manufacturer's engineering representative to perform specified field-testing program.

2. When more than one representative is involved, Contractor to ensure proper coordination.
  3. Provide engineering, technicians and journeymen personnel as necessary to set-up and implement testing.
- C. Authority Tests:
1. The Authority reserves the right to require the Contractor to conduct acceptance tests of voltage regulation and sound level on each UPS at each passenger station within one-year after installation.
  2. In order to perform sound-level tests, the Contractor may re-create test conditions of applicable standards to the extent possible without disturbing existing structure or installed equipment or materials.
- D. Submit certified test report

THIS SPACE NOT USED.

<b>TABLE 16260-1</b>			
<b>SCHEDULE OF SHOP DRAWINGS AND MANUFACTURER'S LITERATURE</b>			
Item	Requirements	Submit (a)	Within Days (b)
1.	Outline dimensions, including weights and foundation requirements for equipment furnished.	X	90 (c)
2.	Front views, floor plans, and mounting details for equipment furnished.	X	90 (c)
3.	One-line block diagrams.	X	120 (c)
4.	List of standard symbols and nomenclature.	X	120 (c)
5.	Elementary diagrams with description of each circuit.	X	120 (c)
6.	Interconnection wiring diagram.	X	120 (c)
7.	Wiring diagrams, showing internal wiring of equipment furnished.	X	150 (c)

<b>TABLE 16260-1 (CONT.)</b>			
<b>SCHEDULE OF SHOP DRAWINGS AND MANUFACTURER'S LITERATURE</b>			
Item	Requirements	Submit (a)	Within Days (b)
8.	Certified test reports.	-	30 (d)
9.	<p style="text-align: center;">Storage battery, including:</p> <p>a. Ampere-hour rating at three-hour discharge rate.</p> <p>b. Available short-circuit current.</p> <p>c. Weight of each cell.</p>	-	45 (c)
10.	<p style="text-align: center;">Rectifier/Charger, including:</p> <p>a. kW Output.</p> <p>b. Efficiency at rated load.</p> <p>c. Power factor at rated input voltage with rectifier/charger supplying rated load.</p>	-	45 (c)

<b>TABLE 16260-1 (CONT.)</b>			
<b>SCHEDULE OF SHOP DRAWINGS AND MANUFACTURER'S LITERATURE</b>			
Item	Requirements	Submit (a)	Within Days (b)
11.	<p style="text-align: center;">Static inverter, including:</p> <p>a. kVa rating at 0.8 lagging power factor and unity power factor.</p> <p>b. Efficiency at rated load.</p>	-	45 (c)
12.	<p style="text-align: center;">Power transfer switch, including:</p> <p>a. Current rating.</p> <p>b. Short-circuit withstand capability.</p>	-	45 (c)
13.	<p style="text-align: center;">Clearing time-current curves of circuit breakers and fuses used, including unlatch time of circuit breakers.</p>	-	120 (c)
14.	<p style="text-align: center;">Coordination chart, including time-current fault-clearing curves of protective devices including largest emergency-panelboard fuse.</p>	X	120 (c)

**TABLE 16260-1 (CONT.)**

**SCHEDULE OF SHOP DRAWINGS AND MANUFACTURER'S LITERATURE**

Item	Requirements	Submit (a)	Within Days (b)
15.	Equipment- arrangement drawing for each UPS including battery racks.	X	120 (c)

**NOTES AND LEGEND**

- (a) Initial submittal for approval. Unless otherwise shown, in accordance with General Requirements.
- (b) Approved final drawings or certified data.
- (c) After receipt of Notice to Proceed.
- (d) After completion of tests.
- X Submittal required.
- Submittal not required.

THIS SPACE NOT USED.

TABLE 16260-2			
SCHEDULE OF OPERATIONS AND MAINTENANCE REQUIREMENTS			
Item	Requirements	Submit (a)	Within Days (b)
1.	Shipping and handling data: Instructions and drawings for unloading, handling erection and installation.	-	120 (c)
2.	Bills of Material, with reference to components showing original manufacturer's part numbers.	-	30 (c)
3.	Operation and Maintenance Manuals, complete, including separate manuals for charger/rectifier, inverter, power transfer switch and battery with information on each type of equipment and device furnished, shop drawings from Table 16260-1, excluding manufacturing details and Items 1. and 2. above.	(d)	(d)
4.	Operation and Maintenance Training.	180 (e)	30 (e)

<b>TABLE 16260-2 (CONT.)</b>	
<b>SCHEDULE OF OPERATIONS AND MAINTENANCE REQUIREMENTS</b>	
<b>NOTES AND LEGEND</b>	
(a)	Initial submittal for approval.
(b)	Approved final document.
(c)	Before shipment.
(d)	See General Requirements.
(e)	Prior to commencement of training.
-	Submittal not required.

**END OF SECTION**

## SECTION 16261

### TRANSFORMER-RECTIFIER UNITS FOR TRACTION POWER

#### PART 1. GENERAL

##### 1.01 SUMMARY

- A. This section specifies furnishing, delivering and installing transformer-rectifier units and spare parts.
- B. Transformer-rectifier units consist of equipment from the high-voltage cable entrance on the transformer side to the dc bus connections on the rectifier end, including the low-voltage ac busduct connecting the transformer secondary to the rectifier input.
- C. Related sections include:
  - 1. Section 16051 - Traction Power Scope of Work For Traction Power
  - 2. Section 16052 - Basic Materials and Methods For Traction Power
  - 3. Section 16128 - Wire and Cable For Traction Power
  - 4. Section 16291 - Local Annunciator Panel For Traction Power
  - 5. Section 16321 - High Voltage AC Switchgear (13.8kV) For Traction Power
  - 6. Section 16322 - High Voltage AC Switchgear (34.5kV) For Traction Power
  - 7. Section 16341 - Metal-Enclosed DC Switchgear For Traction Power
  - 8. Section 16441 - Drainage and Negative Switchboard For Traction Power
  - 9. Section 16451 - Substation Busways For Traction Power
- D. Compensation for work related to the traction power equipment specified in this section will be made in the following manner:
  - 1. Equipment For Traction Power Substation: Lump Sum
- E. Compensation for work related to installation specified in this section will be made in the following manner:
  - 1. Included in the lump sum installation cost of each traction power substation.

##### 1.02 REFERENCE

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Codes and regulations of jurisdictional authorities
  - 2. NEC
  - 3. NEMA: CC1, BU1
  - 4. ANSI: C34.2, C57.12.00, C57.12.01, C57.12.90, C57.12.91, C57.113, C57.124, Z55.1, C39.1, C12
  - 5. EIA: RS-282
  - 6. ASTM: D3487

##### 1.03 SYSTEM DESCRIPTION

- A. Design Criteria:
  - 1. Transformer-rectifier units shall be designed for extra heavy duty traction service, capable of carrying two peak period loading cycles per day within a six hour interval of each other as shown in Figure 16261-1 at the end of this section.
  - 2. Connections: The transformer-rectifier units at each sub-station shall be connected per ANSI C34.2 Circuit No. 25, 26 or 31 as shown.,
  - 3. Transformer-rectifier units shall be capable of operating in parallel with two additional units without exceeding 10% maximum deviation from the proportionate share of its

- load when carrying any load between 50 and 150% of rated load.
4. Transformer-rectifier units shall be capable of withstanding 100% of the theoretical short circuit current, with the short circuit applied at the load terminals of the dc cathode circuit breaker, without damage to any component, including diodes and diode fuses, until cleared by the cathode circuit breaker.
  5. Transformer-rectifier unit efficiency shall be greater than the following:
    - a. 97% at 25% of full load rating
    - b. 97.5% at 50% of full load rating
    - c. 98% at 100% of full load rating
    - d. 97% at 150% of full load rating
    - e. 95% at 450% of full load rating.
  6. Transformer-rectifier unit voltage regulation: Inherent dc voltage regulation of six percent plus or minus 0.5% when load is reduced from 100 to one percent of rated load, and when rated tap primary voltage having a sinusoidal wave form is applied to any tap on the ac winding. No load voltage not exceeding 780 Volts dc. Voltage regulation linear between 100% and 450% load. Output voltage not below 535 Volts at 450% load.
  7. Transformer-rectifier unit displacement power factor: 0.945 or greater from 25% to 100% at rated ac voltage.
  8. Rectifier transformers:
    - a. Temperature limits:
      - 1) Oil-filled transformer: Average winding temperature rise 65°C at end of two hour overload cycle (see Figure 16261-1). Average winding temperature rise by resistance not to exceed 55°C after stabilized continuous operation at 100% rated ac voltage and dc load, insulation system class thermally upgraded 120°C
      - 2) Dry-type transformer: Average temperature rise by resistance 80°C at end of two hour Transformer-Rectifier Unit Test (see Figure 16261-1). Average winding temperature rise by resistance not to exceed 65°C after stabilized continuous operation at 100% rated ac voltage and dc load. Insulation system class 220°C.
    - b. Windings (for dry-type transformers): The windings shall be designed not to absorb moisture, and shall be suitable for both storage and operation in adverse environments, including prolonged storage in 100% humidity at ambient temperatures ranging from minus 50°C to plus 50°C, and shall be capable of being switched on immediately after such storage without predrying.
    - c. Impedance: selected to comply with specified voltage regulation requirements.
    - d. Audible sound levels:
      - 1) Oil-filled transformer: 62 dB, maximum, at rated voltage, frequency and no load, with excitation on the transformer, per ANSI C57.12.90.
      - 2) Dry-type transformer: 65 dB, maximum, at rated voltage, frequency and no load, with excitation on the transformer, per ANSI C57.12.91.
  9. Rectifiers:
    - a. Type and rating: Indoor, 700V DC rated output, convection cooled, diodes mounted on air-cooled heatsink, in a free standing enclosure.
      - 1) Continuous rating
        - a) DC voltage: 700 Volts at 400% load.
        - b) DC amperes: 4286A for 3000 kW and 2857A for 2000 kW
        - c) Kilowatts: 3000 kW or 2000 kW, as shown on contract drawings.
      - 2) Overload Ratings: After constant full-load temperatures are reached, operation at 150% of rated load Amperes for two hours

and a superimposed cycle of overloads consisting of five periods of one minute each at 300% of rated load Amperes followed by one period of 450% of rated load Amperes for fifteen seconds at the end of the period. Periods shall be evenly spaced throughout the two hour period as shown in Figure 16261-1.

- 3) An interphase transformer shall be provided between the direct outputs of the six pulse sections to absorb the instantaneous direct voltage differences of the transformer-rectifier is connected per C34.2 circuit no. 31.

- b. Audible sound levels: Octave band sound pressure level at three feet from the rectifier assembly at any location not exceeding the following: Sound Pressure Level, dB,

<u>Octave Band, Hertz</u>	<u>re: 0.0002 Microbar</u>
1) 20 - 75	83
2) 75 - 300	78
3) 300 - 600	75
4) 600 - 1200	71
5) 1200 - 2400	68
6) 2400 - 4800	58
7) 4800 - 9600	48

- c. Surge Protection Devices to limit the reverse voltage across the silicon diodes to a value within the peak-reverse-voltage rating on the diode irrespective of whether the voltage transient originates in either the alternating current or direct current power circuits. Protection also provided against lightning surges on the cathode and anode circuits equivalent to a 1.2 x 50 microsecond wave with a crest voltage of 3500 Volts.

- d. Interference Noise Suppression: The rectifier shall be designed to limit the noise emissions outside the natural inherent harmonic frequencies. The Contractor shall investigate and remediate any potential effect from rectifier generated harmonics and/or noise interfering with electronic communication systems used by the Authority. Harmonic suppression equipment shall be provided to limit noise and harmonic output from the output of the Transformer-Rectifier Unit if the rectifier generated harmonics and/or noise levels interfere with the Authority's operating electronic communication equipment. Frequencies most likely to be affected include:

1)	F1	-	2100 Hz, +/- 30 Hz
2)	F2	-	2320 Hz, +/- 30 Hz
3)	F3	-	2580 Hz, +/- 30 Hz
4)	F4	-	2820 Hz, +/- 30 Hz
5)	F5	-	3100 Hz, +/- 30 Hz
6)	F6	-	3370 Hz, +/- 30 Hz
7)	F7	-	3660 Hz, +/- 30 Hz
8)	F8	-	3900 Hz, +/- 30 Hz
9)	F9	-	4550 Hz, +/- 100 Hz
10)	F10	-	5525 Hz, +/- 100 Hz
11)	TWC	-	9800 Hz, +/- 250 Hz

- e. Current Balance Scheme: Designed to maintain balance between parallel connected diodes in each phase within plus and minus 10% of their proportionate share under all load conditions. Current balancing scheme holds individual diode currents within their capabilities under all load conditions with one fuse per leg open. Current balancing by use of selectively matched diodes shall not be allowed.

#### 1.04 SUBMITTALS

- A. Submit the following for approval in accordance with the Special Conditions and with the

additional requirements as specified for each:

1. Shop Drawings: In accordance with Section 16051 Table I.
2. Certification:
  - a. Certified test reports of design tests performed on each type and rating of Transformer and Rectifier, and of tests performed on each type and rating of Transformer-Rectifier Unit.
  - b. Certified test reports for Routine tests performed on Transformer, Rectifier and Transformer-Rectifier Units.
  - c. Certificates from manufacturers verifying that equipment conforms to specified requirements.
3. Operations and Maintenance Manuals: In accordance with Special Conditions.
4. Spare Parts Lists.

## 1.05 QUALITY ASSURANCE

- A. For Codes, Regulations, Reference Standards and Specifications, refer to Article 1.02 above.
- B. Factory Testing: All design criteria and qualities of the transformer-rectifier units shall be proven by actual test on transformers, rectifiers and transformer-rectifier units to be provided. Tests shall be of three types; Design Tests, made on a single transformer, rectifier of each type and rating to be provided under this Contract, Routine Tests, made on each transformer, rectifier and diode to be provided under this Contract, and Transformer-Rectifier Unit Tests, made on a transformer-rectifier unit of each type and rating. Design and Routine Tests shall be conducted according to guidelines given by applicable ANSI Standards. Transformer-Rectifier Unit Tests shall be done as specified. Factory testing may be accomplished at the manufacturers' facilities, or at an independent testing facility upon approval by the Engineer. Test plans and procedures shall be submitted for approval at least 20 working days in advance of scheduled test dates. Design and Routine Tests for transformers and rectifiers may be combined with Transformer-Rectifier Unit Tests where feasible and approved in advance. No test results will be accepted prior to receipt and approval of test plans and procedures. Field Inspection and Testing is defined in Section 16051 (Scope of Work). Test requirements are as follows:
  1. Transformer testing in accordance with ANSI C57.12.90, C57.12.91, C57.113 and C57.124 and as follows:
    - a. Transformer Design Tests, including temperature and two hour loading cycle test specified in Figure 16261-1 to verify the temperature limits specified. Transformers wired per ANSI 34.2 Circuit No. 25, ANSI 34.2 Circuit No. 26 and ANSI C34.2 circuit no. 31 are considered different types for purposes of design testing.
    - b. Routine tests including the following:
      - 1) Resistance measurement.
      - 2) Ratio test.
      - 3) Polarity and phase relation test.
      - 4) No-load loss test and excitation current test.
      - 5) Impedance voltage and load loss test.
      - 6) Applied potential test.
      - 7) Induced potential test.
      - 8) Reduced, chopped and full-wave impulse tests.
      - 9) Partial Discharge test.
        - a) Perform partial discharge test to certify the transformer has a minimum partial discharge-free voltage of 120% of rated voltage. Provide oscillograph recordings of measured test. Measure partial discharge inception and extinction voltage during induced voltage test in accordance with ANSI/IEEE C57.113 (oil type) and C57.124 (dry type) and the following requirements.

- b) Measure partial discharge inception voltage when the voltage is raised, in 10% increments, from 70% to 200% and lowered, in 10% decrements, from 200% to 70% of rated voltage during the induced voltage test to verify the following requirements:
    - c) Inception of partial discharge occurs above 120% of rated voltage when voltage is raised from 70% to 200%. At 120%, the partial discharge reading shall be discharge-free.
    - d) Extinction of partial discharge occurs above 120% of rated voltage when voltage is lowered from 200% to 70%.
- 2. Rectifier tests in accordance with ANSI C34.2, EIA RS-282 and as follows:
  - a. Rectifier design tests including:
    - 1) Reduced voltage load test, including overloads shown in Figure 16261-1 after temperature stabilization at rated load. Test shall be conducted with one string of diodes in series removed from service from each major branch of the rectifier circuit, without exceeding safe junction temperature on the active diodes.
    - 2) Current balance test to demonstrate proportional sharing between parallel diodes with plus or minus 10% at 161% overload.
    - 3) Loss measurement test in accordance with ANSI C34.2 Section 6.3.2 and 6.3.3.
    - 4) At loads of one, 25, 50, 100, 150, and 450% of rated load, determine efficiency, voltage regulation and power factor.
  - b. Rectifier routine testing including:
    - 1) Dielectric strength test.
    - 2) Rated voltage test.
- 3. Diode Tests in accordance with EIA RS-282:
  - a. Diode design tests Including:
    - 1) Surge current test.
    - 2) Life test.
    - 3) Thermal resistance test.
    - 4) Reverse recovery time test.
  - b. Diode routine tests including:
    - 1) Diode routine tests for characteristics of forward voltage drop and reverse current.
    - 2) Dielectric tests.
- 4. Transformer-Rectifier Unit Tests shall be conducted on each type and rating of transformer-rectifier unit furnished under this Contract.
  - a. After rectifier temperature stabilization at 100% load, the transformer-rectifier unit Peak Period Loading Cycle Test shall be performed as specified in figure 16261-1 followed by a 6 hour 100% load cycle. Testing shall be in accordance with ANSI C34.2, Section 5.3.4.3. Test results shall prove that the temperature rise for the transformer at the end of the overload cycle does not exceed 65°C for an oil filled type, 80°C for a dry type, followed by a 6 hour 100% load cycle with a temperature rise at the end of the 6 hour limit, not to exceed 55°C for an oil filled type and 65°C for a dry type transformer. Test shall also prove that rectifier diode junction temperature does not exceed the safe operating limit. The ac busduct (copper bus and enclosure) temperature rise does not exceed 65°C for copper bus and 40°C for enclosure.
  - b. Transformer-rectifier Unit efficiency, voltage regulation and power factor shall be determined at one, 25, 50, 100, 150, and 450% of rated load in accordance with ANSI C 34.2, prior to, during, or immediately following the Peak Period Loading Cycle. Test Circuit No. 2, as described in Section 6.3.2.2 of ANSI C 34.2, shall be used to make loss measurements at the

specified loads.

- C. Test Acceptance Criteria:
  - 1. Transformers:
    - a. Successfully pass all specified Design, Routine and Transformer-Rectifier Unit Tests with no physical damage to and meet all temperature limits, including the duty cycle.
    - b. Satisfy all design criteria as demonstrated by measured tests results.
  - 2. Rectifiers:
    - a. Successfully pass all specified Design, Routine and Transformer-Rectifier Unit Tests with no physical damage and meet all temperature limits.
    - b. Satisfy all design criteria as demonstrated by measured test results.
  - 3. Transformer-Rectifier Units:
    - a. Successfully pass all specified Design, Routine and Transformer-Rectifier Unit Tests with no physical damage and meet all temperature limits.
    - b. Satisfy all design criteria as demonstrated by measured test results.

## **1.06 DELIVERY, STORAGE, AND HANDLING**

Equipment shall be delivered after its completion and testing in accordance with the access dates. Arrangement for delivery shall be made in coordination with the Engineer.

- A. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.
- B. Design enclosures to permit lifting by jacks or slings and moving horizontally on rollers or skidding in any direction.
- C. Maximum dimensions of shipping sections to be coordinated with the dimensions of equipment access to ensure shipping dimensions will allow movement of the transformer and rectifier equipment through structure without damage to equipment or structure or undue difficulty.
- D. Temporary Bracing: Where necessary, brace transformer and rectifier for hoisting, lowering and skidding into position. Label temporary internal bracing: TEMPORARY-REMOVE BEFORE OPERATION.
- E. Protection Against Concealed Damage: Include within shipping container mechanical impact recorder of rating recommended by manufacturer for shipment by railroad and submit impact chart with manufacturer's instructions for disposition of damaged material.
- F. Store transformers and rectifiers in secure and dry storage facility.

## **PART 2 PRODUCTS**

### **2.01 MANUFACTURERS**

- A. Qualifications: Select manufacturers/installation contractors who are regularly engaged in production of similar transformers or rectifiers and have demonstrated successful record of providing equipment and installation of similar type and rating for extra heavy duty traction service, for at least five similar projects.
- B. Rectifier transformers shall be manufactured by one of the following manufacturers or equal:
  - 1. Asea Brown Boveri
  - 2. Niagara Transformer
  - 3. Ferranti-Packard

4. Virginia Transformer Corporation
5. Powell-ESCO

## 2.02 EQUIPMENT

- A. Requirements for transformer-rectifier units:
  1. Nameplates:
    - a. Three-ply, laminated phenolic plates, engraved through black face to white core and attached by means of stainless steel rivets or screws. Vertical gothic lettering using a round or square cutter. V-shaped groove is prohibited.
    - b. Provide nameplate on each transformer and rectifier showing manufacturer's name and brand designation, the referenced standard, type, class and rating as applicable in accordance with reference standard.
    - c. Provide additional functional nameplates for each component.
      - 1) Each transformer and rectifier labeled, front and back, with nameplate 2-1/2 inches by 6-1/2 inches, inscribed in letters 1/2 inch high: RECTIFIER-TRANSFORMER NO. 1 (2), (3) or RECTIFIER NO.1 (2), (3) as appropriate.
      - 2) In addition to other information normally displayed on equipment, provide one-inch nameplate showing in letters 1/2 inch high switch positions, meaning of indicator lamp and other pertinent information.
- B. Rectifier Transformers:
  1. Type and rating: Indoor dry-type or outdoor oil filled, self-cooled, designed for extra heavy duty traction service with kVA rating suitable for the specified rectifier.
  2. Windings:
    - a. High voltage: Copper only rated 13.8 kV, 110 kV BIL or 34.5 kV, 200 kV BIL.
    - b. Low voltage: Copper only, suitable voltage rating for supplying rectifier to produce 700 Volt dc rated output, 10 kV BIL for dry type indoor and 30kV BIL for outdoor oil filled.
    - c. Connections: As specified.
    - d. Electrostatic shield: Between primary and secondary windings to suppress electrical noise.
  3. Tap Changer:
    - a. Oil filled transformer: Manually operated no-load full capacity, on the high voltage winding. Four 2.5% taps above rated voltage providing rated kVA and four 2.5% taps below rated voltage providing rated kVA. Operating handle conveniently located on exterior of tank arranged for operation at no-load only through key interlocking with the transformer feeder breaker. Operating handle lockable in any position. Position indicator clearly visible from the ground.
    - b. Dry-type transformer: No-load full capacity, on the high voltage winding. Four 2.5% taps above rated voltage providing rated kVA and four 2.5% taps below rated voltage providing rated kVA. Taps changed by removable links on a tap board with taps and connections identified. Tap board accessible through a door key interlocked with transformer feeder breaker to prevent access to the tap board when transformer is energized. Tap board segregated from the winding so that winding cannot be touched when changing taps.
  4. Bushings: In accordance with ANSI and NEMA standards for indoor interchangeable bushings. Silver plated terminal pads.
    - a. High Voltage: Glazed porcelain jacket, mounted in a suitable air filled junction box on transformer sidewall, rated 13.8 kV, 110 kV BIL or 34.5 kV,

- 200 kV BIL.
- b. Low Voltage: Rated 1.2 kV, 10 kV BIL for dry type indoor and 30kV BIL for outdoor oil filled. Parallel bushings are allowable if they are solidly connected at the terminals.
5. High voltage Connections:
- a. Oil filled transformer: High voltage bushings connected to terminators with stress cones for single conductor shielded cables enclosed in a junction box with removable covers and designed for termination of one conduit with three single-conductor and one single conductor cables entering from above or below as shown on contract drawings.
  - b. Dry-Type Transformer: Clamp-type terminators with stress cones for single conductor shielded cables enclosed in a junction box with removable covers and designed for termination of one conduit with three single-conductor and one single conductor shielded cable from above as shown on contract drawings.
6. Low Voltage Connection: Bus connections for bolted connection to ac multi-phase bus designed to align, match, connect and be compatible with the flange and busbar connections of the ac bus duct specified. Bonding strap for bonding bus enclosure to transformer case.
7. Monitoring and Protective devices for dry type transformers. All contacts electrically separate. All devices shall be heavy duty industrial type.
- a. Winding temperature indicator, with maximum reading pointer to detect transformer winding over temperature, and with factory-set two-stage contact device. The first stage provided with a contact which opens on temperature increase to initiate annunciation. The second higher temperature stage shall be provided with two contacts; one opening on temperature increase to initiate annunciation and one closing on temperature increase to actuate the rectifier-transformer ac feeder breaker lock-out relay. Settings as recommended by the manufacturer (Devices 49T1 & 49T2).
8. Monitoring and Protective devices for oil filled transformers: All contacts electrically separate. All devices shall be heavy duty industrial type.
- a. Winding temperature indicator, with maximum reading pointer to detect transformer winding over temperature, and with factory-set two-stage contact device. The first stage provided with a contact which opens on temperature increase to initiate annunciation. The second higher temperature stage shall be provided with two contacts; one opening on temperature increase to initiate annunciation and one closing on temperature increase to actuate the rectifier-transformer ac feeder breaker lock-out relay. Settings as recommended by the manufacturer (Devices 49T1 & 49T2).
  - b. Low oil level indicator with factory set contact device. Contact opens on decrease of oil level to initiate annunciation (Device 63QL).
  - c. Dial-type top oil thermometer, with maximum reading pointer to detect transformer oil over temperature, and with factory-set two-stage contact device. The first stage provided with a contact which opens on temperature increase to initiate annunciation. The second higher temperature stage shall be provided with two contacts; one opening on temperature increase to initiate annunciation and one closing on temperature increase to actuate the rectifier-transformer ac feeder breaker lock-out relay. Settings as recommended by the manufacturer (Devices 26T1 & 26T2).
  - d. Pressure relief device, self resetting type, factory set contact device and hand reset contact. The pressure relief device shall be provided with three contacts, one opening on gas pressure increase in the transformer to initiate the alarm and two closing on the gas pressure increase to initiate the tripping of ac rectifier transformer ac feeder breaker and actuate the rectifier

- transformer ac feeder breaker lock-out relay. Settings as recommended by the manufacturer (Device 63MR).
- e. Sudden pressure relay, designed for alarm and tripping on occurrence of a fault in the transformer, causing an abnormal rise of pressure. The relay shall have a pressure-sensitive device which would detect a pressure differential and through a occurrence would energize the relay. The relay shall have three contacts. On energization of relay, one opened contact shall initiate the alarm and two closed contacts shall initiate the tripping of the rectifier transformer ac feeder breaker and actuate the rectifier-transformer ac feeder breaker lock-out relay (Device 63SP).
  - f. Pressure gauge.
  - g. Combination lower drain and filter valve, upper filter valve and sampling valve.
9. Ground Pads: Copper-faced steel grounding pads two-hole with NEMA standard CC1 mounting holes for connection of grounding cables, mounted on diagonally opposite corners of each transformer, near the bottom.
10. Design and Construction of Dry-Type Transformer:
- a. Design so that all parts are readily accessible for maintenance.
  - b. Enclosures: Ventilated metal enclosure, substantial enough to prevent physical damage to transformer coils. Provided with louvers in side panels only for ventilation. Enclosure top cover shall be without openings to prevent entrance of falling dirt and liquid. Designed to keep out moisture. Base constructed of I-beams or formed channel. Suitable for skidding in any direction on rails or rollers and with jacking facilities at each corner.
  - c. Insulation System Class: 220 degree C.
  - d. Core Assembly: Joints in winding or at terminals either brazed or clamped. Core-bolt insulation high temperature resistant. Stepped mitered lap core construction and entire assembly braced or bolted adequately to prevent displacement and distortion under all normal conditions of handling and operation under normal, overload and short circuit conditions. Locking provisions for units at all inside bolted members or connections. Serial number stamped on core in conspicuous place.
  - e. Windings: The windings shall be designed for harsh environment using an enhanced Vacuum Pressure Impregnated (VPI) process. Each coil shall be oven dried at atmospheric pressure through which hot air is continuously circulated to remove any moisture. After the coil is preheated and dried, the bottom coil ends shall be sealed with a cast-in-place epoxy end ring formulated to match the material characteristic of the coil. Each coil shall be vacuum pressure impregnated with a flexible silicon varnish under vacuum of 3 to 5 mm mercury minimum for at least three hours, then pressurized at four or more atmospheres of pressure for 3 hours to allow trapped air bubbles to be purged. Immediately following each VPI cycle, the coil shall be oven baked and cured following an established temperature vs time baking cycle in a hot air circulating oven. The vacuum pressure impregnation process and baking cycle shall be completed four times for each coil. Adequate drying time shall be allotted to allow curing of the insulating liquid. Upon completion of the four step VPI process, the second cast-in-place coil end ring shall be made to seal the top coil end. Each coil shall receive a final seal using a modified 220C epoxy cladding. The entire transformer assembly shall be dipped in a cladding mixture of high temperature varnish, resin and silica baked to impart the final seal against the environment. All resins shall be oven cured under controlled temperature and air circulation.
  - f. Wiring: All control, auxiliary power and alarm circuits completely wired in the factory. Wiring run in rigid metallic raceway, except that watertight fittings may be used on runs of two feet or less. All connections to external circuits

- brought to one junction box equipped with bolted gasketed cover and terminated on terminal blocks.
- g. Finish: Metallic surfaces degreased, primed and finished with light gray enamel, Color No. 61 ANSI Z55.1 in accordance with referenced standard.
11. Design and Construction of Oil Filled Transformer:
- a. Transformers shall be so designed that parts are easily accessible for maintenance.
  - b. Tank Construction for Oil Filled Transformers: Sealed tank, welded cover type, liquid tight with all fittings in place. Designed to withstand internal pressure under normal and fault conditions without leaks and suitable for full-vacuum filling and drying in the field; with tanking guides to center core and coil assembly, handholes sized for convenient access to required devices or connections with covers sealed by corrosion and insulating liquid resistant gaskets; with lifting eyes on tank and tank cover. Tank base constructed of I-beams or formed channel, suitable for skidding in any direction on rails or rollers and with jacking facilities at each corner.
  - c. Joints and Gaskets: All gasketed joints shall have machined surfaces on both sides, and shall be provided with gasket retainers and metal-to metal stops so as to assure even and effective pressure and avoid overstressing gasket. Gaskets shall maintain liquid and gas tightness of joints under all service and fault conditions.
  - d. Insulating Oil: ASTM D3487, free of PCB and PCB based compounds.
  - e. Core and Coil Assembly: Laminations shall be non-aging alloy. Joints in winding or at terminals to be either brazed or multi-indent clamped. Insulation material, varnish and compounds in contact with liquid shall neither affect the liquid nor be affected by it. Core bolt insulation shall be high temperature resistant. Entire assembly shall be braced or bolted adequately to prevent displacement and distortion under all normal conditions of handling and operation under short-circuit conditions. Locking provision shall be made for all inside bolted members or connections. Serial number shall be stamped on core or core clamp in conspicuous place.
  - f. Wiring: All control, auxiliary power and alarm circuits completely wired in the factory. Wiring run in rigid metallic raceway, except that watertight fittings may be used on runs of two feet or less. All connections to external circuits brought to one junction box equipped with bolted gasketed cover and terminated on terminal blocks.
  - g. Insulation System Class: Thermally upgraded 120°C.
  - h. Finish: Metallic surfaces degreased, primed and finished with light gray enamel, Color No. 61 ANSI Z55.1 in accordance with referenced standard.
- C. Silicon Rectifier: Operative assembly consisting of silicon diodes, protective fuses, cooling system and all necessary accessories.
- 1. Rectifiers shall be manufactured by one of the following, or equal:
    - a. Asea Brown Boveri/Impulse
    - b. English Electric
    - c. Siemens
    - d. Powell Power Electronics Company
    - e. SMC
  - 2. Silicon Diodes
    - a. Description: Hermetically sealed and mounted on adequate heat sinks, rated and tested in accordance with EIA Publication No. RS-282. Parallel strings of diodes electrically and geometrically similar and as symmetrical as practical to help balance the normal and surge electrical characteristics of each string.
    - b. Rating: Such that the rectifier is capable of carrying the specified overloads and short-circuit loads with one diode removed from service from each major branch of the rectifier circuit, and without exceeding safe junction

- temperature on the active diodes. Each diode capable of withstanding, at its maximum operating temperature during blocking periods, voltages having a value of 2.5 times its working peak reverse voltage without permanent change in diode characteristics.
- c. Current Balance Scheme: Designed to maintain current balance between parallel-connected diodes within plus and minus 10 percent of their proportional share in each phase under all load conditions. Current balancing scheme holds individual diode currents within their capabilities under all load conditions with one fuse per leg open. Current balancing by use of selectively matched diodes not allowed.
  - d. Voltage Equalizing Devices: For diodes connected in series proportion reverse voltage equally across each individual diode. Transformers, bleeder resistors, or capacitors are devices which may be used to achieve reverse voltage division.
  - e. Fuses: Current limiting, provided to protect each diode individually. Designed to disconnect the diode in case of failure and protect the other components of the rectifier. Sized so that they will not blow on any external dc fault or loading condition but will blow to clear any fault permitting reverse conduction.
3. Cooling System:
- a. Convection cooled, designed for 40C ambient air temperature. Heat transfer surfaces designed for easy cleaning and to minimize accumulations of dust and other contaminants. If heat pipes are used for convection cooling, the Contractor shall:
    - 1) Provide for each type and rating of heat sink assembly, 2 each, complete spare heat sink assemblies.
    - 2) Provide the Authority with complete detailed manufacturing shop drawings (mylar) and manufacturing specifications for each type and rating of heat sink assembly.
    - 3) Provide at a minimum, three manufacturing sources capable of providing the heat pipe/heat sink assembly. Include manufacturer's part numbers and certification by an officer of each company that the entire assembly can be provided as specified.
4. Protective Devices: Coordinated to prevent false tripping or misoperation. All relays devices and connections accessible without disassembling interior portions of the rectifier assembly. Drawout type, semi-flush mounted on the front of the rectifier enclosure where possible; otherwise mounted internally and provided with insulating dust covers. All devices shall be heavy duty industrial type.
- a. A rectifier over temperature device (1st stage) provided to detect an abnormal rise in diode heat sink temperature, furnished with a factory-set NC contact to initiate alarm at the annunciation panel upon excessive temperature increase. Temperature setting as recommended by the manufacturer (Device 26RT1).
  - b. A second rectifier over temperature device with a factory set stage to detect a diode heat sink temperature higher than the first stage setting, furnished with a NC contact to initiate alarm at the annunciation panel and a NO contact to initiate the tripping of the rectifier-transformer ac circuit breaker and the rectifier cathode breaker via lockout relay. Temperature setting as recommended by the manufacturer (Device 26RT2).
  - c. A diode failure device provided to detect the loss of one or more diode paths, furnished with a NC contact to initiate annunciation and a NO contact to initiate tripping. One diode failure shall initiate an alarm at the annunciator panel and two diode failures in one string shall initiate the tripping of the rectifier-transformer ac circuit breaker and the rectifier cathode breaker via lockout relay. In addition, each diode shall be supervised by a readily visible diode-failure indicating lamp or self-indicating

- fuse (Device 95).
- d. Enclosure Ground Detection System: Provided to monitor enclosure insulation and including the following relays:
    - 1) A high-resistance ground relay, connected between the rectifier metal enclosure and ground, to detect any accidental grounding of the rectifier metal enclosure, furnished with a NC contact to initiate alarm at the annunciation panel upon metal enclosure grounding or malfunction of the ground relaying network (Device 64X).
    - 2) A rectifier hot structure relay, connected between the rectifier metal enclosure and ground, to detect any part of the metal enclosure becoming energized in the event of a fault between the enclosure and any of the current carrying components, furnished with a NC contact to initiate alarm at the annunciation panel and three NO contacts to initiate tripping of the dc rectifier cathode air circuit breaker, the ac rectifier-transformer feeder circuit breaker and actuate the ac rectifier-transformer feeder breaker lock-out relay. Relaying network to be fail-safe, and supervised by the high-resistance ground relay (Device 64C).
  - e. Door interlocks: Provide interlock contacts in trip and close circuits to trip and prevent closing of both rectifier-transformer feeder breaker and cathode circuit breaker with any rectifier enclosure door open. (Device 33)
  - f. Control power: 125 Volt dc, ungrounded for all devices.
5. Meters: ANSI C39.1 and ANSI C12. Switchboard type with 250 degree or 270 degree scale and plus or minus 1% accuracy.
    - a. One, dc voltmeter with zero to 1000 Volt scale, complete with current limiting fuses.
  6. Enclosure:
    - a. Description: High resistance grounded, ventilated structure, mounted on a rigid self-supporting structural steel or formed metal framework with all principal members bonded together and containing louvered expanded metal or mesh opening for ventilation.
    - b. Materials: Chosen to preclude the possibility of corrosion or galvanic action interfering with the proper operation or appearance during the life of the equipment. Similar and completely compatible materials used for diode cases, studs and the heat sinks.
    - c. Openings: Openings and mounting holes for front-mounted indicating and control devices neatly cut out, drilled or punched without marring or distorting the exposed finished surfaces.
    - d. Accessibility: Convenient access provided for all normal maintenance and inspection. Each door equipped with a mechanical latch and door stop to hold the door in the open position.
    - e. Diode Visibility: Diodes and fuses located and internal lighting provided to allow visual inspection of all fuses and diodes without opening enclosure doors. Source of power for light fixture shall be from 125V dc control bus.
    - f. Finish: Metallic surfaces degreased, primed and finished with light gray enamel, Color No. 61, ANSI Z55.1 in accordance with referenced standard.
  7. Anode Negative Disconnect Switch:
    - a. Location: Located within a separate metal enclosed space in the rectifier unit.
    - b. Rating: Single pole, hook stick operated, 1000 Volts dc, ampere rating to match with the rating of the negative bus duct.
    - c. Key Interlocks: Provided to prevent switch operation unless the cathode circuit breaker is open and to prevent closing the cathode circuit breaker unless the disconnect switch is closed.
    - d. If a door access is provided, door interlock shall be provided to trip the associated cathode breaker when door is opened.

8. Buses and Bus Terminations: NEMA BU1
  - a. Design and construction: High quality, electrical conductivity grade copper suitably braced between each other and the enclosure with high-strength, non-tracking insulators and designed to safely withstand the available short circuit current without damage to the bus or enclosure.
  - b. Bus connections and terminations: Bus connections to be bolted with silver or tin plated surfaces or welded. Bus connections for terminations to be silver or tin plated. Anode disconnect switch connected to negative bus duct. Negative bus duct connected through an insulating throat section at the rectifier.
  - c. Rectifier negative terminal: Bus connected to the anode disconnect switch.
  - d. Rectifier ac input: Three phase, bus duct with insulated throat section with minimum insulation level of 1000 Volts provided between the rectifier enclosure and the ac bus duct enclosure, three feet long if horizontally mounted.
  - e. Rectifier dc Output: Positive bus, connected to the cathode bus duct through a metal enclosed throat with enclosure insulated from the cathode bus duct enclosure but bonded with a removable link of at least 1000 Amperes continuous capacity.
9. Interference Noise Suppression: Harmonic suppression equipment shall be provided to limit noise and harmonic output from the output of the transformer-rectifier unit if the rectifier generated harmonics and/or noise levels interfere with the Authority's electronic communication systems.

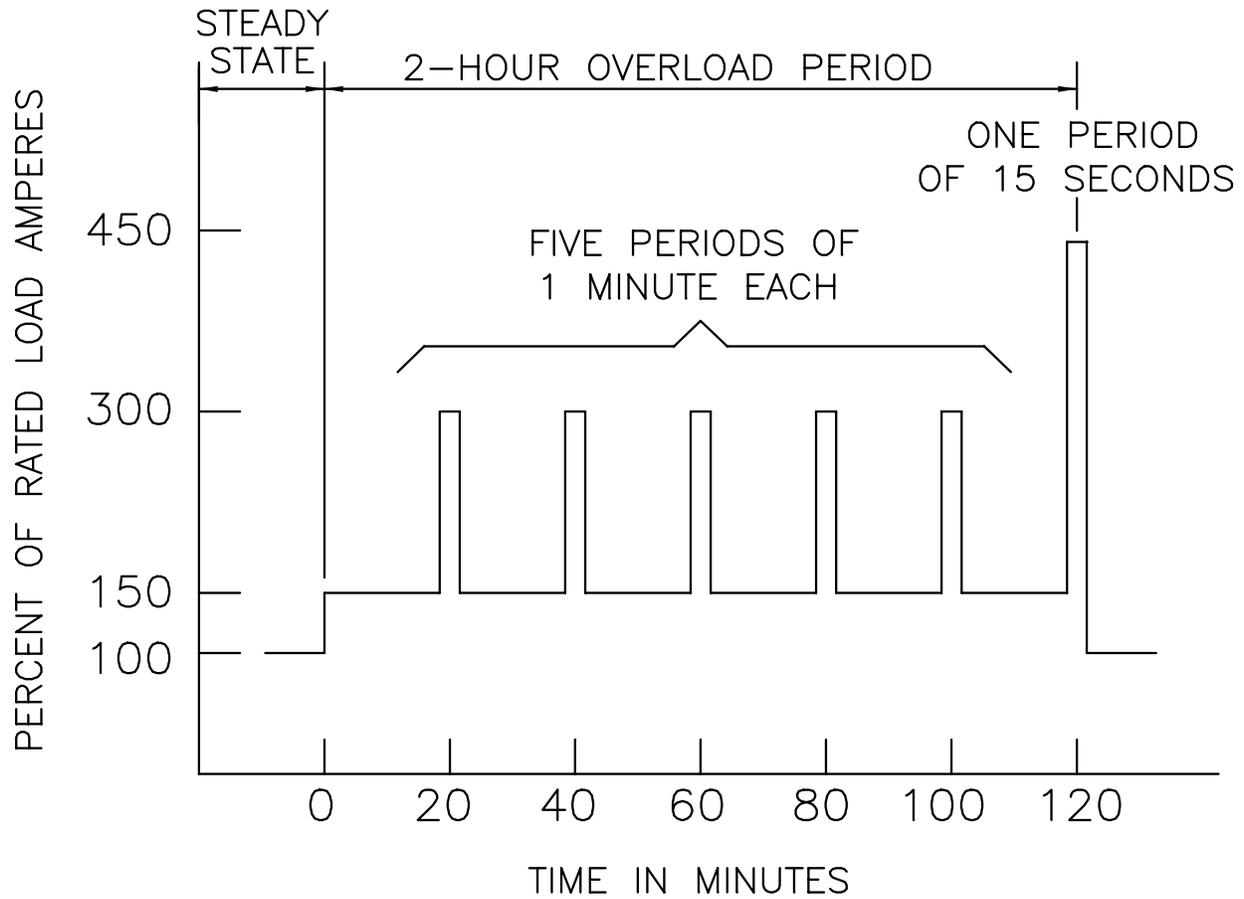
## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install insulated floor topping as shown and in accordance with Section 16052 (Basic Materials and Methods). Furnish and install floor anchors, in accordance with approved design documents.
- B. Install transformer-rectifier units and busways in accordance with approved shop drawings.
- C. Install conduit and wire connections as approved and in accordance with Section 16052 (Basic Materials and Methods).
- D. Use services of manufacturer's engineering representative for assistance in field assembly and installation in accordance with Section 16051 (Scope of Work).

### **3.02 FIELD QUALITY CONTROL**

- A. Field Testing and Inspection: As specified in Section 16051.
- B. Interference Noise Suppression: In accordance with ANSI C34.2, Section 7.1, the Contractor shall, at no additional cost to the Authority, investigate and remediate any interference problem with the Authority's communication electronic systems which result from transformer-rectifier generated noise and harmonics during transformer-rectifier unit operation.



TRANSFORMER-RECTIFIER PEAK  
PERIOD LOADING CYCLE

FIGURE 16261-1

\* \* \*

END OF SECTION

## SECTION 16270

### TRANSFORMERS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing transformers and automatic voltage regulators.
- B. Related Work Specified Elsewhere:
  - 1. Wire connection accessories: Section 16125
  - 2. Grounding and bonding: Section 16060.
  - 3. Unit substations: Section 16360.
- C. Design Criteria:
  - 1. Floor loading: Transformer base compatible with floor design-loading of 250 pounds per square foot.

##### 1.02 QUALITY ASSURANCE:

- A. Qualifications: Select a manufacturer who is regularly engaged in the repetitive production of transformers and automatic voltage regulators of the types and ratings described in these specifications using the latest technology and who has a proven record of successful manufacturing and testing of same or similar type equipment. The equipment manufacturer shall have and maintain ISO 9001 or ISO 9002 certification.
- B. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of jurisdictional authorities.
  - 2. NEC.
  - 3. NEMA: ST1, ST20, 107, 250.
  - 4. ANSI: C57.12.50, C57.12.51, Z55.1.
  - 5. ASTM: D3487.
  - 6. ANSI/IEEE: C57.12.00, C57.12.90, C57.12.91, C57.15, C57.94, C57.113, C57.124, C62.11.
  - 7. IEEE: C57.12.01.
  - 8. UL: 506, 1561, 1562.
- C. Factory Testing:
  - 1. General requirements for distribution transformers:
    - a. Perform design tests and short-circuit tests on one transformer of each type and rating furnished in this Contract.
    - b. Perform routine tests, impulse test and partial discharge test on each transformer furnished in this Contract.
  - 2. Dry-type transformers: Perform design and routine tests in accordance with IEEE C57.12.01 and ANSI/IEEE C57.12.91 and the following additional tests:
    - a. Perform impulse test without using surge arrestors to protect the transformer.
    - b. Perform partial discharge test to establish partial discharge inception and extinction voltage during induced voltage test in accordance with ANSI/IEEE C57.124 and the following requirements:
      - 1) Measure partial discharge in pico-coulombs at 10-percent increments when the voltage is raised from 70 percent to 200 percent and lowered from 200 percent to 70 percent of rated

- voltage during the induced voltage test to verify the following requirements:
- a) Inception of partial discharge occurs above 120 percent of rated voltage when voltage is raised from 70 percent to 200 percent. At 120 percent, the partial discharge reading shall be 10 pico-coulombs or less.
  - b) Extinction of partial discharge occurs above 120 percent of rated voltage when voltage is lowered from 200 percent to 70 percent and partial discharge level is below 10 pico-coulombs.
- c. Perform short-circuit tests in accordance with IEEE C57.12.01 and ANSI/IEEE C57.12.91.
3. Oil-filled transformers: Perform design and routine tests in accordance with ANSI/IEEE C57.12.00 and C57.12.90 and the following additional tests:
- a. Perform lightning impulse test without using surge arrestors to protect the transformer.
  - b. Perform partial discharge test using one of the following test methods:
    - 1) Perform partial discharge test to determine radio-influence voltage and associated partial discharge inception and extinction in accordance with NEMA 107 and the following requirements:
      - a) Measure radio-influence voltage in micro-volts at 25-percent increments when the voltage is raised from 100 percent to 200 percent and lowered from 200 percent to 100 percent of rated voltage during the induced voltage test to verify the following requirements:
        - (1) Radio-influence voltage not to exceed 250 micro-volts for transformers with 13.8 kV primary voltage and 650 micro-volts for transformers with 34.5 kV primary voltage.
        - (2) Inception (i.e. sudden increase in radio-influence voltage as the voltage is raised from 100 percent to 200 percent) occurs above 120 percent of the highest tap voltage.
        - (3) Extinction (i.e. sudden decrease in radio-influence voltage as the voltage is lowered from 200 percent to 100 percent) occurs above 120 percent of the highest tap voltage.
    - 2) Perform partial discharge test to determine terminal partial discharge level and partial discharge at five-minute intervals on each terminal during a 60-minute period of induced voltage test in accordance with ANSI/IEEE C57.113 and to verify the following requirements:
      - a) Terminal partial discharge level not-to-exceed 200 pico-coulombs.
      - b) Partial discharge measurements during a 60-minute period meet the requirements of ANSI/IEEE C57.113.
    - 3) Perform short-circuit tests in accordance with ANSI/IEEE C57.12.00 and C57.12.90.
4. Perform design and routine tests for general-purpose transformers in accordance with NEMA ST20.
5. Notify the Engineer not less than 14 days prior to factory testing to allow witnessing of tests.

### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings: In accordance with Section 16360.
  - 2. Certification:
    - a. Furnish certified test report of all design and short-circuit tests performed on one transformer of each type and rating furnished in this Contract or on identical transformers built by same manufacturer within the last five years.
    - b. Furnish certified test report of all routine, impulse and partial discharge tests performed on each transformer furnished in this Contract.
    - c. Furnish certificates from manufacturers verifying that products conform to specified requirements. Include certificates with submittal of shop drawings.
  - 3. Documentation:
    - a. Field-testing plan: In accordance with Section 16360.
  - 4. Operation and Maintenance Manuals: In accordance with Section 16360.

**1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.
- B. Temporary Bracing: Where necessary, brace transformer for hoisting, lowering and skidding into position. Label temporary internal bracing: TEMPORARY - REMOVE BEFORE OPERATION.
- C. Protection Against Concealed Damage: Include within shipping container mechanical impact recorder of rating recommended by manufacturer for shipment by railroad and submit impact-record chart with manufacturer's instructions for disposition of damaged materials.
- D. Store transformers in secure and dry storage facility.

**1.05 OPERATION AND MAINTENANCE TRAINING:**

- A. In accordance with the General Requirements and Section 16360.

**PART 2 - PRODUCTS**

**2.01 PRODUCTS AND MATERIALS:**

- A. General Requirements for Transformers:
  - 1. Interchangeability: Components of the same type, size, rating, functional characteristics, and make are to be interchangeable.
  - 2. Nameplate provided on each transformer in accordance with reference standard.
  - 3. Efficiency/losses:
    - a. Dry-type, three-phase transformers, 501 kVA and larger:
      - 1) Full-load efficiency: 98.0-percent minimum.
      - 2) Half-load efficiency: 98.5-percent minimum.
      - 3) No-load loss, maximum, of nameplate kVA rating:
        - a) 34.5 kV - 480Y/277-volt units: 0.7 percent.
        - b) 13.8 kV - 480Y/277-volt units: 0.5 percent.
    - b. Oil-filled, three-phase transformers, 501 kVA and larger:
      - 1) Full-load efficiency: 98-percent minimum.
      - 2) Half-load efficiency: 98.5-percent minimum.
      - 3) No-load loss: 0.4-percent maximum of nameplate kVA rating.
  - 4. Impedance voltages:

- a. Three-phase transformers, 501 kVA and larger:
    - 1) 34.5 kV - 480Y/277 volt units: 5.75 or 6.25 percent.
    - 2) 13.8 kV - 480Y/277 volt units: 5.75 percent.
  - b. Other transformers, lower ratings or lower voltages: In accordance with applicable standard or manufacturer's standard.
5. Magnetic circuit:
- a. Material: Best quality non-aging silicon steel sheet with high-magnetic permeability and low hysteresis and eddy-current losses. Sheet insulated on both sides with inorganic material to minimize eddy current.
  - b. Laminations cut in direction of grain, free of burrs and uniformly stacked in same direction without gap. Lap and butt joints closely fitted and rigidly clamped to minimize core loss and noise level.
  - c. Capable of up to 10-percent overvoltage excitation while maintaining magnetic-flux density below saturation level.
6. Audible sound level: Distribution transformers designed to limit average sound level to within the following maximum values when measured at the factory in accordance with ANSI/IEEE C57.12.91 for dry-type transformers and in accordance with ANSI/IEEE C57.12.90 for oil-filled transformers:
- a. Dry-type, three-phase transformers:

Transformer Rating in kVA	Sound Level in dB for Ventilated, Self-Cooled Rating	Sound Level in dB for Ventilated, Forced-Air-Cooled Rating
150	55	-
225, 300	58	-
500	60	67
750, 1,000	64	67
1,500	65	68
2,000	66	69
3,500	68	71
3,750	70	73

- b. Oil-filled, three-phase transformers:

Transformer Rating in kVA	Sound Level in dB for Ventilated, Self-Cooled Rating	Sound Level in dB for Ventilated, Forced-Air-Cooled Rating
150, 225, 300	55	-
500	56	61
750	57	61
1,000	58	61

- c. General-purpose transformers designed to limit average sound level to within maximum values in NEMA ST20.

7. Winding:
  - a. Dry-type, 3-phase transformer , 501KVA and larger.
    - 1) Copper conductors free from burrs, kinks or slivers. Each winding braced for high-mechanical strength and spaced to provide adequate circulation for coolant.
  - b. Dry-type, 3-phase and single-phase transformer 500KVA and smaller.
    - 1) Copper or aluminum conductors free from burrs, kinks or slivers. Each winding braced for high-mechanical strength and spaced to provide adequate circulation for coolant.
    - 2) Aluminum-to-aluminum conductor joints welded to withstand mechanical and electrical short-circuit stresses.
    - 3) Copper-to-aluminum conductor joints outside winding made using one of the following:
      - a) AMP Copalum crimp connector consisting of tin-plated copper barrel with one perforated tin-plated brass cylinder inserted inside barrel or equal. Hydraulic crimping tool used for electrical and mechanical effectiveness of joint.
      - b) Du Pont Detaclad explosively bonded aluminum and copper plate bus connection at transition consisting of aluminum face of Detaclad piece welded to aluminum leads from winding and copper face of Detaclad piece silver-soldered to copper bus.
8. Buses: Transformers equipped with adequately supported copper or aluminum buses, with the following additional requirements:
  - a. Busbar silver-plated or tin-plated at bolted connection point.
  - b. Joints welded or bolted for mechanical and electrical short-circuit stresses.
  - c. For bolted connections on aluminum busbar, mark recommended torque permanently and legibly at points of connection. Joints treated to prevent corrosion.
  - d. For bolted connection of aluminum-to-aluminum or aluminum-to-copper buses, provide Belleville washers or helical spring locknuts to maintain positive pressure on joint.
9. Ground pad: Enclosure equipped with grounding pad, drilled and tapped for connection to station grounding system.
10. Finish: Metallic surfaces degreased, cleaned with iron-phosphate solution, rinsed with chromic acid solution, dried and finished with light-gray coating, ANSI Z55.1, Color 61; two mils minimum DFT as follows:
  - a. Indoor location: Electrostatically deposited polymer polyester powder or epoxy powder, cured by baking and UL recognized, or spray enamel.
  - b. Outdoor location: Epoxy enamel.
11. Nameplate: Provided on each transformer showing manufacturer's name and brand designation, reference standard, type, class, rating and other required information as applicable in accordance with reference standard.
12. Space heaters:
  - a. Each distribution transformer for indoor use provided with 120-volt, single-phase, 60 Hertz heating element to facilitate drying and prevent condensation under no load or light load conditions.
  - b. Heaters enclosed in grille guard with no sharp edges and located so that they are accessible for replacement. Heaters controlled by thermostat adjustable from 40F to 80F. Panel ammeter, approximately 2-1/2 inches square, marked to indicate heater load. Thermostat set in accordance with manufacturer's recommendations.
  - c. Power and control circuits to heaters and thermostat connected and protected up to devices and to incoming junction box with galvanized-steel rigid conduit or liquid-tight flexible conduit. Heater power junction box sized four inches square by two inches minimum depth and located at top of

transformer for top entry of minimum 3/4-inch conduit. Remote connection leads to power source labeled: 120-volt and NEUTRAL.

B. Distribution Transformers:

1. Transformers for indoor use:
  - a. IEEE C57.12.01, ANSI C57.12.50, C57.12.51, ANSI/IEEE C57.12.91, UL 1562, floor-mounted, dry-type, ventilated self-cooled/forced-air-cooled, Class AA/FA, or ventilated self-cooled, Class AA, as specified, double-wound, three-phase, 60 Hertz with secondary neutral brought out, and using the following type of winding construction for both primary and secondary windings of a transformer:
    - 1) Solid cast-epoxy windings.
  - b. kVA rating:
    - 1) Transformers, 501 kVA and larger: Ventiladed self-cooled kVA rating as shown, with capacity in current-carrying parts to permit 33-1/3 percent increase in kVA rating (Class AA/FA) by operation of integral forced-air cooling fans.
    - 2) Transformers, 300 kVA and smaller: Ventiladed self-cooled, Class AA, kVA rating as shown.
  - c. Voltage rating: 34.5 kV delta to 480Y/277 volts or 13.8 kV delta to 480Y/277 volts, as shown.
  - d. Enclosure:
    - 1) NEMA 250, Type 2 dripproof enclosure with removable front and rear panels and ventilation louvers to prevent entrance of falling dirt and liquids and accidental access to live parts.
    - 2) Provision for jacking, lifting, skidding, and towing in any direction.
    - 3) Provision for complete isolation of core and coils from the enclosure using rubber vibration isolation pads or other suitable means.
    - 4) Core visibly grounded to ground pad with flexible grounding conductor sized in accordance with applicable ANSI and UL Standards.
    - 5) Exterior surfaces of core and structural members of core and coil assembly protected from corrosion after assembly with a coating having a temperature rating exceeding the temperature rating of the associated transformer insulation system.
  - e. Rated insulation-level withstand:
    - 1) 34.5 kV - 480Y/277 volt units:
      - a) High-voltage winding, lightning basic-impulse voltage (BIL) without the use of surge arrestors: 150 kV
      - b) High-voltage winding, low-frequency withstand: 50 kV.
      - c) Low-voltage winding, lightning basic-impulse voltage (BIL):
        - (1) Transformers with solid cast-epoxy windings: 30 kV.
      - d) Low-voltage winding, low-frequency withstand: 4kV.
    - 2) 13.8 kV - 480Y/277 volt units:
      - a) High-voltage winding, lightning basic-impulse voltage (BIL) without the use of surge arrestors: 95 kV.
      - b) High-voltage winding, low-frequency withstand: 34 kV.
      - c) Low-voltage winding, lightning basic-impulse voltage (BIL):
        - (1) Transformers with solid cast-epoxy windings: 30 kV.
      - d) Low-voltage winding, low-frequency withstand: 4 kV.
  - f. Transformer terminals:
    - 1) High-voltage side: Provide tin-plated terminal pads in air-filled transition compartment suitable to receive and terminate cable or bus connections from high-voltage switchgear, as applicable.

- Bushings or terminations through sidewall of transformer enclosure to have minimum BIL equal to that of transformer.
- 2) Low-voltage side: Provide tin-plated terminal pads in air-filled transition compartment opposite high-voltage side, suitable for bus connection to low-voltage switchgear. Terminations and transformer secondary bus or terminal supports to have short-circuit current-withstand equal to that of low-voltage switchgear; minimum BIL equal to that of transformer.
- g. Insulation system:
- 1) 185°C insulation system for dry-type transformers having solid cast-epoxy windings with maximum allowable continuous full-load temperature rise above average ambient temperature of 30C and maximum ambient temperature of 40°C:
    - a) By winding resistance: 80C.
    - b) By hottest spot in winding: 110C.
  - 2) 185C insulation system for dry-type transformers having solid cast-epoxy windings with maximum allowable continuous full-load temperature rise above average ambient temperature of 30C and maximum ambient temperature of 40C:
    - a) By winding resistance: 80C.
    - b) By hottest spot in winding: 110C.
- h. Taps:
- 1) Capable of delivering rated output at each setting.
  - 2) 34.5 kV - 480Y/277 volt units: Two 2-1/2 percent taps above and two 2-1/2 percent taps below rated voltage on primary side.
  - 3) 13.8 kV - 480Y/277 volt units: Two 2-1/2 percent taps above and four 2-1/2 percent taps below rated voltage on primary side.
  - 4) Tap changing on face of coil using removable links accessible from front or back of transformer.
- i. Thermometer/auxiliary relay:
- 1) Digital-type thermometer with scale range as required and two sets of contacts.
  - 2) One set of thermometer contacts designed to operate two auxiliary relays powered by associated transformer:
    - a) First relay with minimum of one NC and one NO contact for remote supervisory indication.
    - b) Second relay for operation of forced-air cooling fans through an automatic-manual selector switch on transformers rated 501 kVA and larger.
  - 3) Second set of thermometer contacts to trip essential main feeder at impermissible transformer over temperature.
  - 4) Contacts set in accordance with manufacturer's recommendations.
  - 5) Auxiliary relay may be located in associated low-voltage switchgear.
  - 6) Relay contacts for remote indication to be wired to accessible terminal block, with the following additional requirements:
    - a) Rated 250 milliamperes at 250 volts dc or three amperes at 24 volts dc.
    - b) Dry-sealed, with resistance of 0.10 ohms maximum.
    - c) Contact bounce: Five milliseconds maximum.
- j. Solid cast-epoxy winding construction:
- 1) Each winding for each phase separately cast as a rigid tubular coil and installed coaxially around the core.
  - 2) Each winding reinforced with glass cloth.
  - 3) Epoxy characteristics:
    - a) High electrical, mechanical and thermal strength.

- b) Non-flammable and self-extinguishing.
        - c) Coefficient of expansion compatible with that of copper windings.
        - d) Suitable for operation in ambient temperature range from minus 40C to plus 40C without cracking or degradation.
        - e) Nonhygroscopic and suitable for operation at 40C ambient temperature and 100-percent humidity.
      - 4) Epoxy cast in metal mold under vacuum to ensure homogeneous casting free from voids.
      - 5) Windings fabricated in a facility with successful experience in the manufacture of solid cast-epoxy transformer windings.
    - k. Forced-air cooling fans and control panel:
      - 1) Forced-air cooling fans to permit 33-1/3 percent increase in transformer ventilated self-cooled kVA rating.
      - 2) Power supply for fans and control panel provided from associated transformer. Fans, control panel and associated circuits equipped with protective devices.
      - 3) Control panel flush-mounted with transformer enclosure and equipped with the following:
        - a) Automatic-manual selector switch for controlling forced-air cooling fans. Fans activated by thermometer in automatic position.
        - b) Indicating lights:
          - (1) Green light for control power available.
          - (2) Amber light for fans operating.
        - c) Automatic exercising of fans once a month.
2. Transformers for outdoor use:
  - a. ANSI/IEEE C57.12.00, C57.12.90, floor-mounted, oil-filled, self-cooled/forced-air cooled, Class OA/FA or self-cooled, Class OA, as specified, double-wound, three-phase, 60 Hertz with secondary neutral brought out through insulating bushing.
  - b. kVA rating:
    - 1) Transformers, 501 kVA and larger: Self-cooled kVA rating as shown, with capacity in current-carrying parts to permit 15-percent increase in kVA rating (Class OA/FA) by operation of integral forced-air cooling fans.
    - 2) Transformers, 300 kVA and smaller: Self-cooled, Class OA, kVA rating as shown.
  - c. Voltage rating: 34.5 kV delta to 480Y/277 volts or 13.8 kV delta to 480Y/277 volts as shown.
  - d. Enclosure:
    - 1) Sealed-tank construction with lifting brackets, cooling radiator, braced and anchored to withstand jacking, skidding and towing.
    - 2) Equipped with two one-inch pipe fittings, one at top and one at bottom of tank, for filling and filter connection; one one-inch drain valve; and one 3/8-inch sampling valve.
  - e. Insulating oil: ASTM D3487. Mineral insulating oil free from polychlorinated biphenyl (PCB) contamination.
  - f. Rated insulation level:
    - 1) For 13.8 kV to 480Y/277-volt transformers: Class 15 kV, capable of withstanding:
      - a) Low-frequency voltage: 70 kV.
      - b) Full-wave basic-impulse voltage: 200 kV.
    - 2) For 34.5 kV to 480Y/277-volt transformers: Class 34.5 kV, capable of withstanding:
      - a) Low-frequency voltage: 70 kV.

- b) Full-wave basic-impulse voltage: 200 kV.
- g. Bushings:
  - 1) 34.5 kV - 480Y/277-volt transformers:
    - a) Primary bushings with glazed-porcelain surface, located on sidewall of transformer, with 34.5 kV insulation class with minimum 200 kV BIL in an air-filled junction box.
    - b) Secondary-line bushings with glazed-porcelain surface, located on sidewall of transformer opposite primary bushings, with 1.2 kV insulation class with minimum 10 kV BIL in an air-filled junction box.
  - 2) 13.8 kV - 480Y/277-volt transformers:
    - a) Primary bushings with glazed-porcelain surface, located on sidewall of transformer, with 15 kV insulation class with minimum 110 kV BIL in an air-filled junction box.
    - b) Secondary-line bushings with glazed-porcelain surface, located on sidewall of transformer opposite primary bushings, with 1.2 kV insulation class with minimum 10 kV BIL in an air-filled junction box.
  - 3) Secondary neutral bushings:
    - a) Low-voltage neutral bushings to be provided for each transformer.
    - b) Low-voltage neutral bushings same as low-voltage line bushings, except neutral bushings may have reduced low-frequency insulation level in accordance with ANSI/IEEE C57.12.00.
  - 4) Provide silver-plated terminal pads suitable to receive cable terminals on high-voltage side and to receive cable terminals or bus connectors on low-voltage side, as necessary.
- h. Maximum allowable temperature rise under continuous full-load above ambient temperature of 30C average, 40C maximum.
  - 1) By winding resistance: 55C.
  - 2) By hottest spot in winding: 65C
- i. Taps:
  - 1) Capable of delivering rated output in each position.
  - 2) For 13.8 kV to 480Y/277-volt transformers: Two 2-1/2 percent taps above and four 2-1/2 percent taps below rated voltage on primary side.
  - 3) For 34.5 kV to 480Y/277-volt transformers: Two 2-1/2 percent taps above and two 2-1/2 percent taps below rated voltage on primary side.
- j. Tap changer:
  - 1) Externally mounted and manually operated no-load tap changer with locking provision for each position.
  - 2) Tap-change operating handle arranged for operation at no-load only through key interlocking with associated primary breaker in open position.
- k. Thermometer/auxiliary relay: As specified for transformers for indoor use.
- l. Liquid-level indicator: Float-operated magnetic-type continuously indicating liquid level, installed for easy removal and replacement without unsealing transformer enclosure.
- m. Pressure-relief device: Mechanically operated self-resetting and self-reclosing type with manually resettable visual indicator and set of NO contacts to initiate tripping of associated primary breaker when pressure-relief device is activated.
- n. Pressure vacuum-gauge range: Minus 10 to plus 10 psig.
- o. Forced-air cooling fans and control panel:

- 1) Forced-air cooling fans to permit 15-percent increase in transformer self-cooled kVA rating.
  - 2) Power supply for fans and control panel provided from associated transformer. Fans, control panel and associated circuits equipped with protective devices.
  - 3) Control panel with NEMA 250, Type 3R enclosure and equipped with the following:
    - a) Automatic-manual selector switch for controlling forced-air cooling fans. Fans activated by thermometer in automatic position.
    - b) Indicating lights:
      - (1) Green light for control power available.
      - (2) Amber light for fans operating.
      - (3) Automatic exercising of fans once a month.
- p. Surge arrester: ANSI/IEEE C62.11, intermediate class with metal-oxide varistor construction, one per phase, mounted on high-voltage terminals in air-filled junction box with the following requirements:
- 1) For 13.8 kV - 480Y/277 volt unit: Hubbell/The Ohio Brass Company Type PVR, Catalog Number 218613, or equal, with ratings as follows:
    - a) Duty-cycle voltage, kV, rms: 15.
    - b) Maximum continuous operating voltage, kV, rms: 12.7.
    - c) Insulation-withstand impulse test voltage, kV: 110.
  - 2) For 34.5 kV - 480Y/277 volt unit: Hubbell/The Ohio Brass Company Type PVR, Catalog Number 218629; General Electric Company Tranquell XE, Catalog Number 9L12PGB036; or equal; with ratings as follows:
    - a) Duty-cycle voltage, kV, rms: 36.
    - b) Maximum continuous operating voltage, kV, rms: 29.
    - c) Insulation-withstand impulse test voltage, kV: 200.

C. General-Purpose and Specialty Transformer:

1. NEMA ST20 and ST1, UL 506 and 1561, indoor, dry, double-wound with insulated copper conductor, suitable for operation on 60 Hertz.
2. Rating:
  - a. kVA rating: As shown.
  - b. Voltage rating:
    - 1) Three-phase transformers: 480 volts primary to 208Y/120 volts secondary with secondary neutral brought out.
    - 2) Single-phase transformers: 480 or 277 volts primary to 120 volts secondary.
3. Enclosures:
  - a. 9 kVA and below: Non-ventilated, NEMA 250, Type 3R weatherproof enclosure with encapsulated core and coils.
  - b. Above 9 kVA: Ventilated, NEMA 250, Type 2 drip-proof enclosure with removable front panel and louvers to prevent entrance of falling dirt and accidental access to live parts, and with lifting brackets or holes.
  - c. 45 kVA and below: Wall-mounted unless otherwise shown.
  - d. Above 45 kVA: Floor-mounted or platform-mounted as shown.
4. Insulation system as specified below, capable of withstanding full-wave impulse of 10 kV.

kVA Rating	Insulation System
1 - 2	150C
3 - 30	185C
Above 30	220C

5. Maximum allowable temperature rise under continuous full-load above an average ambient temperature of 30C and maximum of 40C.

kVA Rating	1 - 2	3 - 30	Above 30
By winding resistance	150C	115C	150C
By hottest spot in winding	185C	145C	180C

6. Taps:
- Tap-changing links providing taps as follows, capable of delivering rated output in each position.
  - Single-phase transformers: Provide taps on primary side in accordance with the following:

kVA Rating	Taps		
	Quantity	Size:	Percent-age of rated voltage
3 - 15	2	5	below
25 - 100	4	2-1/2	below
	2	2-1/2	above

- Three-phase transformers: Provide taps on primary side in accordance with the following:

kVA Rating	Taps		
	Quantity	Size:	Percent-age of rated voltage
30 - 300	4	2-1/2	below
	2	2-1/2	above
9 - 15	2	5	below
6 and below	None	required	

- D. Automatic Voltage Regulator:
- ANSI/IEEE C57.15, indoor, self-air-cooled, induction-type.
  - Compensating automatically for voltage drop on long feeder runs of nominal 480-volt, three-phase, three-wire or nominal 480/277-volt, three-phase, four-wire, 60 Hertz system as shown.
  - Range of regulation: As necessary to maintain output voltage of regulator at receiving end of feeder not less than 466 volts or 480 volts as specified, minimum

range of plus 10 percent and minus 10 percent range of regulation. Regulation adjustable over full range in increments of one percent or less.

4. Circuit kVA rating: As shown.
5. Equipped with automatic solid-state control for maintaining output voltage within plus-or-minus one percent of pre-selected voltage level over temperature range of minus 30C to plus 40C.
6. Speed of response: Voltage correction to start within four cycles and complete within three seconds for two-percent change and within 10 seconds for adjustment to required voltage.
7. Capable of withstanding a minimum of 15 times rated full-load current under short-circuit condition.
8. Operating mechanism permanently lubricated.
9. Full-load efficiency: 98-percent minimum.
10. 150C insulation system; maximum allowable temperature rise under continuous full-load above an average ambient temperature of 30C and maximum ambient temperature of 40C: 80C.
11. Enclosure: Fabricated from sheet steel, wall-mounted or floor-mounted as appropriate, as follows:
  - a. Electric rooms, traction-power substations and tie-breaker stations: NEMA 250, Type 1.
  - b. Fan shafts and pumping stations: NEMA 250, Type 3R.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION:**

- A. Install each transformer and automatic voltage regulator in position shown and in accordance with manufacturer's recommendations and NEC requirements.
- B. Make power-conductor and control-wire connections in accordance with manufacturer's drawings, Section 16125 and as shown.
- C. Ground each transformer and automatic voltage regulator as shown and in accordance with Section 16060.
- D. Connect space heater circuit to prevent condensation during installation.

#### **3.02 FIELD QUALITY CONTROL:**

- A. Prior to testing, check transformer installation in accordance with ANSI/IEEE C57.94.
- B. Submit field-testing plan including, but not limited to, the following tests. Furnish equipment and perform the following tests in the presence of Engineer, in accordance with approved procedure:
  1. Distribution transformers: In accordance with Section 16360.
  2. General-purpose and specialty transformers:
    - a. Perform insulation-resistance tests winding-to-winding and winding-to-ground. Record and correct resistance value to temperature.
    - b. Perform ac high-voltage tests between high-voltage winding and low-voltage winding, between high-voltage winding and ground and between low-voltage winding and ground. Perform tests at 65 percent of factory test voltage for one-minute duration.
    - c. Test voltage ratio of each tap. Results not to deviate more than 0.5 percent from calculated ratio. Set taps as directed.
    - d. Check polarity by means of vector check.

3. Automatic voltage regulator:
  - a. Test circuit for connection in accordance with wiring diagram.
  - b. Test insulation of nongrounded conductors to ensure 10-megohms minimum resistance to ground.
  - c. Test regulator enclosure for continuity to grounding bus.
  - d. Set output voltage and check actual output voltage and speed of voltage correction as follows:
    - 1) For regulator supplying ventilation fans in fan shaft, set output voltage to 466 volts minimum and check actual output voltage and speed of voltage correction for providing required voltage output within specified time for each increment of additional load brought on line by sequential automatic starting of fan motors when load is supplied by each of two sources.
    - 2) For regulator supplying pumps in drainage pumping station, set output voltage to 466 volts minimum and check actual output voltage and speed of voltage correction for providing required voltage output within specified time for each increment of additional load brought on line by automatic starting of the first pump followed by the second pump when load is supplied by each of two sources.
    - 3) For regulator supplying facilities other than fan shafts and drainage pumping stations described above, set output voltage to nominal 480 volts and check actual output voltage and speed of voltage correction for providing required voltage output within specified time to the connected load.
  - e. For regulators supplying ventilation fans in fan shafts and pumps in drainage pumping stations, check actual output voltage and speed of voltage correction for providing required output when total load of all connected motors is transferred from one source to the second source by simulating power failure in each of the two sources connected to the automatic transfer switch.
- C. Submit certified test reports.

**END OF SECTION**

## SECTION 16291

### LOCAL ANNUNCIATOR PANEL FOR TRACTION POWER

#### PART 1. GENERAL

##### 1.01 SUMMARY

- A. This section includes the following:
  - 1. Furnishing, delivering to the job-site and installation of local annunciator panels and furnishing spare parts.
  
- B. Related sections
  - 1. Section 16051 - Scope of Work For Traction Power
  - 2. Section 16052 - Basic Materials and Methods For Traction Power
  - 3. Section 16128 - Wire and Cable For Traction Power
  - 4. Section 16260 - Uninterruptible Power System (Static)
  - 5. Section 16261 - Transformer-Rectifier Units For Traction Power
  - 6. Section 16321 - High Voltage AC Switchgear (13.8kV) For Traction Power
  - 7. Section 16322 - High Voltage Switchgear (34.5kV) For Traction Power.
  - 8. Section 16341 - Metal-Enclosed DC Switchgear For Traction Power
  
- C. Payment and measurement basis:
  - 1. Compensation for work specified in this section associated with equipment will be made in the manner of lump sum.
  - 2. Compensation for work specified in this section associated with installation will be made in the lump sum installation cost of each traction power substation, tie-breaker station and Yard Control Tower.

##### 1.02 REFERENCES

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Codes and regulations of jurisdictional authorities.
  - 2. NEC
  - 3. NEMA: 250
  - 4. ANSI/IEEE: C37.90.1
  - 5. UL: 94

##### 1.03 SUBMITTALS

- A. Submit the following for approval in accordance with the Division 1 and with the additional requirements as specified for each:
  - 1. Shop Drawing: In accordance with Section 16051 Table I.
  - 2. Certification:
    - a. Certificates from manufacturer verifying that equipment conforms to the specified requirements.
  - 3. Operation and Maintenance Manuals: In accordance with Special Conditions.
  - 4. Spare Parts Lists.

##### 1.04 QUALITY ASSURANCE

- A. Qualifications: Select a manufacturer who is regularly engaged in production of similar equipment and has supplied for at least five similar projects.

- B. For Codes, Regulations, Reference Standards, and Specifications, refer to Article 1.02 above.

#### **1.05 DELIVERY, STORAGE, AND HANDLING**

- A. Equipment for each facility shall be delivered in accordance with the access dates in Special Conditions, and shall be coordinated with the Engineer
- B. Ship each unit securely packaged, braced and labeled for safe handling in shipment and to avoid damage or distortion.
- C. Temporary Bracing: Where necessary, brace each unit for hoisting, lowering and skidding into position. Temporary internal bracing of the equipment labeled as follows:  
TEMPORARY-REMOVE BEFORE OPERATION
- D. Store equipment in secure and dry storage facility.

#### **1.06 OPERATION AND MAINTENANCE TRAINING:**

- A. In accordance with Section 16053.

### **PART 2 PRODUCTS**

#### **2.01 PRODUCTS AND MATERIALS:**

- A. Local Annunciator Panel:
  - 1. General Requirements
    - a. Solid-state circuitry utilizing microprocessor technology.
    - b. Signal input circuits passing Surge Withstand Capability Test in accordance with ANSI/IEEE C37.90.1.
    - c. Solderless, universal bus network suitable for field modification. Buses and terminals made of tin-plated copper alloy.
    - d. UL plastic rating of 94-VO.
- B. Cabinet:
  - 1. Modular design with each module capable of housing up to four plug-in cards. Each card socket provided with a seven-point, barrier-type terminal block at the bottom of the module array for field use. Terminals capable of accepting up to two #14 AWG wires with or without lugs. Plug-in-cards accessible from the front of the cabinet upon removal of the lightboxes.
  - 2. NEMA 250, Type 12, 16 gauge minimum steel enclosure with lightboxes and back-lighted nameplates suitable for surface mounting on wall.
  - 3. Each vertical and horizontal row provided with two conduit knockouts.
  - 4. Panalarm Series 90, or RIS AN-3100A or approved equal with the following total quantities of modules of accommodate active nameplate displays and blank nameplates:
    - a. Forty-two (42) modules for traction power substation arranged in six rows and seven columns. Panalarm Model 94CAS67 or approved equal.
    - b. Eight (8) modules for tie breaker station arranged in two rows and four columns. Panalarm Model 94CAS24 or approved equal.
    - c. Twelve (12) modules for yard control tower.
    - d. Zinc-plated blue chromate dipped finish.
- C. Lightboxes:

1. Each lightbox displays one annunciation point using LED display lamp.
  2. Each nameplate minimum 3 inches high by 3 - 5/16 inches wide molded of translucent white polycarbonate plastic and fitted to front of lightbox with snap action.
  3. Points identified as trip functions provided with a red filter or film located behind the white nameplate to show a display with red background when lamps in lightbox behind nameplate are illuminated.
  4. Nameplates engraved with black characters or blank with no characters.
  5. Each lightbox removable from cabinet with pull-out plates.
  6. Each lightbox keyed to prevent improper installation.
- D. Sequence cards:
1. Plug-in type with a plastic ejection handle on one end.
  2. Each card provided with a selectable (dip-type) switch for field selection of normally open or normally closed field contacts and an LED display to indicate a change in the position for the field contacts.
  3. Each card provided with a selectable (dip-type) switch for the lock-in or non-lock-in of the input signal.
  4. Flashing sequence provided.
  5. Each card designed with a nominal response time of 20 milliseconds.
- E. Flasher card:
1. Flasher card similar in construction to sequence cards.
  2. One card containing capacity to generate fast flash and slow flash rates for all lightbox displays on annunciator panel.
  3. Card equipped with three LED displays to monitor the fast flash/slow flash buses, the alert audible drives and the return audible driver.
  4. Card input and output circuits provided with overload protection.
- F. Power supply;
1. Input power supply circuit to integral annunciator power supply rated at 125 volts DC and protected with fuses.
  2. Nominal output from power supply consisting of 24 volts DC for logic circuits and 125 volts DC for signal contact circuits, or as required. Signal contact circuits provided with short circuit protection.
- G. Auxiliary contacts:
1. One Form C sealed relay for each point with the following additional requirements:
    - a. Dry contacts with a maximum load rating of 5 amperes at 250 volts AC or 28 volts DC resistive.
    - b. Contacts with a maximum series current of 3 milliamperes, maximum series resistance of 5 kilo-ohms and minimum leakage resistance of 150 kilo-ohms at 125 volts DC.
    - c. Contact bounce not to exceed five milliseconds.
  2. Relay field selectable via removable jumper for fail-safer or non fail-safe operation.
    - a. Auxiliary contacts to follow the signal contact and not operate on test or follow the horn circuit.
    - b. Located on sequence card and accessible via the cards associated with the rear terminal block
- H. Pushbuttons:
1. Two, black, heavy-duty, oil-tight, each with one normally open and one normally closed double break momentary contact mounted on door of cabinet and identified as ACKNOWLEDGE and TEST.
  2. Pushbutton interlock to prevent operation of buttons out of proper sequence from affecting sequence card function.
- I. Annunciator power "ON" indicating light: White, heavy-duty, oil-tight, 125 volts DC.

- J. Audible devices:
  - 1. Electronic device capable of generating multiple tones that are selectable via dip switches with a maximum sound rating of 80 dB at a distance of 10 feet. Mounted on door of cabinet.
  - 2. Or, provided with a horn with a minimum sound rating of 68 dB at a distance of 10 feet capable of producing either a continuous or fast pulse tone. Mounted on door of cabinet.
  
- K. Operation: Arranged for operation from normally closed trouble contacts with the following sequence:
  - 1. Alarm: On opening of any trouble contact, alarm locks in and causes lamps in lightbox behind nameplate for that point to flash at regular intervals.
  - 2. Acknowledge: Operation of ACKNOWLEDGE pushbutton causes lamps behind nameplate to change from the flashing to continuous illuminated display.
  - 3. Return to normal: Lamps behind nameplate are extinguished.
  - 4. Test: Operation of TEST pushbutton causes all alarm cards to go through their operations and lamps behind nameplates flash.

### **PART 3 EXECUTION**

#### **3.01 INSTALLATION**

- A. Install local and remote annunciator panel as shown and in accordance with approved shop drawings.
- B. Make connections as shown and approved in accordance with Section 16052 (Basic Materials and Methods).
- C. Use services of manufacturer's engineering representative for assistance during field assembly and installation of the equipment in accordance with Section 16051 (Scope of Work).

#### **3.02 FIELD QUALITY CONTROL**

- A. Field Testing and Inspection: As specified in Section 16051 (Scope of Work)

**END OF SECTION**

## SECTION 16293

### MIMIC PANEL FOR TRACTION POWER - STORAGE YARD

#### PART 1. GENERAL

##### 1.01 SUMMARY

- A. This section specifies furnishing and installing a Mimic Display Panel for remote supervision of equipment status, display of storage Yard third-rail layout, yard dc one-line and selected analog data, and control of specified circuit breakers in storage Yard Substation, from the Yard Control Tower.
- B. Related Sections:
  - 1. Section 16051- Scope of Work For Traction Power
  - 2. Section 16052 - Basic Materials and Methods For Traction Power
  - 3. Section 16121 - Wire and Cable For Traction Power
- C. Payment and Measurement: Compensation for work specified in this section will be made in the following manner:
  - 1. Materials: Lump Sum.
  - 2. Installation: Lump Sum.

##### 1.02 SUBMITTALS

- A. Submit the following for review in accordance with the Special Conditions and with the additional requirements as specified for each:
  - 1. Shop Drawings: Shop drawings for complete supervisory system including mimic panel, Schematic diagrams, terminal block diagrams and interconnections.
  - 2. Certification: Certificates from manufacturers verifying that equipment furnished conforms to the specified requirements.
  - 3. Product Data: Manufacturer's product data for all components used.
  - 4. Screen Mock-Ups: Provide color plans which depict mimic panel displays as shown and specified. Provide narrative description of the means of operator interaction and displayed results for the selection of operand, object and execution of available commands.
  - 5. Field Test Plan: Submit test procedure describing component level tests and end-to-end operational test to comply with system performance requirements.

##### 1.03 QUALITY ASSURANCE

- A. Qualifications: Select manufacturers/installation contractor who are regularly engaged in production/installation of specified materials.
- B. The equipment shall be tested and certified at the factory in accordance with the manufacturer's recommendations and product specifications.

##### 1.04 DELIVERY, STORAGE, AND HANDLING

- A. Mark each item in accordance with applicable reference standard.
- B. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage.

- C. Store products in secure and dry storage facility.
- D. O & M Manuals: In accordance with Special Conditions.

**1.05 OPERATION AND MAINTENANCE TRAINING:**

- A. In accordance with Section 16053.

**PART 2 PRODUCTS**

**2.01 MANUFACTURERS**

- A. The Mimic panel shall be manufactured by one of the following or equal:
  - 1. Panalarm Ametek.
  - 2. Mosaik EMK.

**2.02 EQUIPMENT**

- A. Remote Control and Monitoring System Description:
  - 1. General Requirements
    - a. The system shall consist of a Mimic Display Panel located at the Yard Control Tower, an interface cabinet (Remote Control & Monitoring Cabinet) at the Yard Traction Power Substation, hard wired connections between substation equipment and interface cabinet, and between interface cabinet and mimic panel through relays isolating mimic panel and the R, M and C cabinet.
  - 2. System Description
    - a. The system shall provide control and indication functions per Table below, or as applicable (Site Specific) display of yard layout, as shown and comply with the following requirements.

<b>Remote Control and Indication Point Count</b>			
<u>Equipment/Device</u>	<u>No. Off</u>	<u>Control</u>	<u>Indication</u>
DC Feeder Breaker	[ TBD ]	X	X
DC Cathode Breaker	[ TBD ]	-	X
DC Positive Tie Breaker	[ TBD ]	-	X
DC Negative Tie Breaker	[ TBD ]	-	X
15kV RT Feeder Breaker	[ TBD ]	-	X
Yard Isolation Switch	[ TBD ]	X	X
Yard Master Trip	[ TBD ]	X	X
DC Bus Voltage	[ TBD ]	-	X

- b. Control dc and ac circuit breakers: Allow the operator at the yard control tower to trip and close breakers from heavy duty pistol grip miniature switches on the mimic panel.

- c. Permit "Yard Isolation" from the mainline and vice-versa through a single switching device, which in turn operates the dc positive and negative tie breakers in accordance with interlocks provided.
- d. Trip all dc feeder breakers connected to the yard third-rail system when the "Yard Master Trip" switch is activated.
- e. Monitor circuit breaker status and provide an audible and visual alarm when these change.
- f. Monitor system analog outputs and provide visual display.

B. Mimic Panel

- 1. The Graphic Display Mimic Panel shall be custom-designed with dimensions of 6 feet (wide) x 3 feet (high), suitable for wall mounting, and with the following additional requirements:
  - a. Graphic panel: Constructed from modular tiles using either a self-locking, self-supporting design or mounted on non-metallic grid system, supported on aluminum frame, completely factory-assembled, wired and tested for operation.
  - b. Tiles:
    - 1) Material: Polycarbonate or equal, non-reflecting, ultraviolet-resistant with anti-static surface.
    - 2) Size: Nominal one inch by one inch.
    - 3) Color:
      - a) Tiles used for background with light color to provide maximum contrast with dark uncolored and colored graphic displays.
      - b) Tiles used for illuminating graphic display lines with translucent narrow rectangular area aligned with non-illuminated graphic display lines on adjacent tiles.
      - c) Tiles used for illuminating circuit breaker and isolation switch positions with opaque (black) color, formed-outline and translucent lens inserts. Inscriptions identifying device positions appear in illuminated areas of lens inserts.
    - 4) Graphic display lines and inscriptions: Engraved or painted characters or silk screen stencil.
  - c. Illuminated display: Plug-in type LED used for illuminating lines and inscriptions through translucent tiles or lens inserts as specified. LED shall be General Electric Company Type ET-16 or equal.
  - d. Overall graphic and illuminated display: Alternating array of five consecutive background tiles with individual matching graphic lines and one translucent tile backlit with LED of appropriate color.
  - e. Inscription and symbol size: Proportional to overall mimic panel size shown with dimensions as follows:
    - 1) Inscriptions for nameplates: ½ inch high minimum.
    - 2) Inscriptions for circuit breaker and isolation switch positions: Maximum size that can be accommodated in illuminated area of tile lens insert.
    - 3) Symbols: One inch by one inch minimum.
  - f. Cabinet: NEMA 12 cabinet with 6 feet wide by 3 feet high opening in hinged front cover to accommodate mimic panel, with the following additional requirements:
    - 1) Construction: Fabricated from minimum 14-gauge galvanized steel with continuously welded seams ground smooth and rolled lip on perimeter of open end of cabinet. Top of cabinet reinforced with structural steel brackets or braces in a minimum of two locations to support weight of mimic panel attached to cover without causing stress or deflection in the cabinet.

- 2) Size: Size as required to accommodate mimic panel attached to cover with adequate space reserved to mount terminal strips. Depth not to exceed 16 inches.
- 3) Cover: Cover with rolled lip on perimeter to match rolled lip on cabinet, closed-cell neoprene gasket, piano hinge at top edge to permit 90 degrees of movement and reinforcement as required to rigidly support mimic panel without twisting or distorting when cover is opened or closed. Cover provided with mechanical or gas-strut devices to hold cover safely in fully-open position and a mechanical latch to secure cover in the closed position.
- 4) Finish: Phosphatized, primed and finished with two coats of lightgray enamel or epoxy coating, ANSI Z55.1, Color 61, minimum dry film thickness, two mils.
- g. Control and Indication Devices:
  - 1) Circuit Breaker Control Switch: Pistol Grip three-position, Selector switch, momentary type with CLOSE/OPEN positions clearly marked. Rating 125V dc, 10 Amps.
  - 2) Pushbutton Switch (Master Trip): Momentary push-button, normally-closed contact with illuminated display showing ON/OFF position. Rating 125V dc, 10 Amps.
  - 3) Indication Device: The circuit breaker status shall be shown using two illuminated displays on the tile. The "CLOSED" position shall be illuminated in red color; the "OPEN" position in green color.
  - 4) Voltmeter: Digital voltmeter, 1000V dc range, displaying Yard dc bus voltage, suitable for 0-1 mA signal obtained from voltage transducer in Yard Substation.
- h. Nameplates: Provided for all contact rails identified by CR numbers, control and indication functions. Permanently engraved on tiles with descriptions as shown.
- i. Terminal strips: 1000V DC suitable for terminating external multiconductor cables between Yard Substation RC&M cabinet and mimic panel and for wiring internal devices like lamps, switches, pushbuttons. Number of terminals to accommodate all incoming and outgoing cables and wires and include ten percent spare terminals.
- 2. System Description
  - a. Graphic display of Storage Yard Contact- Rail Layout and dc one-line diagram using color-coded power zones as shown. The Third Rail System and dc one-line display shall consist of translucent tiles with behind-the-tile LED lamp assembly, and applicable color coding. The color-coded power zones shall be illuminated when the associated dc feeder breaker is closed and not illuminated when the associated dc feeder breaker is open.
  - b. The panel shall be hard-wired back to the Remote Control and Monitoring Cabinet in Yard Substation through isolation relays. All signals to and from the substation equipment shall be terminated in this cabinet for interfacing with the remote system.
  - c. Power supply: Suitable for 125V DC supply from local power panel.
- C. Spares: As recommended by the manufacturer for two years operation beyond the warranty period.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install in accordance with approved shop drawings.

- B. Nameplates, Tags and Wire Labels:
  - 1. Nameplates: Provide nameplate descriptions on mimic panel as shown.
  - 2. Cable Tags: Attach cable tags to each cable at all pull boxes, manholes and terminations.
  - 3. Wire labels: Attach wire labels to all control, annunciation and supervisory wiring at each terminal point. Attach label to a clean, dry section of wire as close as possible to the terminal point.

### **3.02 FIELD QUALITY CONTROL**

- A. The Contractor shall demonstrate the proper functioning of all system components in the presence of the Engineer by systematically operating the circuit breakers, master-trip and yard isolation switch from the mimic panel, observing status points, and annunciating all functions.
- B. Submit Certified test report within ten days.

**END OF SECTION**

## SECTION 16294

### CONSTANT WATTAGE CONTACT RAIL HEATING SYSTEM FOR TRACTION POWER

#### PART 1. GENERAL

##### 1.01 SUMMARY

- A. This section specifies furnishing installation of a complete contact rail heating system (comprised of numerous sub-systems and components) or of any identified subcomponents or systems at various locations of WMATA rail systems.
- B. This work includes but is not limited to the following:
  - 1. Furnishing and delivery to job site of all materials.
  - 2. Installation of a complete contact rail heating system comprised of individual sub-systems (or of any identified subcomponents) at various locations of WMATA rail system. Each sub-system requires removal of contact rail protection cover assemblies where required, cleaning of contact rail, installation of contact rail heater, contact rail protection cover assemblies, trackside heater control panel, trackside fusebox disconnect, zone heater control panel, master heater control panel, remote heater controller, installation and connection of power and control cable and other associated items as specified, shown and required for completion of the work to provide an operational system. Regardless of whether the contract requirements call for partial or complete replacement of the contact rail heater system, the completed work shall provide for an integrated system whose components (whether new or existing-to-remain) function together as a complete system in the manner described herein.
  - 3. Furnishing and installing trackside heater control panels, zone heater control panels, fusebox disconnects, master heater control panel, remote heater controller and associated wiring and control connections.
  - 4. Providing contact rail heaters and heater components for the purpose of deicing contact rails whose third rail voltage will vary from 900V DC to 450V DC during normal operating conditions.
- C. Related Work Specified Elsewhere
  - 1. Section 16051 - Scope Of Work For Traction Power
  - 2. Section 16052 - Basic Materials and Methods For Traction Power
  - 3. Section 16053 - Operation and Maintenance Training for traction power
  - 4. Section 16128 - Wire and Cable For Traction Power

##### 1.02 DEFINITIONS

- A. Definitions:

1. Contact Rail Heater: A heating cable installed on the contact rail to electrically heat the mass of the rail. The cable is one of parallel circuit design utilizing a metal alloy/fiber composite heating element spirally wrapped around the parallel bus wires of the cable.
2. 32°F Substrate: A metal surface that is maintained at 32°F.
3. Nominal service voltage: The voltage at which the heater cables are expected to operate when in normal operation, i.e., 750V DC.
4. Rated Power Output: The watt/foot of heating cable, eight feet or longer, energized at 750V DC, when mounted on a 32°F substrate.
5. Sheath Temperature: The temperature of the outermost jacket.
6. Maximum Sheath Temperature: The highest sheath temperature that a heater is capable of generating when powered at 900V DC in still air.
7. Factory Fabricated: A heating cable including terminations and lead wires completely assembled and tested at the manufacturer's plant prior to shipment.
8. Heat Transfer Aids: Includes any materials that are extruded on to the heater for the purpose of conducting heat from the heater to the contact rail.
9. Traction Power Zone: Includes all contact rail fed from a DC switchgear feeder breaker.

### **1.03 SYSTEM DESCRIPTION**

- A. Interpretation of Drawings and Specifications
  1. Lengths of jumper cable between segments of heater are approximate. Field verify actual lengths.
  2. The contract drawings are diagrammatical and do not show all offsets and other details at every point of the contact rail. Make all field measurements required to install a complete and operational contact rail heating system. Furnish and install, at no extra cost to Authority, any additional fittings, conduits, cable/wire or specialties, and other appurtenances necessary due to field conditions.

### **1.04 SUBMITTALS**

Submit the following for approval in accordance with the Division 1 and with the additional requirements as specified for each:

- A. Heater controller shop drawings including the following:
  1. Manufacturer's catalog cuts and literature for each item.
  2. Power and control internal wiring diagram and equipment layout for the following:
    - a. Trackside heater control panel.
    - b. Zone heater control panel.
    - c. Fusebox disconnect.

- d. Master heater control panel.
    - e. Remote heater controller.
  3. Time-current curve for fuses.
  4. Drawings showing full details of each type of enclosure.
- B. Heater assembly shop drawings including the following:
  1. Drawings showing details of heater, termination, fiberglass channel or extrusion and clip.
  2. Installation details on steel or composite contact rail and at contact rail joints.
  3. Manufacturers catalog cuts and literature.
  4. Submit samples of the following items to the Engineer for approval: Heater cable, fiberglass channel, spring clip for steel rail and composite rail, spring clip for composite rail and steel rail splice joint, end cap kit, splice kit, power lead termination kit.
- C. Heater system shop drawings:
  1. Within seven (7) days after receipt of notice to proceed, submit shop drawings for the following:
    - a. Power and control wiring for each typical sub-system consisting of contact rail heater assemblies, fusebox disconnects, trackside heater control panels, zone heater control panels, master heater control panel and remote heater controller.
    - b. Inrush current type test data for heater cables on log-log time-current graphs for 450 to 750V DC for 0 C to 40 C.
    - c. Proposed fuse time-current curve for main fuse disconnect and for individual heater circuit fuses.
    - d. Maximum Sheath Temperature.
- D. Heater Controllers and Contact Rail Heater Assembly Certification: Certificates from manufacturers verifying that equipment furnished conforms to WMATA's requirements as specified in this document.
- E. Contact Rail Heater Assembly Certification of Test Results:
  1. Two original copies of certified test reports for factory design and production tests for the Authority's approval prior to the shipment of heaters.
- F. Documentation:
  1. Contact rail heater assembly documentation includes:
    - a. Projected power outputs of the heater as a function of rail temperature, voltage and circuit length.
    - b. Start-up current characteristics.

- c. A list of minimum two transit authorities with contact information where a third rail heater by the same manufacturer has been used for de-icing contact rails on 600V DC or above system.
2. Documentation for Contact Rail Heating System includes:
- a. Submit composite coordination curves of main fuse, circuit fuse and heater maximum in-rush currents to demonstrate that the proposed fuse will not cause nuisance blowing under all operating conditions.
  - b. Field Test Plan and Documentation:
    - 1) Submit field test plan within 60 days before shipment of Equipment, with accompanying documentation in the form of test data recording sheets and list of proposed test equipment.
    - 2) Do not proceed with testing until the plan and documentation are approved.
    - 3) Indicate in scope of test plan how equipment will be tested to ensure safe and orderly transition from installation, through initial energizing to approved field tests.
    - 4) Submit certified copies of test data, within two weeks after completion of testing.
3. Submit Operations and Maintenance Manuals and Preventive Maintenance Instructions(PMI): Section 16053 and as required by Division 1.

**1.05 QUALITY ASSURANCE**

- A. Qualifications:
- 1. The heater controller manufacturer selected shall be regularly engaged in production of similar control panel fuse-box disconnects.
  - 2. The contact rail heater assembly manufacturer shall be regularly engaged in the production of contact rail heaters and heater components for de-icing contact rails for transit systems.
- B. Codes, Regulations, Reference Standards and Specifications:
- 1. Codes and regulations of jurisdictional authorities.
  - 2. NEMA: ICS2, ST-20, WC3.
  - 3. UL: 94, 224, 1087.
  - 4. ASTM: A283, B368, B633, D88, D130, D149, D217, D256, D495, D543, D570, D638, D648, D696, D790, D792, D942, D1056, D1263, D1264, D2509, D2565, D3032, F593, G3, PRACTICE G26 METHOD 1.
  - 5. ANSI: Z55.1.
  - 6. MIL-STD-202F Methods 101D, 106E, 107G.
  - 7. IEEE STD 515

8. ICEA: S-95-658 (NEMA WC70)
9. AAR: 581.
10. NESC.C2

C. Factory Testing

1. Submit certified original copies of test reports performed on identical types of heaters and heater components in the heater assembly.  
Tests shall have been conducted not more than 36 months prior to submittal to the Authority, for materials which are identical to those of the furnished components.
2. Heater Tests:
  - a. Design Tests: All design tests shall be performed on heater samples of two to ten feet long, unless otherwise dictated by the respective testing standard(s). Pass/fail criteria are as indicated herein, or within the respective standard.
    - 1) Voltage withstand test (on a new sample) in accordance with ASTM D3032:
      - (a) Withstand 500V DC with a maximum current leakage of 50 microamps/ft.
    - 2) Insulation Resistance test (on a new sample) in accordance with ASTM D3032:
      - (a) Insulation resistance greater than 1000 megohm-ft.
    - 3) Dielectric test (on a new sample) in accordance with IEEE 515 4.1.1. At the completion of this test, conduct insulation resistance test per IEEE 515 4.1.2.
    - 4) Water resistance test (on a new sample) in accordance with IEEE 515 4.1.3.
    - 5) Connection/termination water resistance test (on new samples) in accordance with IEEE 515 4.1.4.
    - 6) Elevated temperature exposure dielectric test (on a new sample) in accordance with IEEE 515 4.1.5.
    - 7) Deformation test (on a new sample) in accordance with IEEE 515 4.1.7, except performed at maximum sheath temperature..
    - 8) Impact test (on a new sample) in accordance with IEEE 515 4.1.8. Verify no loss of heater element continuity after test.
    - 9) Cold bend test (on a new sample) in accordance with IEEE 515 4.1.9.
    - 10) Flammability test (on a new sample) in accordance with IEEE 515 4.1.10.
    - 11) Power output test (on a new sample) on 32F substrate 15 minutes after energization in accordance with IEEE 515 4.1.11:
      - (a) Nominal power output: 30 or 40 watt, as specified in the

contract for the heater, per foot at 750V DC.

- (b) Maximum Sheath Temperature shall be verified in accordance with IEEE 515 4.2 during power output test.
- 12) Over voltage test (on a new sample): Use 1200V DC for one hour and determine sheath temperature with sheath not in contact with substrate in still air and air temperature not less than 50°F:
- (a) Sheath temperature not to exceed 400°F.
  - (b) No melting, charring or burning of heater elements or outer jacket occur during test.
  - (c) Pass voltage withstand and resistance test after over voltage test.
- 13) Corrosion test (on a new sample) in accordance with MIL-STD-202F Method 101D, Test condition A with outer jacket removed:
- (a) No pitting or cracking of heater element during test.
- 14) Light Exposure Test (on a new sample) in accordance with ASTM D2565 practice G26, Method 1:
- (a) No cracking or splitting of material during test.
  - (b) Pass voltage withstand and insulation resistance test after light exposure test.
- 15) Perform Voltage Spikes Test (on new sample) by applying 1000 cycles with 5000 volt impulse having 1.2 microsecond rise time and 50 microsecond fall time. After voltage spikes test:
- (a) Retain 90 percent minimum of initial power.
  - (b) Pass voltage withstand and insulation resistance test.
- 16) Performance After Thermal Aging Test (on new samples, per IEEE 515 4.1.6): Conduct indicated test. Aging temperature shall be 104 degrees F. For the purposes of this test, the heat tape should be considered as not having an intermittent temperature exposure rating. Test shall consist of operation (energized) for 120 hours, followed by output measurement, followed by operation (energized, with a 12 minute "on" 3 minute "off" cycle) for 32 weeks, followed by output measurement. This test may be completed concurrently with supply on a multi-year contract with engineering approval.
- (a) Power output shall change no more than 15% (including experimental tolerance) from the original power value prior to thermal aging.

b. Production Test:

- 1) Each completed heater length, including terminations shall be subjected to the following tests:
  - (a) Pass voltage withstand test in accordance with ASTM

D3032. Withstand voltage in accordance with IEEE 515 4.1.1.

- (b) Insulation Resistance Test in accordance with ASTM D3032. Insulation resistance greater than 1000 megohm-ft.
  - (c) Upon completion of test, thoroughly clean each length to remove saline solution residue.
- 2) Nominal Power Output Test: Test a minimum of three (3) heater samples out of each 10,000 feet of heater production as below:
- (a) Method of sampling: Obtain one or more test samples of two feet minimum length per 1,000 feet of heater production. Choose three samples at random from the set of samples taken from a given production run.
  - (b) Nominal power output: 30 or 40 watt per foot at 750V DC on a 32°F substrate 15 minutes after energization.
  - (c) If any sample has a power output value less than 95 percent of specified watts per ft., then that particular production run heater produced is to be considered as rejected by Authority. If the Contractor chooses, a retest on three (3) additional samples for that production run of 10,000 ft. tests may be made by the Contractor at no additional cost to Authority. Submit the results of all tests for review and a decision on approval by the Authority.
- 3) Authority reserves the right to require the Contractor to supply production samples at no cost to Authority in order that Authority can have samples tested for compliance by an independent laboratory selected by Authority. These test costs will be paid by Authority.
- 4) Authority reserves the right to witness manufacture of and to witness all tests conducted upon the heater. Notify Authority in writing at least two weeks in advance of the first heater testing date so that they can witness the test, if so desired. All materials to be furnished under the Contract are subjected at all times during manufacture, fabrication, construction and testing to such inspection by the Authority as to give due assurance that the terms and requirements of this Specification are being complied with.

3. Fiberglass Channel/Extrusion Tests:

a. Design Tests:

- 1) Tensile modulus in accordance with ASTM D638:
  - (a) Greater than  $1 \times 10^6$  psi.
- 2) IZOD impact strength in accordance with ASTM D256:
  - (a) Notch impact strength greater than 10 ft lbs/in of notch.
- 3) Thermal co-efficient of expansion in accordance with ASTM-D696:

- (a) Thermal Co-efficient:  $13 \times 10^{-6}$  in/in/°F maximum.
    - 4) Solvent resistance in accordance with ASTM D543:
      - (a) Less than 2 percent weight change in diesel fuel, gasoline, and salt water. Less than 0.5 percent change in water.
    - 5) Accelerated aging in accordance with ASTM G23:
      - (a) A minimum of 2000 hours.
    - 6) Flammability Test in accordance with UL 94:
      - (a) Flammability Classification: VO
  - b. Production Tests:
    - 1) Visual examination for overall uniformity and acceptable surface quality.
    - 2) Dimensional check according to manufacturing tolerances.
4. Attachment Clip Tests:
  - a. Design Tests:
    - 1) Finish in accordance with ASTM B633, zinc chromate or coating providing equivalent corrosion protection.
    - 2) Corrosion test in accordance with ASTM B368:
      - (a) No rusting after 130 hours in a copper acetic acid bath.
  - b. Production Tests:
    - 1) Visual examination for quality of finish and absence of burrs, sharp edges and cracks.
    - 2) Dimensional check of at least 3 clips per 1000 chosen at random according to manufacturing drawing tolerances.
5. Splice and Termination Tests:
  - a. Design tests:
    - 1) Pull out strength at least 40 lbs measured under static load for one hour with no evidence of slippage.
    - 2) Thermal Shock Test in accordance with MIL STD 202E, Method 107G, Test Condition A:
      - (a) Heater pass voltage withstand and insulation resistance tests after thermal shock test.
    - 3) Light Exposure Test in accordance with ASTM D 2565 practice G26, Method 1:

- (a) No cracking or splitting of material during test.
    - (b) Heater pass voltage withstand and insulation resistance tests after weather-resistance test.
  - 4) Corrosion Test in accordance with MIL STD 202F, Method 101D, Test Condition A:
    - (a) No pitting or cracking of heater element during test.
    - (b) Heater pass voltage withstand and insulation resistance tests after corrosion test.
  - 5) Moisture resistance test in accordance with MIL STD-202F Method 106E:
    - (a) No cracking or splitting of material during test.
    - (b) Heater pass voltage withstand and insulation resistance tests after moisture resistance test.
- b. Production Tests:
  - 1) Visual Examination for overall uniformity and acceptable surface quality.

**1.06 DELIVERY, STORAGE, AND HANDLING**

- A. Delivery, storage and handling for trackside, zone, master and remote heater controllers shall include:
  - 1. Mark each item in accordance with applicable reference standards.
  - 2. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage and distortion.
  - 3. Store products in secure and dry facility.
  - 4. Deliver spare parts to be stored to Rail System Maintenance Facility, 195 Telegraph Road, Alexandria, Virginia 22314.
- B. Delivery, storage and handling for contact rail heater assembly shall include:
  - 1. Stamp with permanent ink on the finished length of the heater cable, the following information on the outside surface (side away from rail) in ¼" high (minimum) black letters repeated every six (6) feet (maximum):
    - a. Manufacturer's name
    - b. Manufacturer's part number
    - c. Voltage rating
    - d. Wattage per foot
  - 2. Supply heater cable on approximately five-foot diameter reels for the A and B sides of the trackside heater control panel in the lengths as required per contact rail heater plan on each side of control panel as developed by the contractor. Length of heater

cable on each side (A or B) of controller shall not exceed 500 feet. Terminate each heater circuit in the factory to circuit lengths as required, and in accordance with contact rail heating plan.

- a. Designate each reel by the trackside heater control panel number.
  - b. Where the combined length of the heating cable on side A and B of a control panel is 500 feet or less, contractor has the option of placing each of them on the same reel.
3. Ship items securely packaged and labeled for safe handling in shipment and to avoid damage.

## **1.07 WARRANTY**

1. In addition to the Division 1 "Warranty of Construction". Warrant each heater cable length covered by this Specification to be free from defects in material and workmanship, for an additional period of one year for a total of two years after date of final installation and acceptance.
2. If any product furnished under this Section has an annual failure rate of twelve percent or more of the total of heater sections supplied and the failure is determined to be a fault of the product as supplied, replace all such products required to eliminate the cause of the failures without any additional cost to the Authority. The five (5) year warranty period shall be applied to all replaced heaters. Output below ninety percent of rated output at 750V DC at specified rail temperature is considered as failure.

## **PART 2 PRODUCTS**

### **2.01 EQUIPMENT - CONTACT RAIL HEATER ASSEMBLY**

- A. Contact rail heater shall be manufactured by Thermon Manufacturing or approved equal.
- B. Contact rail heater assembly: Consisting of following items suitable for installation on aluminum-clad (composite) contact rail or steel contact rail as required per WMATA contact rail system:
  1. Contact rail heater cable: Constant wattage output (i.e., effectively independent of rail temperature):
    - a. The heater cable shall consist of two (2) parallel 10 AWG (30 or 40 watt per foot) nickel plated copper conductors. Each of the two (2) conductors is insulated with fluoropolymer resin. Over these two (2) parallel insulated conductors, a pairing jacket is extruded to form a parallel core. This core is then alternately notched at the outermost edge exposing the bare conductors. A nickel alloy/fiber composite resistance wire is then spirally wrapped around the core. The wrapper core is then covered with a fluoropolymer jacket minimum 30 mils thick. The jacket material shall be free of PVC and PVC base compounds. The heater assembly is then covered with a metallic braid of nickel-plated copper.
    - b. A silicone based composition is extruded over the cable assembly to aid in even heat distribution to the contact rail. This outer covering also protects the cable assembly and is electrically non-conductive for ease of installation. The silicone composition shall be suitable for extended exposures to high temperatures.

- c. Nominal power output on 32°F substrate after 15 minutes of energization.
  - (1) Nominal Output: 30 or 40 watt per foot at 750V DC.
  - (2) Maximum sheath temperature of heater cable not in contact with substrate, operating at 750V DC in still air at 50°F ambient air temperature: 400°F.
- d. Suitable to pass specified design and production tests.
- e. Length: As required per contact rail heating plans developed by the contractor subject to a maximum tolerance of minus three percent. Number of splice in any section of heater tape not to exceed the following:

<u>Length of Heater Tape</u>	<u>Number of Splices</u>
100 ft. or less	None
100 ft. to 200 ft	One
200 ft. to 500 ft.	Two

- f. Marking: Mark heater cable sheath at intervals of not more than 6 feet in ¼ inch high letters with manufacturer's name, system voltage, rated power output and product batch number.
2. Fiberglass Channel or Extrusion: Designed to hold contact rail heater cable in intimate contact with steel or aluminum clad (composite) contact rail as shown on contract drawings, with the following additional requirements:
    - a. Size and Shape: As required by heater manufacturer.
    - b. Material: Ultra-violet stabilized fiberglass reinforced polyester.
    - c. Suitable to pass specified design and production test.
  3. Attachment Clips: Designed to hold the fiberglass channel with heater cable in intimate contact with steel or aluminum clad (composite) contact rail, as shown on contract drawings, with the following additional requirements:
    - a. Suitable for easy installation and removal and not interfering with coverboard assembly.
    - b. Material: Spring steel, minimum of 1-¼ inch wide and 64 mils thick.
    - c. Heat treated after fabrication to Rockwell scale hardness of C30-C40.
    - d. Finish: Zinc chromate coating, 0.9 mils thick for service condition SC-4, Type 2, in accordance with ASTM B633.
    - e. Suitable to pass specified design and production tests.
    - f. Spacing of clips: As specified by heater cable manufacturer, nominally eighteen-inch center to center or as approved by the Engineer.
  4. Heater Factory Terminations: Terminate power leads at both ends or for power leads at one end and end cap at the other end as shown on contract drawings with following additional requirements:

- a. Power lead and end cap terminations designed to provide water tight seal using polymeric and/or adhesive materials.
  - b. Power lead terminations: The heater element bus wires are connected to the power lead wires using crimp connectors. The power lead wires shall be Exane or approved equal, 110°C, #10 stranded minimum, single conductor copper wire insulated with heat resistant rubber compound, with a 2000 volt rating. Standard lead length is 10 feet and complying with the following requirements:
    - 1) Conforming to NEMA WC 70, ICEA S-95-658 and AAR 581.
    - 2) Suitable for use in wet and dry outdoor locations, open air, conduit, cable trench, underground ducts or direct buried.
    - 3) Lead wire ends suitably protected to prevent ingress of moisture during shipment.
    - 4) Each lead wire marked with manufacturer's name, conductor size, insulation material and voltage rating.
    - 5) Furnish compression splice terminals and heat shrinkable tube with each lead wire end for field connections with # 10 AWG minimum, 2000 volt insulated wire specified in Section 16128. Do not provide splices in cables at other than at indicated locations without approval of the Engineer.
6. Shop Assembled Terminations: Terminate using materials recommended by heater manufacturer and in accordance with manufacturer's instruction in a clean and dry area. Each termination shall be subjected to the following tests:
- a. Perform a voltage withstand test in accordance with ASTM D3032 at 500V DC without failure.
  - b. Perform insulation resistance test in accordance with ASTM D3032 at 500V DC. Insulation resistance must be greater than 1000 megohms-ft.
7. Abrasion Pad:
- a. Continuous extruded EPDM rubber.
  - b. Durometer Hardness (Shore A± B): 60.
8. Operating Requirements:
- a. The design and fabrication of the contact rail heater system, comprising of materials and components described herein, shall assure successful operation when installed on Authority contact rail installation.
  - b. The contact rail heater cable system is to be designed to withstand ambient temperatures of -40°F to +120°F, with rail temperature excursions to +180°F; also rain, sleet, snow, vibration (as generated by passing rapid transit vehicles), roadway salts, common chemicals found in the Metropolitan Washington Area Rapid Rail Transit environments, solar exposure and rail expansion/contraction without deleterious effect.

## 2.02 EQUIPMENT - HEATER CONTROLLERS

A. General Requirements for Trackside Heater Control Panel, Zone Heater Control Panel, Master Heater Control Panel, Remote Heater Controller and Fuse-Box Disconnect:

1. Auxiliary Relays:

- a. Type - Electrically held.
- b. Standard - NEMA ICS2 - 212.
- c. Contacts:
  - 1) Number and type - 2 N.O., 2 N.C. or as specified.
  - 2) Voltage - 120V AC or DC as specified.
  - 3) Current - 0.45A resistor load and 0.3A inductive load.
- d. Coil - 125V DC.
- e. General Electric - CR120BD01141

2. Auxiliary Time-Delay Relays:

- a. Type - Electrically held.
- b. Standard - NEMA ICS2.
- c. Contacts:
  - 1) Number and Type - Two normally open, or 1 N.O., 1 N.C. as required.
  - 2) Voltage - 120V AC or DC as required.
  - 3) Current - 1.0 A DC resistive load, 2.0A AC inductive load.
  - 4) Time-Delay - Time Delay pick up adjustable as specified.
- d. Coil - 120V DC.
- e. AGASTAT Series 7012, or approved equal.

3. Magnetic Current Relays / Shunt Device:

- a. Type - Current actuated magnetic. Supervisory indications via shunt device.
- b. Standard - NEMA ICS2.
- c. Contacts:
  - 1) Number and type - Two, normally open.
  - 2) Voltage - 120V DC.
- d. Coil:
  - 1) Connection - In series with load.

- 2) Insulation - 1000V DC to ground or contacts.
  - 3) Continuous current rating of series coil - coil rating suitable for pick-up as required for length of heater to indicate heater energization.
- e. G.E. Cat. #IC2820A100WB or approved equal.
- 4. 24V DC Auxiliary Relays (Supervisory Control):
  - a. Type - Dual-coil, mechanically latching, with electrical reset coil.
  - b. Standard - NEMA ICS2.
  - c. Contacts:
    - 1) Number and type - 2 form 'C' with N.O. Contact for HCR-ON, as shown on drawings.
    - 2) Voltage - 125V DC.
    - 3) Current - 0.45A DC. resistive load.
  - d. Coil - 24V DC.
  - e. Clifford and Snell, catalog number D2600/LES; Potter & Brumfield, catalog number KBP-11D-G-24 with screw terminal socket catalog number 27E123; or approved equal.
- 5. D.C. Contactors:
  - a. Type - Electrically held.
  - b. Standard - NEMA ICS2.
  - c. Size - NEMA Size 3.
  - d. Poles:
    - 1) Number - Two.
    - 2) Voltage - 1000V DC.
    - 3) Current - 100 A continuous.
    - 4) Withstand: 3000V DC high pot test for 10 seconds.
  - e. Arc chute - With 50 A blowout coils.
  - f. Auxiliary contacts - 1 N.O., 1 N.C. at 10A, 120V AC.
  - g. Coil - DC, for operation from 120 VAC via rectifier and dropping resistor.
  - h. G.E. Cat. #DS 303 Form B3 C01FXA 650 interlock XH or approved equal.
- 6. Indicating Lights for Trackside Heater Control Panel:
  - a. Type - Rain-tight, factory sealed.

- b. Housing - Aluminum guard and body assembly with steel clamping ring. Maintain NEMA 3R rating when installed to enclosure.
  - c. Lamps:
    - 1) Type - LED.
    - 2) Voltage - 120V AC.
  - d. Lens color - Amber
  - e. GE Type ET-16 or approved equal.
7. Indicating Lights for Zone Heater Control Panels and Master Heater Control Panels:
- a. Type - Oil tight, heavy duty push-to-test.
  - b. Standard - NEMA ICS 2.
  - c. Lamps:
    - 1) Type - Incandescent.
    - 2) Voltage - 125V DC.
  - d. Lens - Color as shown on drawings.
  - e. Contacts - 1 N.O., 1 N.C., 1.0 A. 125V DC.
  - f. G.E. CR 104P LT 22 or approved equal.
  - g. DTS
8. Lamp Test Switch for Trackage Heater Control Panel:
- a. Type - Push button, rain-tight construction to maintain NEMA 3R rating when installed to enclosure.
  - b. Standard - NEMA ICS 2.
  - c. Contacts:
    - 1) Number and type - 2 NO.
    - 2) Voltage - 120V AC.
    - 3) Current - 10 A continuous.
    - 4) Momentary contact.
  - d. Surface mounted, location as shown on drawings.
  - e. G.E. CR104P BG92B1 or approved equal.
9. Selector Switches:
- a. Type - Oil tight NEMA 3R, to maintain NEMA 3R rating when installed to trackage enclosures, otherwise NEMA 12.

- b. Standard - NEMA ICS 2.
  - c. Switch - Knob operated.
    - 1) 1-pole 2-position, 1-pole 3-position, or 2-pole 2-position as shown on drawings and required.
  - d. Contacts:
    - 1) Number and type - As shown on drawings.
    - 2) Voltage - 120V AC.
    - 3) Current - 10 A continuous.
    - 4) Maintained contact.
  - e) GE SG21B91, GE SG34B91, or approved equal.
10. Fuse and Fuseblock:
- a. 120V AC. Rating:
    - 1) Fuse - UL Class H with current rating as required and approved.
    - 2) Fuseblock - Porcelain, phenolic or polycarbonate, surface mounted single pole for 30 ampere Class H fuse. G.E. # CR151KJC21AQ or approved equal.
  - b. 480V AC rating:
    - 1) Fuse - UL Class H with current rating as required and approved.
    - 2) Fuseblock - Porcelain, phenolic or polycarbonate, surface mounted, two pole for 30 ampere Class H fuses. G.E. CR151KJC22CQ or approved equal.
  - c. 120V DC Rating:
    - 1) Fuse - UL Class RK5 with current rating as required and approved.
    - 2) Fuseblock - Porcelain, phenolic or polycarbonate, surface mounted single pole for 30 ampere Class RK5 fuse.
    - 3) Mounting track - Suitable for mounting of 120V DC fuseblock. Size as required, G.E. CR 151 or approved equal.
11. 1000V DC Fuse and Fuseblock:
- a. Fuse:
    - 1) Type - Current limiting, blade type, for stud bolt-on mounting.
    - 2) Voltage - 1000V DC.
    - 3) Gould Shawmut, Form 101 AMP-TRAP, Cat. A150X Type 4, current rating as shown on drawings, or approved equal.

- 4) Interrupting capacity - Capable of interrupting up to 80,000 A. fault current with system time constant of 40 milliseconds.
  - b. Fuseblock:
    - 1) Surface mounted type.
    - 2) Insulating material - Phenolic or polycarbonate.
    - 3) Two fuse-mounting studs for bolt-on mounting.
    - 4) Type and size - As appropriate for type of fuse used.
12. Molded Case Switches (Non-Automatic Molded Case Circuit Breaker):
  - a. Type - Non-automatic molded case circuit breaker.
  - b. Standard - UL 1087.
  - c. Contacts:
    - 1) 3 Pole.
    - 2) Voltage - 600V AC, 250V DC, (3 poles connected in series to provide 750V, DC isolation).
    - 3) Current rating - 100A. continuous.
  - d. G.E. Cat. #TED 136 Y 100 or approved equal.
13. Space Heater for Trackside Heater Control Panel:
  - a. Rating:
    - 1) Voltage - 120V, 60Hz.
    - 2) Rating - 35 Watts.
  - b. Housing - Grill guard with no sharp edges with low operating surface temperature.
14. Terminal Boards for Control Wiring:
  - a. Type - Box terminal.
  - b. Number of terminals - As shown on drawings.
  - c. Voltage - 300V AC or DC.
  - d. Current - 30 A.
  - e. Mounting - Direct mounted or rail mounted as shown.
  - f. G.E. CR 151A or approved equal.
15. Terminal Board for DC Power:
  - a. Type - Heavy duty stud terminal.

- b. Number of terminals - As shown on drawings.
  - c. Voltage - 1000V DC.
  - d. Current - 300A DC.
  - e. G.E. CR 2960, SY 139D3A or approved equal.
16. Limit Switch (Door Interlock):
- a. Type - Precision plunger or roller-plunger, snap action.
  - b. Contact - Minimum rating 5A, 250V AC.
  - c. G.E. Cat. CR115MB, G.E. Cat. CR115H or approved equal.
17. Control Power Transformers for Trackside Heater Control Panels:
- a. Type: Indoor dry type.
  - b. Standard: NEMA ST-20.
  - c. Rating:
    - 1) Voltage ratio: 480V to 120V, 60 Hz.
    - 2) VA rating: 100.
  - d. Insulation System: 150°C - Allowable temperature rise under continuous full load above an average ambient temperature of 30C and maximum of 40C.
    - 1) By winding resistance - 80C.
    - 2) By hot spot in winding - 110C.
  - e. GE 9T58B2804 or approved equal.
18. Fiberglass Enclosure for Trackside Heater Control Panels:
- a. Type - NEMA Type 3R.
  - b. Material:
    - 1) Molded fiberglass reinforced polyester material 1/8 inch minimum thickness and in accordance with the following:

<u>Physical Properties</u>	<u>Value</u>	<u>Method</u>
Flexural Strength	17,000 psi	ASTM D790
Deflection Temperature	400 degree F	ASTM D570
Water Absorption (24 hours)	0.5%	ASTM D570
Tensile Strength	6,500 psi	ASTM D638

Specific Gravity	1.8	ASTM D792
Flammability	94-5V	UL 94
Dielectric Strength	400 Volts/Mil	ASTM D149
Arc Resistance	180 Sec.	ASTM D495

- c. Ultra-violet protection: Fiberglass material containing ultra-violet inhibitor, or coated with polyurethane paint, 1.5 mils minimum dry film thickness on both inside and outside surfaces.
  - d. Gasket: Oil-resistant 100 percent neoprene ASTM-D1056 grade SCE-42 with oil-resistant adhesive.
  - e. Provide each front panel with 8 stainless steel quick-release fasteners and handle as shown and approved.
  - f. Back plates: 10 gauge Type 304 stainless steel or fiberglass reinforced polyester or equal, ¼" minimum thickness as shown. Plate to be electrically connected to terminal board ground terminal
  - g. Hardware: Type 316 stainless steel bolts, nuts and screws; ASTM F593, size as shown on drawings and required.
  - h. Drainage: As shown on drawings and approved.
  - i. Ventilators: As shown on drawings and approved to maintain NEMA 3R integrity with wind-driven rain.
  - j. Color: Fiberglass material, gray inside and outside.
19. Enclosure for Zone Heater Control Panels, Master Heater Control Panel and Remote Heater Controller:
- a. Wall-mounted type, single-door, NEMA 12, with panel, Hoffman Engineering Company or equal, as shown on drawings.
  - b. Enclosure: Formed of minimum 14-gauge steel, seams continuously welded and ground smooth, without opening or knockouts, with threaded conduit entrance hubs, lugs for mounting enclosure and collar studs for mounting panel. Rolled lip formed on all sides of door opening. Enclosure reinforced when size exceeds 30 inches square. Size as required.
  - c. Door: Formed of minimum 14-gauge steel, with rolled lip along top and sides to match with enclosure. Fitted with removable print pocket. Closed-cell neoprene gasket attached with oil-resistant adhesive and steel retaining clips.
  - d. Hardware: Corrosion-resistant steel continuous piano hinge with removable pin. Hasp and staple for padlocking.
  - e. Panel: Formed of 12-gauge steel.
  - f. Breather drain: One ½-inch diameter, Crouse-Hinds Catalog No. ECD11 or equal.
  - g. Finish: Galvanized enclosure, door, panel and latch mechanism. Prepared for painting by manufacture's standard method in accordance with the

following:

- 1) Outside: Phosphatized, primed and finish with two coats of light gray enamel or epoxy coating, ANSI Z55.1, Color 61; minimum dry film thickness, two mils.
- 2) Inside, including panel: Two coats of white enamel or epoxy coating.

20. Nameplates, Tags and Wire Labels:

a. Nameplates:

- 1) Three-ply, laminated phenolic plates, engraved through black face to white core, attached by stainless steel rivets or screws.
- 2) Lettering: Vertical gothic using round or square cutter. V-shape groove is prohibited.
- 3) Size: 1 ½-inch high with 1-inch high lettering, one-inch high with ½-inch high lettering or ½-inch high with ¼-inch high lettering as specified and required.

b. Cable Tags: Non-ferrous tags or pressure sensitive labels, stamped or printed with cable number shown on wiring diagram.

c. Wire labels: Sleeve-type, heat shrinkable, flame retardant Raychem TMS product line, Type XLPE or equal and conforming to UL 224. Wire identification same as corresponding terminal block identification unless otherwise shown.

21. Control Wiring: All internal control wiring in each control panel factory installed in accordance with the following requirements:

a. Wire: Copper conductor minimum 14 AWG, insulation rated 600V, or as shown Type SIS or equal. Use flexible Class C or high-strand insulated copper wire for wiring across hinged joints.

b. Use one continuous length of wire from terminal to terminal without splice or tap.

c. Design and install control wiring so that trouble in one circuit can not be communicated to control wiring of another circuit.

d. Make connections only at terminals of device, on terminal blocks or on control buses. Make wiring connections using insulated-shank ring-type terminals.

e. Terminal blocks: With washerhead screw-type terminals, circuit-marking strips for indicating control wire number, phenolic laminated dust cover and 10 percent minimum spare terminal points.

f. For each wire, use corresponding identification on terminal block marking strips and identify internal wiring at each termination, with same number as that shown on wiring diagram, using plastic sleeve.

g. External wiring:

- 1) External control wiring to enter from top or bottom as required.

- 2) Allow space to route and terminate external single-conductor or multiple-conductor control cable.

B. Trackside Heater Control Panels:

1. Equipped with the following components mounted in a fiberglass enclosure.
  - a. 2 - Molded case switches.
  - b. 2 - Magnetic current relays (IA & IB).
  - c. 1 - Auxiliary time delay relay (Contactor Closing Relay CX) with 125V DC coil, 5 to 50 seconds adjustable delay on pick-up.
  - d. 1 - Control power transformer.
  - e. 1 - 480V AC fuseblock with two fuses.
  - f. 1 - 120V AC fuseblock with one fuse.
  - g. 1 - DC contactor (with bridge rectifier & dropping resistance).
  - h. 2 - 1000V DC fuses and fuseblocks.
  - i. 1 - 14-point terminal board for control wiring.
  - j. 1 - 3-stud terminal board for nominal 750V DC heater power.
  - k. 1 - Space heater.
2. Insulated barrier around DC contactor for isolation from other equipment.
3. Indicating lights, lamp test switch, and selector switch (ON-OFF-REMOTE) mounted on sides of enclosure, as shown on drawings, so as to maintain NEMA 3R rating of the enclosure.
4. Two limit switches (door interlock) provided so as to de-energize DC contactor upon removal of front panel.
5. All internal wiring of components up to terminal boards completed and tested at the factory.
6. All control wiring within trackside heater control panels shall leave a minimum voltage rating of not less than 1000V.
7. Nameplates:
  - a. Each lamp test and selector switch provided with ½-inch high nameplate inscribed with lettering ¼-inch high as shown below and applicable.
    - 1) LAMP TEST SWITCH
    - 2) SELECTOR SWITCH
  - b. Each panel provided with 1-½-inch high nameplate inscribed with 1-inch high lettering identifying the trackside heater control panel and associated number as shown below. A typical example of engraving is as follows:

- 1) TRACKSIDE HEATER CONTROL PANEL
- 2) HC-J02-62-1\*

SPECIFIER'S NOTE (\*): NUMBER SHOWN IS AN EXAMPLE. SPECIFIER SHALL COORDINATE AND PROVIDE CORRECT DESIGNATION.

8. Provide one spare fuse of each type and rating for each panel.

C. Zone Heater Control Panels provided in tie breaker stations and traction power substations.

1. Equipped with the following components mounted in an enclosure: (Quantities may be adjusted to suit site conditions and contact rail heating plans/zones.)

- a. 4 - Auxiliary relays with 125V DC coils (1X1-A, 1X1-B, 1X2-A, & 1X2-B).
- b. 2 - 24V DC auxiliary relays for Supervisory Control (HCR-1,HCR-2).
- c. 4 - 125V DC fuses and fuseblocks on mounting tracks.
- d. 1 - 24-Point terminal board for power and control wiring.
- e. 1 - 18-Point terminal board for future remote control and indication.

2. Following components mounted on the door: (Quantities may be adjusted to suit site conditions and contact rail heating plans/zones.)

- a. 4 - Indicating lights (push to test).
- b. 2 - Selector switches (ON-OFF), two pole.
- c. 1 - Selector switch (LOCAL/REMOTE), two pole.

3. All internal wiring of components up to terminal boards completed and tested at the factory.

4. Nameplates:

- a. Each indicating light and selector switch provided with ½-inch high nameplate inscribed with ¼-inch high lettering identifying the track number as per contact rail heating plans developed by the contractor. A typical example of engraving is as follows:

TRACK #1-A

- b. Each panel provided with 1-½-inch high nameplate inscribed with 1-inch high lettering identifying the zone heater control panel and associated number as per traction power zones. A typical example of engraving is as follows:

ZONE HEATER CONTROL PANEL

E-J02-60\*

SPECIFIER'S NOTE (\*): NUMBER SHOWN IS AN EXAMPLE. SPECIFIER SHALL COORDINATE AND PROVIDE CORRECT DESIGNATION.

5. Provide one spare fuse of each type and rating for each panel.

D. Fusebox Disconnect:

1. Weatherproof outdoor construction box equipped with cover which removes fuse and disconnects 750V DC circuit when cover is removed. Rated for 100A at 1000V DC.
2. Fuse:
  - a. Type - Current limiting blade type.
  - b. Voltage rating - 1000V DC.
  - c. Current rating - 70 A.
  - d. Interrupting capacity - Capable of interrupting up to 80,000A fault current for bolted fault with system time constant of 40 milliseconds.
  - e. Gould Shawmut Form 101 AMP-TRAP Cat A150C - Type 4 or approved equal.
3. Box: "Shoe Box" shaped enclosure. Gasketed cover with insulated handle and weatherproof hold down devices, with the following additional requirements:
  - a. Removable cover designed to hold fuse and provide connections to the fixed terminals inside the box, minimum pull-out force of 6 pounds.
  - b. Fixed terminals provided in box with spring reinforced clips for making connection to fuse, and bolted connection for cable lugs.
  - c. Material: ½"-thick NEMA grade GPO-3 fiberglass laminate, flame and track resistant material.
  - d. Drain hole: ½"-diameter with nylon screen in bottom.
  - e. Mounting: For side mounting to galvanized steel plate with studs or bolts as furnished with the box.
  - f. Cable entry at one end for 1-#4 AWG, 2000V, single - conductor cable and at other end for 2-#8 AWG, 2000V single-conductor cables. Seal fittings with compression gasket to suit as approved.
  - g. Ultra-violet protection: Fiberglass material containing ultra-violet inhibitor or coated with polyurethane paint 1.5 mils minimum dry film thickness on both inside and outside surfaces.
  - h. Cover gasket: Oil-resistant neoprene with oil-resistant adhesive to cover.
  - i. Danger labels: Both sides of box shall be labeled with prominent and permanent labels with red background and white letters stating:

DANGER-750 VOLTS - DO NOT OPERATE UNDER LOAD:
4. Provide one spare fuse for each fusebox disconnect.
5. Fusebox disconnect shall be manufactured by Mining & Urban Transit System Corporation or approved equal.

E. Master Heater Control Panel:

1. Yard Substation
    - a. Equipped with the following components mounted in an enclosure: (QUANTITIES TO BE SPECIFIED BY SPECIFIER).
      - 1) Auxiliary time delay relays (T) with 125V DC coil adjustable from 5 to 50 seconds, AGASTAT 7012 PD or Equal. Provide one relay per traction power zone.
      - 2) Auxiliary relays with 125V DC coil (IX1). Provide one relay per traction power zone.
      - 3) One auxiliary relay with 125V DC coil (RX)
      - 4) 125V DC fuses and fuseblocks on a mounting track.
      - 5) 42-Point terminal board for power and control wiring.
      - 6) 42-Point terminal board for future use.
    - b. Following components mounted on the door: (QUANTITIES TO BE SPECIFIED BY SPECIFIER).
      - 1) Indicating lights. One light per traction power zone.
      - 2) Selector switches (ON-OFF), single pole. One selector switch per traction power zone.
      - 3) Selector switch (LOCAL-REMOTE), single pole.
  2. All internal wiring of components up to terminal board shall be completed and tested at the factory.
  3. Nameplates:
    - a. Each indicating light and selector switch provided with ½-inch high nameplate inscribed with ¼-inch high lettering identifying the zone number as per contact rail heating plans developed by contractor. A typical example of engraving is as follows:
 

ZONE #1
    - b. Each panel provided with 1-½-inch high nameplate inscribed with 1-inch high lettering identifying the master heater control panel and associated number as per contact rail heating plans developed by contractor. A typical example of engraving is as follows:
 

MASTER HEATER CONTROL PANEL  
E-GY-B98-30\*
- SPECIFIER'S NOTE (\*): NUMBER SHOWN IS AN EXAMPLE. SPECIFIER SHALL COORDINATE AND PROVIDE CORRECT DESIGNATION.
4. Provide one spare fuse of each type and rating for each panel.

F. Remote Heater Controller (Yard Control Tower):

1. Equipped with the following components mounted in a metallic, NEMA 12, heavy duty enclosure as shown:
  - 1-Selector switch (ON-OFF)
  - 2-Indicating lights, lens color as shown on drawings.
2. Nameplates:
  - a. Each controller provided with 1½-inch high nameplate inscribed with 1-inch high lettering stating:

REMOTE HEATER CONTROLLER

**2.07 SOURCE QUALITY CONTROL**

- A. Trackside heater control panel, zone heater control panel, fusebox disconnects, master heater control panel and remote heater controller:
  1. Verify that wiring is in accordance with approved wiring diagrams.
  2. Check wiring for accuracy, open circuits, short circuits, ground connections and insulation integrity by means of high-potential, continuity and operational tests.
  3. Subject wiring to high-potential test of 2,500 volts, 60 Hertz to ground for one minute.

**PART 3 EXECUTION**

**3.01 INSTALLATION**

- A. Install trackside heater control panels, zone heater control panels, fusebox disconnects, master heater control panel and remote heater controller where shown by contractor and approved by the Engineer.
- B. Complete the power wiring circuits and the control power circuits as shown on drawings and in accordance with approved shop drawings.
- C. Contact Rail Preparation:
  1. Steel or Aluminum-Clad (Composite) Contact Rail: Clean the side of contact rail where heater cable is to be installed in accordance with manufacturers instructions. Exercise extreme care when cleaning the aluminum extrusion (composite rail) to prevent surface gouging.
  2. Install heater cable elements within four (4) hours of rail surface preparation at each individual job location.
  3. Obtain written approval from Engineer when motorized tools are to be used to accomplish wire brushing of rail surface.
- D. Installation of Heater Cable:
  1. Heater circuit lengths shown on contract drawings are diagrammatic. Contractor may make field survey and measurements for actual lengths in order to avoid wastage.
  2. Prepare contact rail surfaces prior to heater cable installation.

3. Where heater cable is installed on field side, terminate the heater cable as close as possible to either the end-approach or the traction power cable connections to the third rail. Do not install heater cable over end-approach, power cable connections or expansion joint.
4. Where heater cable is installed on railside, terminate the heater cable as close as possible to the end-approach of the contact rail. The cables for connections and power termination on either side shall be routed to the field side for continuation of circuits and shall be secured safely without any slack to avoid their interference with rail or equipment movement on the rail side.
5. Adhere to the installation instructions noted in these Specifications, as well as those contained on the Plans and in the heater cable manufacturer's installation instructions. Bring any differences to the immediate attention of the Engineer for clarification.
6. For aluminum clad contact rail, and for steel contact rail, install heater cable on side of contact rail. Installed location as indicated on drawings is on the side of the web of the rail, near the foot of the rail. However, an alternate (and preferred) location for the heater cable is on the side of the rail web as close as possible to the underside of the rail head, to maximize transfer of heat from the heater cable into the rail head (provided that such an installation maintains contact between the heater cable and the rail during typical temperature cycles and extremes.) Regardless of location, make sure that complete heater assembly does not interfere with operation of collector shoe or contact rail protection covers, assemblies, etc.
7. In general, installation of heater cable involves utilization of a fiberglass channel and clip system to provide intimate contact between the element itself and the rail surface. Mechanical strain relief clamps are also used when going around rail splice bars and at element ends.
8. Each particular contact rail site scheduled for heater installation work, will require discrete heater cable lengths. Provide all required heater cable lengths.
9. Provide special abrasion pads for protection of the heater cable at any protrusion or burrs on rail and splice plates. Do not install fiberglass channel on such locations.
10. Route power lead wires away from the head of the rail and secure to prevent damage by passing trains.

### **3.02 IDENTIFICATION**

- A. Identify field assembled heaters at the power termination and with Circuit number description using a heat shrinkable permanent ink labeling system.

### **3.03 FIELD QUALITY CONTROL**

- A. Furnish equipment required to perform tests. Prior to insulation resistance tests, isolate the heater circuit. Conduct tests in the presence of the Engineer.
- B. Perform heating system testing (which includes all of the control panels and the fusebox disconnects) in each subsystem to complete the testing of the total installed system specified in Article 1.05.
- C. Submit test procedure for approval and perform approved tests. Do not perform tests without approved test procedure. Schedule all tests through the WMATA Engineer. Tests include but not limited to the following:

1. Visually inspect heater for continuous coverage by the containment channel, sufficient attachment clips, and abrasion pads at all welds, brackets, and obstructions.
2. Measure insulation resistance using 1000V DC megger between heater conductors and contact rail. Must be greater than 1000 megohms - ft.
3. Perform operation tests.

D. Field Testing and Inspection:

1. General Requirements:

- a. Conduct field testing and inspection of each sub-system to ensure proper operation of equipment provided.

2. Field Inspection:

- a. Prior to field testing, check equipment installation, including verification of the following:
  - 1) Integrity of insulation.
  - 2) Integrity of #4 AWG cable exothermic connection to contact rail and running rail.
  - 3) Tightness of connections for control, power and ground wiring.
  - 4) Adequate support to provide proper contact between heater cable and contact rail.
  - 5) Adjustment of pick-up current of each magnetic current relay.
  - 6) Adjustment of time-delay pick-up time for each time-delay relay.
  - 7) Proper operation of door safety interlocking in track-side heater control panel.

3. Field Testing:

- a. Furnish equipment required to perform tests and provide evidence of calibration.
- b. Provide services of manufacturer's engineering representative and supporting field crew.
- c. Prior to insulation resistance tests, disconnect instruments and equipment which might be damaged during such tests. Conduct tests in presence of the WMATA Engineer.
- d. Submit test procedure for approval and perform approved tests. Do not perform tests without approved test procedure. Schedule all test through the WMATA Engineer.
- e. Perform insulation resistance test of 60-second duration on all equipment in accordance with the following requirements:
  - 1) Test Voltage:

Voltage Rating

Test Voltage

150-750V

1,000V, DC

2) Insulation resistance: kV rating plus one megohm but not less than minimum value recommended by manufacturer.

f. Continuity Check

g. Perform functional tests on control, interlocking, and supervisory indication circuits, including verification of interconnections between equipment and interface points.

h. Energize and test each heater circuit for proper operation.

D. Field Testing Personnel:

1. Provide services of qualified manufacturer's engineering representatives to perform specified field testing program.
2. When more than one representative is involved, the Contractor is responsible for coordination of testing effort.
3. Provide engineers, technicians and journeymen as necessary to set up and implement testing.

E. Submit certified test reports within seven days after field tests.

**END OF SECTION**

## SECTION 16320

### HIGH-VOLTAGE SWITCHGEAR

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing 13.8 kV and 34.5 kV metal-clad switchgear.
- B. Related Work Specified Elsewhere:
  - 1. Raceways, boxes, and cabinets: Section 16130.
  - 2. Wire, cable and busways: Section 16120.
  - 3. Wire connection accessories: Section 16125.
  - 4. Grounding and bonding: Section 16060.
  - 5. Unit substations: Section 16360.
- C. Design Criteria:
  - 1. Floor loading: Switchgear compatible with floor design-loading of 250 pounds per square foot.
  - 2. Switchgear suitable for anchoring to a concrete floor steel-trowel finished to tolerance level of 1/8 inch in 10'-0".

##### 1.02 QUALITY ASSURANCE:

- A. Qualifications: Select a manufacturer who is regularly engaged in production of similar switchgear.
- B. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of jurisdictional authorities.
  - 2. NEC.
  - 3. NEMA: SG4.
  - 4. ANSI: C37.06, Z55.1.
  - 5. ANSI/IEEE: C37.09, C37.20.2, C37.90, C57.13, C62.11.
  - 6. AHA: IS1.
- C. Factory Testing: Submit design tests or certified copies of test reports for identical units performed for each type and rating of circuit breaker as assembled in its complete switchgear unit including bus compartment.
  - 1. Circuit-breaker tests: In accordance with the requirements of ANSI/IEEE C37.09 including the following:
    - a. Design tests:
      - 1) Rated maximum voltage.
      - 2) Rated voltage-range factor.
      - 3) Rated frequency.
      - 4) Rated continuous-current test.
      - 5) Short-circuit rating.
      - 6) Rated standard operating duty.
      - 7) Rated permissible tripping delay.
      - 8) Rated interrupting time.
      - 9) Rated reclosing time.
      - 10) Rated dielectric strength.
      - 11) Rated control voltage.
      - 12) Load-current switching.
      - 13) Mechanical life.

- b. Production tests: Applicable tests in accordance with ANSI/IEEE C37.09.
  - 2. Switchgear assembly tests: In accordance with ANSI/IEEE C37.20.2 and including the following:
    - a. Design tests for metal-clad switchgear:
      - 1) Dielectric tests.
      - 2) Rated continuous-current tests.
      - 3) Short-time current-withstand test.
      - 4) Momentary-current test.
      - 5) Mechanical endurance tests.
      - 6) Flame-resistance and tracking-resistance tests for sheet, molded or cast insulating materials for support of primary buses and connections.
      - 7) Flame-resistance test for applied insulation metal-clad switchgear.
      - 8) Paint qualification test.
    - b. Production tests for metal-clad switchgear: Applicable tests in accordance with ANSI/IEEE C37.20.2.

### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings: In accordance with Section 16360.
  - 2. Certification:
    - a. Certify switchgear complies with 250 pounds per square foot floor-load design.
    - b. Certified test reports for specified factory testing.
  - 3. Documentation:
    - a. Short-circuit calculations and coordination study: In accordance with Section 16360.
    - b. Field-testing plan: In accordance with Section 16360.
  - 4. Operations and Maintenance Manuals: In accordance with Section 16360.

### 1.04 PRODUCT DELIVERY, STORAGE, AND HANDLING:

- A. Ship each unit securely packaged, braced and labeled for safe handling in shipment and to avoid damage or distortion.
- B. Temporary Bracing:
  - 1. Where necessary, brace switchgear for hoisting, lowering and skidding into position. Label temporary internal bracing of switchgear:
    - a. TEMPORARY-REMOVE BEFORE OPERATION
- C. Protection Against Concealed Damage:
  - 1. Include within shipping container mechanical impact recorder of rating recommended by manufacturer for shipment by railroad and submit impact-record chart with manufacturer's instructions for disposition of damaged material.
- D. Assembly for Shipment:
  - 1. Design enclosures to permit lifting by jacks or slings and moving horizontally on rollers or skidding in any direction.
  - 2. Maximum dimensions of shipping sections to be coordinated with the dimensions of access hatches, corridors and doors to ensure shipping dimensions will allow movement of switchgear through structure without damage to equipment or structure or undue difficulty.

3. For shipping split, coil interconnecting wiring on one side of the shipping split with matching terminal block on other side of split. Identify wiring and terminal-block points for reconnection.
  4. Draw-out relays mounted in their proper cases with moving parts properly secured and packed for shipment.
  5. Removable circuit-breaker elements packaged separately.
- E. Store switchgear in secure and dry storage facility.

#### **1.05 OPERATION AND MAINTENANCE TRAINING:**

- A. In accordance with the General Requirements and with Section 16360.

### **PART 2 - PRODUCTS**

#### **2.01 PRODUCTS AND MATERIALS:**

- A. General Requirements for 13.8 kV and 34.5 kV Metal-Clad Switchgear:
1. ANSI/IEEE C37.20.2, for indoor use.
  2. Common ratings of switchgear:
    - a. Rated frequency: 60 Hertz.
    - b. Rated continuous current: 1,200 amperes.
    - c. Rated momentary current: Corresponding to circuit-breaker momentary ratings.
  3. Insulation structure:
    - a. Material not to support combustion, produce toxic gases, absorb moisture or track.
    - b. When subjected to electric arc, emission of conducting materials from insulating structure limited so as not to interfere with performance of circuit breaker.
  4. Primary circuit breaker:
    - a. NEMA SG4 and ANSI C37.06, for indoor use.
    - b. Type: Three-pole, single-throw, drawout-type.
    - c. Electrically powered, spring-charged, stored-energy operating mechanism, with the following additional requirements:
      - 1) Voltage requirements:
        - a) Charging of stored-energy operating mechanism: 125 volts dc.
        - b) Closing by means of closing release coil capable of operation from 100-140 volts dc.
        - c) Tripping by means of shunt trip coil capable of operation from 70-140 volts dc.
      - 2) Mechanically and electrically trip-free.
      - 3) Unless otherwise specified, closing release coil energized by means of push-button.
      - 4) Shunt trip coil energized manually by push-button or automatically by relay.
      - 5) Equipped with mechanical devices on front of breaker to actuate closing and tripping operations in case of failure of control power.
      - 6) Compressed-spring, stored-energy operating mechanism, with sufficient energy storage for closing/opening operation at rated short-circuit current or at related capabilities.
      - 7) Stored-energy mechanism automatically charged within 10 seconds following each closing of circuit breaker.

- 8) Stored-energy mechanism suitable for manual charging by means of removable handle in case of failure of control power.
  - 9) White indicator light on control panel of circuit-breaker unit or mechanical indicator on front of breaker to indicate that stored-energy closing mechanism is charged.
- d. Racking mechanism:
- 1) Horizontal-drawout breaker: Manually-operated mechanism designed to permit racking of breaker with door closed by inserting crank through opening of limited size in door.
  - 2) Vertical-lift breaker:
    - a) Racking accomplished electrically using control switch inserted into receptacle mounted on breaker door to permit racking with door closed.
    - b) White and amber indicator lights provided at raise/lower control switch.
    - c) Manual racking mechanism for emergency use.
  - 3) Racking-mechanism gear ratio: To permit one man to raise or lower breaker or rack it in and out manually in four minutes maximum.
  - 4) When breaker element is in fully-lowered or racked-out position, circuit breaker, complete with its operating mechanism, capable of being withdrawn from housing and moved on wheels integral with mechanism. Separate handling device for moving circuit breaker, other than transfer truck or fifth-wheel steering bar, is prohibited.
  - 5) Positive stops for preventing overtravel and guides for proper alignment of breaker.
- e. Grounding:
- 1) When breaker is in connected position, case and frame grounded by positive contact with ground bus.
  - 2) Breaker ground shoe designed to connect breaker frame to ground bus prior to engagement of primary-breaker terminals.
  - 3) Ground connection capable of carrying fault current equal to rated short-circuit current and related necessary capabilities.
- f. Interlocks: Provide suitable interlocks to perform the following functions:
- 1) Automatic discharge of stored-energy mechanism of the circuit breaker prior to its withdrawal from the unit.
  - 2) Prevent raising and lowering or racking in and out unless circuit breaker is in OPEN position.
  - 3) Prevent removal of vertical-lift breaker until it is entirely lowered.
  - 4) Prevent either electrical or manual operation of the breaker unless it is in the operating or test position.
  - 5) Automatically trip associated secondary main breaker when the primary breaker trips. This interlocking scheme does not prevent primary breaker from closing when associated secondary main breaker is open.
- g. Primary connection: Connection between the removable and stationary unit made by male-and-female contacts, with the following additional requirements:
- 1) Silver-plated, high-pressure contacts.
  - 2) Automatic shutter to cover contact orifice when breaker is withdrawn and to uncover orifice when breaker is returned to connected position.
  - 3) Automatic shutters constructed to withstand force of racking mechanism in case shutters fail to open when breaker is racked into position.

- h. Secondary connection: Control and interlocking-circuit connections between stationary and removable elements of switchgear made using device consisting of recessed stationary receptacle and set of self-aligning multiple-contact plugs on removable elements with sufficient number of contacts to accommodate control and interlock circuits, including spares, without resorting to auxiliary relays.
  - i. Non-resettable mechanical-operation counter registering one count for each circuit-breaker closing operation.
  - j. Mechanical position indicator, showing breaker as OPEN or CLOSED.
  - k. Auxiliary contacts for indicating CLOSED and OPEN position of the circuit breaker at remote location, with the following additional requirements:
    - 1) Dry contacts, minimum of one NC and one NO, rated 250 milliamperes at 250 volts or three amperes at 24 volts dc, wired to accessible terminal block.
    - 2) Contact resistance not to exceed 0.10 ohm in closed state when operating in circuit with open-circuit voltage of three volts dc and closed-circuit current of 10 milliamperes.
    - 3) Contact bounce not to exceed five milliseconds.
5. Current transformers:
- a. ANSI/IEEE C57.13, molded rubber or epoxy construction, wound-type transformer, complying with ANSI/IEEE requirements for relaying accuracy classification under burden imposed by devices specified. Minimum relay current transformer accuracy class is C-200. Mounted in a compartment isolated from the control panel. When approved by the Engineer, fully insulated, window-type current transformer may be used.
  - b. Quantity: Three.
  - c. Current ratio: As shown and determined by approved coordination study.
  - d. Insulation class:
    - 1) 13.8 kV with basic-impulse insulation level of 95 kV full-wave.
    - 2) 34.5 kV with basic-impulse insulation level of 150 kV full-wave.
  - e. Capable of withstanding thermal and magnetic stresses from flow of current equal to the momentary and interrupting rating of the circuit breaker.
  - f. Maximum allowable-temperature rise under continuous full load above an average ambient temperature of 55C:
    - 1) By winding resistance: 30C.
    - 2) By hottest spot in winding: 40C.
  - g. Transformer secondary neutral and frame individually grounded by copper wire to switchgear ground bus. Keep each ground connection run as short as possible. Avoid grouping such connections with control or other wiring.
6. Potential transformers:
- a. ANSI/IEEE C57.13, molded rubber or epoxy, one of the following configurations:
    - 1) Current-limiting primary fuses mounted on drawout carriage.
    - 2) Drawout transformer with integrally mounted fuses.
  - b. Quantity: One.
  - c. Connection:
    - 1) For 13.8 kV source: Phase-to-ground.
    - 2) For 34.5 kV source: Phase-to-phase.
  - d. Voltage ratio:
    - 1) For 13.8 kV source: 14.4 kV to 120 volts.
    - 2) For 34.5 kV source: 34.5 kV to 115 volts.
  - e. Insulation class:
    - 1) For 13.8 kV source: 13.8 kV with basic-impulse insulation level of 95 kV full-wave.
    - 2) For 34.5 kV source: 34.5 kV with basic-impulse insulation level of 150 kV full-wave.

- f. Maximum allowable temperature rise under continuous full load above average ambient temperature of 55C:
    - 1) By winding resistance: 30C.
    - 2) By hottest spot in winding: 40C.
  - g. Install in switchgear so as to allow access from the floor without use of ladder.
7. Protective relays:
- a. General requirements:
    - 1) Semi-flush mounted, adjustable drawout relays each with test switches.
    - 2) Rustproof-metal rectangular cases finished in dull black.
    - 3) With targets, hand reset for targets and seal-in units.
    - 4) Contact and adjusting device readily visible, accessible and adjustable from front of relay.
    - 5) Designed, constructed and tested in accordance with applicable requirements of ANSI/IEEE C37.90.
  - b. Overcurrent relays:
    - 1) Three 50/51 phase-time and instantaneous-overcurrent relays and one 50N/51N residual ground-time and instantaneous-overcurrent relay for 34.5 kV service or three 50/51 phase-time and instantaneous-overcurrent relay and one 50N residual-ground instantaneous-overcurrent relay for 13.8 kV service, as appropriate.
    - 2) Exact characteristics and settings determined by manufacturer to provide necessary protection and coordination.
    - 3) Having very inverse time characteristics where protection and coordination permit.
    - 4) Relays set as low as practicable, time-dial setting and current tap, to provide fault protection and coordination with overcurrent device on associated secondary main breaker.
    - 5) Relays operating associated lockout relay as follows:
      - a) 13.8 kV switchgear: Relays 50/51 and 50N.
      - b) 34.5 kV switchgear: Relays 50/51 and 50N/51N.
  - c. Voltage relay:
    - 1) For 13.8 kV source: One undervoltage/overvoltage (27/59), single-phase, time-voltage relay.
    - 2) For 34.5 kV source: One undervoltage (27), single-phase, time-voltage relay.
  - d. One rotary, hand-reset, 125-volt dc lockout relay, equipped with green light for indicating reset position.
  - e. Auxiliary relays: Provided where required, General Electric Company Type HGA or HFA or equal, mounted inside instrument compartment.
  - f. Relay test equipment: One test set suitable for testing all solid-state relays furnished.
8. Circuit-breaker control switch:
- a. Heavy-duty, rotary, with red pistol-grip operating handle, switch position marked TRIP/NORMAL/CLOSE, with spring return to normal and indicator lights as follows:
    - 1) Red light: Circuit breaker is closed.
    - 2) Green light: Circuit breaker is open.
    - 3) Amber light: Circuit breaker is automatically tripped.
9. Test switches:
- a. Provided between instrument transformers and the protection relays as follows:
    - 1) One test switch on line side of overcurrent relays and lockout relay.
    - 2) One test switch on line side of undervoltage/overvoltage relay.
10. Control panel:

- a. For relays, meters and control equipment, hinged panel of formed steel, with rolled edges and conveniently located handle for opening.
11. Line-voltage indicators:
- a. Three neon glow-tube, capacitance-coupled, high-voltage indicators, Airco Type RS or equal.
12. Surge arrester:
- a. ANSI/IEEE C62.11, intermediate class with metal-oxide varistor construction, one per phase, mounted on line side of circuit breaker with the following requirements:
    - 1) For 13.8 kV source: Hubbell/The Ohio Brass Company Type PVI, Catalog Number 218613, or equal, with ratings as follows:
      - a) Duty-cycle voltage kV, rms: 15.
      - b) Maximum continuous operating voltage, kV, rms: 12.7.
      - c) Insulation-withstand impulse test voltage, kV: 110.
    - 2) For 34.5 kV source: Hubbell/The Ohio Brass Company Type PVR, Catalog Number 218629; General Electric Company Tranquell XE, Catalog Number 9L12PGB036; or equal; with ratings as follows:
      - a) Duty-cycle voltage, kV, rms: 36.
      - b) Maximum continuous operating voltage, kV, rms: 29.
      - c) Insulation-withstand impulse test voltage, kV: 200.
13. Indicator lights:
- a. LED
14. Space heaters:
- a. Each unit of switchgear provided with 120-volt, single-phase, 60-Hertz heating element to facilitate drying and prevent condensation.
  - b. Heaters enclosed in grille guard with no sharp edges and located so that they are accessible for replacement without requiring de-energization of switchgear bus. Heaters controlled by thermostat adjustable from 40F to 80F. Panel ammeter, approximately 2-1/2 inches square, marked to indicate heater load. Thermostat set in accordance with manufacturer's recommendations.
  - c. Power and control circuits to heaters and thermostat connected and protected up to devices and to incoming junction box with 1/2-inch minimum size conduit. Heater-power junction box sized four inches square by two inches minimum and located at top of switchgear for top entry of minimum 3/4-inch conduit.
15. Instrument and control wiring:
- a. Instrument and control wiring including electrical interlocks and intercompartment wiring factory-installed in accordance with the following requirements:
    - 1) Wire:
      - a) Copper conductor minimum 14AWG, insulation rated 600 volts, Type SIS or equal. Use flexible Class C or higher stranded, insulated copper wire for wiring across hinged joints.
    - 2) Use one continuous length of wire from terminal to terminal without splice or tap.
    - 3) Install and connect removable-element control wiring in accordance with manufacturer's standards for circuit-breaker wiring.
    - 4) Design and install control wiring so that trouble in one main circuit cannot be communicated to control wiring of another main circuit.
    - 5) Make connections only at terminals of device, on terminal blocks or on control buses. Make wiring connections using insulated-shank ring-type terminals.
    - 6) Terminate interconnecting wiring between cubicles and compartments on terminal blocks before wiring to components.

- 7) Terminal blocks: With washerhead screw-type terminals, circuit-marking strips for indicating control-wire number, phenolic laminated dust cover and 10-percent minimum spare terminal points.
  - 8) For each wire, use corresponding identification on terminal-block marking strips and identify internal wiring at each termination, with same number as that shown on wiring diagram, using plastic sleeve.
  - 9) External wiring:
    - a) External control wiring to enter from bottom or top.
    - b) Allow space to route and terminate external single-conductor or multiple-conductor control cable.
    - c) Top entrances provided with removable coverplates for field-drilling of conduit and cable entrance holes.
  - 10) Tests:
    - a) Check wiring for accuracy, open circuits, short-circuits, ground connections and insulation integrity by means of high-potential, continuity and operational tests.
    - b) Subject wiring to high-potential test of 1,500 volts to ground for one minute.
    - c) Verify that wiring is in accordance with manufacturer's wiring diagrams. Check complete wiring, including interconnections at shipping breaks.
16. Enclosure:
- a. Dead-front, free-standing, indoor metal enclosure designed for lineup with 13.8 kV to 480Y/277-volt transformer or with 34.5 kV to 480Y/277-volt transformer, as applicable.
  - b. Steel structure with framework of welded or bolted structural steel, free from distortion and welding strain and sufficiently rigid to support equipment under normal and short-circuit conditions.
  - c. Switchgear cubicles and circuit-breaker compartment equipped as follows:
    - 1) 13.8 kV enclosure:
      - a) Front: Hinged door.
      - b) Rear: Bolted cover with alignment pins or hinged door with padlock provisions.
    - 2) 34.5 kV enclosure:
      - a) Front: Breaker-drawout door or hinged door.
      - b) Rear: Bolted cover or hinged door with padlock provisions.
    - 3) Bolted cover furnished with alignment studs and keyhole slots for positioning prior to bolting.
    - 4) Hinged front door in accordance with the following:
      - a) Handle and three-point latch to hold door securely closed.
      - b) Doorstop to hold door open.
      - c) Structural reinforcing provided as necessary to prevent sagging of door.
      - d) Circuit-breaker compartment door designed not to hinder movement of breaker in and out of compartment when door is open and doorstop set.
    - 5) Circuit breaker cubicles to provide for interchangeability of removable circuit-breaker elements.
  - d. Transition compartment sized as necessary, with front and rear bolted covers to line up and coordinate with transformer.
  - e. Finish:
    - 1) Metallic surfaces degreased, primed and finished light-gray enamel, Color No. 61, ANSI Z55.1 in accordance with reference standard; two mils minimum dry-film thickness.

17. Nameplates:
- a. Three-ply, laminated phenolic plates, engraved through black face to white core and attached by means of stainless-steel rivets or screws. Vertical Gothic lettering using a round or square cutter. V-shaped groove is prohibited.
  - b. Provide nameplate on each switchgear showing manufacturer's name and brand designation, the referenced standard, type, class and rating as applicable in accordance with reference standard.
  - c. Provide additional functional nameplates for each component.
    - 1) Each switchgear labeled with nameplate 1-1/2 inches high, inscribed in letters one-inch high: 13.8 kV METAL-CLAD SWITCHGEAR or 34.5 kV METAL-CLAD SWITCHGEAR, as appropriate.
    - 2) Each switchgear compartment labeled with nameplate one-inch high, inscribed in letters 1/2-inch high: INCOMING LINE PRIMARY BREAKER or AUXILIARY COMPARTMENT, as appropriate.
    - 3) In addition to other information normally displayed on equipment, provide one-inch nameplate showing in letters 1/2-inch high switch positions, meaning of indicator lamp and other pertinent information.
18. Major components to be products of the same manufacturer.
19. Switchgear accessories:
- a. One set of the following accessories for each substation as applicable:
    - 1) One breaker test cabinet with provision for electrical operation of circuit breaker with control switch and provision for other accessories as necessary.
    - 2) One transfer truck or fifth-wheel steering bar.
    - 3) Crank for manually racking circuit breaker in switchgear cubicle.
    - 4) One circuit-breaker maintenance lever.
    - 5) One spare set of each type of high-voltage fuse.
    - 6) One complete set of relay test plugs and relay test switch.
    - 7) One set of special tools necessary for erection, operation and maintenance of switchgear including ones recommended by relay manufacturer including breaker secondary or control disconnect coupler.
    - 8) Pegboard: Hardboard, AHA IS1, tempered, S1S, 1/4-inch nominal thickness, perforated, sized to accommodate all products specified in paragraphs 2.1 A.19.a. through 2.1 A.19.g. Framed with one-inch by one-inch hardwood. Frame and hardboard painted color selected by the Engineer. Include hardware for wall mounting and pegboard accessories suited to the products to be mounted. Provide nameplates as specified in paragraph 2.1 A.17. one-inch wide, with accessory names inscribed in 1/2-inch vertical letters.
    - 9) 13.8 kV grounding, phasing and testing device: Designed to be inserted into the switchgear unit in place of and in the same manner as the circuit breaker removable elements, to permit grounding either the bus or the line, or making external connections to either the bus or the line for phasing purposes, testing purposes or both, with the following additional requirements.
      - a) Momentary and three-second current carrying capacities equal to or greater than those of the circuit breaker removable elements.
      - b) BIL rating: 95 kV.
      - c) Include a power-operated circuit closing device (grounding switch) so arranged with a gang-operated three-pole selector disconnect switch to effectively ground either the

bus or the line when the device is inserted into the unit and closed, with the following additional requirements:

- (1) Closing by means of a portable remote control push-button station mounted on the end of a 50-foot, four-conductor, flexible (class C Stranding) cable providing common, close, trip and ground conductors.
  - (2) Power obtained through the secondary disconnecting device in the switchgear unit.
- d) Grounding device solidly connected to the switchgear ground bus in the operated or grounded position. Make provisions for padlocking in the grounded position.
  - e) No automatic tripping provided.
  - f) Provide suitable windows or transparent enclosure and barriers to permit visual observation of the position of all selector switch blades before the device is inserted into the stationary housing.
  - g) Fabricate steel panels from No. 11 USSG steel.
  - h) Connect the selector switch hinge end directly to the grounding switch.
  - i) Provide insulated covers for bolt heads used to attach insulated panel to the front of the device if not at ground potential.
  - j) External connections for testing made by insulated plug connectors for insertion in deep ports or wells accessible at the face of the device. One set of test ports connected directly to the bus. A second set of test ports connected directly to the line terminals.
    - (1) Mount ports on insulating material and provide closing shutters of like material.
    - (2) Provide separate closing shutter for each set of test ports; each shutter with provisions for padlocking in the closed position.
    - (3) Provide three test plugs or probes for each grounding, phasing and testing device for external connections.
  - k) The Contractor is responsible for obtaining approval of shop drawings and submittal including catalog data from electric utility company for the grounding, phasing and testing device prior to manufacturing. Make submittals to the Engineer for obtaining electric utility company approval.

B. 13.8 kV Metal-Clad Switchgear:

1. Rating for switchgear assembly:
  - a. Rated nominal voltage: 13.8 kV.
  - b. Rated maximum voltage: 15.0 kV.
  - c. Insulation level, 60 Hertz withstand: 36 kV, rms.
  - d. Insulation level, impulse withstand: 95 kV.
2. Potheads or terminators:
  - a. Provision for mounting one three-phase pothead or three single-phase terminators or cables terminated with stress cones furnished by 13.8 kV-source electric utility company (Potomac Electric Power Company) for incoming line connections and grounding.
  - b. Short flexible connector installed between each pothead or terminator connecting lug and rigid bus. Where cables are terminated without potheads or terminators, provide two-hole NEMA drilling for cable terminal

- lugs furnished by 13.8 kV-source electric utility company and furnish cable support.
- c. Pothead or terminator mounted in inverted position with incoming service cable at the top and connecting lugs below unless otherwise shown.
3. Primary circuit breaker:
- a. Type: Air-break or vacuum-break.
  - b. Rating on symmetrical basis:
    - 1) Nominal voltage class, kV, rms: 13.8.
    - 2) Nominal three-phase MVA Class: 750.
    - 3) Rated maximum voltage, kV, rms: 15.
    - 4) Rated withstand test voltage:
      - a) Low frequency, kV, rms: 36.
      - b) Impulse, kV: 95.
    - 5) Rated continuous current at 60 Hertz, amp, rms: 1,200.
    - 6) Rated interrupting-time cycles: Five maximum.
    - 7) Rated voltage-range factor (k): 1.30.
    - 8) Rated short-circuit current at rated maximum, kV, amp, rms: 28,000.
    - 9) Maximum symmetrical interrupting capability, amp, rms: 36,000.
    - 10) Closing and latching capability, amp, crest: 97,000.
4. Buses:
- a. General requirements:
    - 1) Copper bus bars of sufficient size to carry specified current without exceeding allowable-temperature rise stated in ANSI, NEMA and IEEE Standards.
    - 2) Capable of withstanding the mechanical stresses and heat from maximum short-circuit current.
    - 3) Bus connections bolted or welded. Contact surfaces of bolted connections silver-plated or tin-plated.
    - 4) Each joint having impedance not more than that of bus bar of equal length and clamped to maintain such impedance throughout life of equipment.
    - 5) Connection coordinated for proper mating with adjacent equipment terminals and enclosures. Provide flexible joint at transformer connection to avoid overstressing transformer or circuit-breaker insulators and coordinated with transformer-bushing locations. Flexible connection to be leaf or braid-type. Provide access plates for assembly and inspection of connections and joints.
  - b. Power buses: Three-phase, three-wire buses fully insulated with factory-installed, flame-retardant, nonhygroscopic, track-resistant insulation. Provide each bolted connection with minimum of four bolts equipped with palnut or equal and fully insulated.
  - c. Incoming-line bus device for connecting portable ground clamp:
    - 1) Connecting device consisting of copper bracket with 7/16-inch diameter bronze or copper rod positioned horizontally and parallel to rear of switchgear.
    - 2) Connecting device mounted near pothead on each incoming bus.
    - 3) Connecting device to provide three-inch length between end supports of rod and minimum 2-1/2 inch radial clearance around rod.
    - 4) Connecting device accessible from rear of switchgear following removal of bolted cover or opening of padlockable door.
    - 5) Six-inch insulating barriers to be provided on each side of connecting devices or stirrups and extending to rear of switchgear a minimum of six inches all around.

- 6) Size, thickness, insulating material and placement of insulating barriers designed to achieve adequate mechanical strength without compromising voltage withstand specified for switchgear.
  - 7) Design coordinated and approved by 13.8 kV-source electric utility company.
- d. Ground bus:
- 1) Copper bus, not less than two inches by 1/4-inch provided throughout length of switchgear section.
  - 2) In switchgear unit where power cables enter or leave switchgear at top as shown, copper ground bus not less than one inch by 1/8 inch extending from main ground bus to top of unit for grounding incoming cable-ground sheath or shielding tape by short connection to bus.
  - 3) Joints in ground bus made with two bolts minimum and overlap of four inches.
  - 4) Mechanical connector provided in each unit for field connection of 4/0 to 500 KCMIL ground cable to switchgear ground bus.
- e. Control bus:
- 1) 125-volt dc bus not less than 6AWG copper.
  - 2) One two-pole knife switch provided in switchgear cubicle for disconnecting control circuit.
  - 3) UL Class J or RK-5 fuses used for control and auxiliary-service protection.
  - 4) Closing circuit fused; tripping circuit unfused.
  - 5) White light mounted on control panel to indicate availability of dc control power.
5. Auxiliary cubicle:
- a. Indoor metal cubicle for installing metering transformers, design coordinated with 13.8 kV-source electric utility company.
  - b. Separate compartment for mounting two 15 kV current transformers furnished by 13.8 kV-source electric utility company, with the following additional requirements:
    - 1) Current transformer accessible through sealable hinged door. Bolted access plates prohibited.
    - 2) Connection between bus and current transformer of same size and current rating as that of main bus.
    - 3) Compartment sized and arranged so that current transformer can be readily removed or replaced after cubicle is installed as integral part of switchgear assembly.
  - c. Separate compartment for mounting two 14,400/120-volt potential transformers furnished by 13.8 kV-source electric utility company, with the following additional requirements:
    - 1) Equipped with sealable hinged door. Bolted access plates prohibited.
    - 2) Fuse clips one-inch long, mounted on 11-1/2 inch centers for accommodating fuse size 1-9/16 inch diameter ferrules and 12-7/8 inches long.
    - 3) Provide silver-plated contact designed to provide adequate contact pressure.
    - 4) Drawout carriage designed so that contacts are disconnected and visibly grounded before fuses become accessible for checking or replacement.
      - a) Sealable in closed and operating positions.
      - b) Equipped with high-voltage connectors and fuse clips.
    - 5) For grounding cases of transformers, one connection extended from ground bus to the potential-transformer compartment.

- 6) Compartment designed to provide access to potential transformers from the floor without use of ladder.
  - d. One 10-inch square by six-inch deep pull box for secondary connecting of electric utility company metering transformers, with the following additional requirements:
    - 1) Equipped with two 1-1/2 inch conduits, one to current-transformer compartment and one to potential-transformer compartment.
    - 2) Provision for installing one 1-1/2 inch conduit from pullbox to electric utility company metering panel.
- C. 34.5 kV Metal-Clad Switchgear:
- 1. Rating for switchgear assembly:
    - a. Rated nominal voltage: 34.5 kV.
    - b. Rated maximum voltage: 38.0 kV.
    - c. Insulation level, 60 Hertz, withstand: 80 kV, rms.
    - d. Insulation level, impulse withstand: 150 kV.
  - 2. Terminators:
    - a. Provision for mounting one double three-phase pothead or six single-phase terminators furnished by 34.5 kV-source electric utility company for incoming-loop line connections and grounding.
    - b. Short flexible connector installed between each pothead or terminator connecting lug and rigid bus.
    - c. Terminator mounted in inverted position with incoming-service cable at top and connecting lugs below unless otherwise shown.
  - 3. Primary circuit breaker:
    - a. Vacuum-break type.
    - b. Rating on symmetrical basis:
      - 1) Nominal voltage class, kV, rms: 34.5.
      - 2) Nominal three-phase MVA Class: 1,500.
      - 3) Rated maximum voltage, kV, rms: 38.
      - 4) Rated withstand test voltage:
        - a) Low frequency, kV, rms: 80.
        - b) Impulse, kV: 150.
      - 5) Rated continuous current at 60 Hertz, amp, rms: 1,200.
      - 6) Rated interrupting-time cycles: Five maximum.
      - 7) Rated voltage-range factor (k): 1.41.
      - 8) Rated short-circuit current at rated maximum, kV, amp, rms: 21,000.
      - 9) Maximum symmetrical interrupting capability, amp, rms: 35,000.
      - 10) Closing and latching capability, amp, crest: 95,000.
  - 4. Buses:
    - a. General requirements:
      - 1) Copper or aluminum bus bars of sufficient size to carry specified current without exceeding allowable temperature rise stated in ANSI, NEMA and IEEE Standards.
      - 2) Capable of withstanding mechanical stresses and heat from maximum short-circuit current.
      - 3) Bus connections bolted or welded.
      - 4) Contact surfaces of bolted connections silver-plated or tin-plated.
      - 5) Each joint having impedance not more than that of bus bar of equal length and clamped to maintain such impedance throughout life of equipment.
      - 6) Aluminum buses having torque requirements for bolted connections stamped on buses near connection point. Where such stamping is impracticable, use approved alternative methods of providing near

- connection durable and plainly visible statement of torque requirements.
- 7) Make copper-to-aluminum joints using connectors especially designed for the purpose.
  - 8) For each bolted connection of aluminum or aluminum-to-copper buses, provide belleville washer to maintain positive pressure on joint.
  - 9) Connection coordinated for proper mating with adjacent equipment terminals and enclosures. Provide flexible joint at transformer connection to avoid overstressing transformer or circuit-breaker insulators and coordinated with transformer-bushing locations. Flexible connections shall be leaf or braid-type. Provide access plates for assembly and inspection of connections and joints. Where aluminum bus is provided, make connections, between circuit breaker and power bus and between terminators and power bus by means of copper bus or connectors.
- b. Power buses: Three-phase, three-wire buses fully insulated with factory-installed, flame-retardant, nonhygroscopic, track-resistant insulation. Provide each bolted connection with minimum of four bolts equipped with palnut or equal and fully insulated.
- c. Incoming line bus device for connection of portable ground clamp:
- 1) Connecting device consisting of copper bracket with 7/16-inch diameter bronze or copper rod positioned horizontally and parallel to rear of switchgear.
  - 2) Connecting device mounted near pothead on each incoming bus.
  - 3) Connecting device to provide three-inch length between end supports of rod and minimum 2-1/2 inch radial clearance around rod.
  - 4) Connecting device accessible from rear of switchgear following removal of bolted cover or opening of padlockable door.
  - 5) Six-inch insulating barriers to be provided on each side of connecting devices or stirrups and extending to rear of switchgear a minimum of six inches all around.
  - 6) Size, thickness, insulating material and placement of insulating barriers designed to achieve adequate mechanical strength without compromising voltage withstand specified for switchgear.
  - 7) Design coordinated and approved by 34.5 kV-source electric utility company.
- d. Ground bus:
- 1) Copper bus, not less than two inches by 1/4 inch provided throughout the length of the switchgear section.
  - 2) In switchgear unit where power cables enter or leave switchgear at top as shown, bus not less than one-inch by 1/8-inch extending from main ground bus to top of unit for grounding incoming cable-ground sheath or shielding tape by short connection to bus.
  - 3) Joints in bus made with two bolts minimum and overlap of four inches.
  - 4) Mechanical connector provided in each unit for field connection of 4/0 to 500 KCMIL ground cable to switchgear ground bus.
- e. Control bus:
- 1) 125-volt dc bus not less than 6AWG copper.
  - 2) One two-pole knife switch provided in switchgear cubicle for disconnecting control circuit.
  - 3) UL Class J or RK-5 fuses used for control and auxiliary-service protection.
  - 4) Closing circuit fused; tripping circuit unfused.

- 5) White light to indicate availability of dc control power.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION:**

- A. Install switchgear in position as shown and in accordance with manufacturer's recommendation and the NEC.
- B. Install conduit, raceways, boxes and cabinets as shown and in accordance with Section 16130.
- C. Make power-cable and control-wire connections as shown and in accordance with Section 16125.
- D. Make grounding connections as shown and in accordance with Section 16060.
- E. Make arrangements with applicable electric utility company for making connections with incoming lines.
- F. Use services of manufacturer's engineering representative for assistance in field assembly, installation and testing of the switchgear in accordance with Section 16360.
- G. Connect space-heater circuit to prevent condensation during installation.
- H. Install breaker test cabinet and connect it to 125-volt dc supply.
- I. Install pegboard at location approved by the Engineer. Mount switchgear accessories and associated nameplate on pegboard.
- J. Install wire, cable and busways in accordance with Section 16120.

#### **3.02 FIELD QUALITY CONTROL:**

- A. Switchgear Field-Testing and Inspection: As specified in Section 16360.

**END OF SECTION**

## SECTION 16321

### HIGH VOLTAGE AC SWITCHGEAR (13.8 KV) FOR TRACTION POWER

#### PART 1 - GENERAL

##### 1.01 SUMMARY

- A. The scope includes furnishing, delivering, installing 13.8 kV metal-clad switchgear and spare parts for Traction Power Substations.
- B. Compensation for work specified in equipment will be made in the following manner:
  - 1. Equipment For Traction Power Substation: Lump Sum.
  - 2. 13.8 kV AC Circuit Breaker removable element, 1,200 amps: Each.
  - 3. 13.8 kV ground, phase and test device: Each.
- C. Compensation for work specified related to installation will be made in the lump sum installation price for each traction power substation.
- D. Related sections:
  - 1. Section 16051 - Scope of Work For Traction Power for
  - 2. Section 16052 - Basic Materials and Methods For Traction Power
  - 3. Section 16128 - Wire and Cable For Traction Power
  - 4. Section 16260 - Uninterruptible Power System (Static)
  - 5. Section 16261 - Transformer-Rectifier Units For Traction Power
  - 6. Section 16341 - Metal-Enclosed DC Switchgear For Traction Power
  - 7. Section 16291 - Local Annunciator Panel For Traction Power
  - 8. Section 16292 - Remote Terminal Units (AEMS RTU) For Traction Power

##### 1.02 REFERENCES

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Codes and regulations of jurisdictional authorities.
  - 2. NEC.
  - 3. NEMA: CCI, SG4, SG5.
  - 4. ANSI: C37.06, Z55.1, C39.1, C12.
  - 5. ANSI/IEEE: 141, 242, C37.09, C.37.20.2, C37.90, C37.90.1, C57.13.
  - 6. ANSI, NEMA and IEEE standards as applicable to temperature rise.
  - 7. UL: 1244.
  - 8. AHA: ISI.

##### 1.03 SYSTEM DESCRIPTION

- A. Design Criteria:
  - 1. Floor loading: Switchgear compatible with floor design loading of 250 pounds per square foot.
  - 2. Switchgear suitable for anchoring to a concrete floor steel trowel finished to tolerance level of 1/8 inch in 10 feet.
  - 3. Numbers, types and arrangement of switchgear units as shown on drawings and Table 16051-III.
- B. The switchgear shall be manufactured in accordance with specified standards and shall have prior ANSI/NEMA certification as applicable.

- C. NEMA SG5, ANSI C37.20.2 for indoor use.
- D. Ratings of switchgear:
  - 1. Rated nominal voltage: 13.8 kV.
  - 2. Rated maximum voltage: 15.0 kV.
  - 3. Insulation level, low frequency withstand: 36 kV, rms.
  - 4. Insulation level, impulse withstand: 95 kV.
  - 5. Rated frequency: 60 Hertz.
  - 6. Rated continuous current: 1,200 Amperes
  - 7. Rated momentary current: Corresponding to circuit breaker momentary ratings.
- E. Insulation structure:
  - 1. Material not to support combustion, produce toxic gases, or absorb moisture.
  - 2. When subjected to electric arc, emission of conducting materials from insulating structure limited so as not to interfere with performance of circuit breaker.

#### 1.04 SUBMITTALS

- A. Submit the following for approval in accordance with the Division 1 and with the additional requirements as specified for each:
  - 1. Shop Drawings for installation: In accordance with Table 16051-II.
    - a. Submit drawings showing utility incoming supply cable termination details to the appropriate power company for approval through the Engineer.
  - 2. Shop Drawings for equipment: In accordance with Section 16051, Table II. Additionally, submit five (5) sets of the following to the Engineer for appropriate power company approval:
    - a. Drawings showing utility supply cable termination details.
    - b. Incoming line relay ranges and style numbers for 13.8 KV.
    - c. Drawings and catalogs for 13.8 KV switchgear grounding, phasing and testing devices for appropriate power company approval.
    - d. Drawings and catalog cuts of two (2) incoming feeder cubicles and of two (2) auxiliary cubicles including mounting details for metering current and potential transformers.
  - 3. Certification:
    - a. Certify that switchgear complies with floor design loading of 250 pounds per square foot.
    - b. Design test reports or certified copies of design test reports for identical units, performed for each type and rating of circuit breaker as assembled in its complete switchgear unit including bus compartment.
    - c. Certified test reports for specified factory production testing.
    - d. Certificates from manufacturers verifying that equipment conforms to specified requirements.
  - 4. Documentation:
    - a. Submit short-circuit calculations and protective relay coordination study for system protection and selective overcurrent tripping in accordance with Section 16051.
      - 1) In accordance with ANSI/IEEE 141 and ANSI/IEEE 242 for fault calculations and coordinated system protection.
      - 2) Include high-voltage source, relays on high-voltage switchgear, transformer-rectifier units and dc switchgear, and capability curves of rectifiers, rectifier transformers.
      - 3) Available short-circuit currents based on power company contribution of 750 MVA for 13.8 kV service.
      - 4) Recommended settings and adjustment of protective devices
  - 5. Operations and Maintenance Manuals: In accordance with Division 1.

6. Spare Parts Lists.

**1.05 QUALITY ASSURANCE**

- A. Qualification:
  - 1. Select a manufacturer who is regularly engaged in production of similar switchgear and has demonstrated a successful record of providing equipment of similar type and rating for extra heavy duty traction service for at least five similar projects.
  - 2. The proposed switchgear and circuit breaker shall have prior ANSI and NEMA certification.
  
- B. For Codes, Regulations, Reference Standards and Specifications, refer to Article 1.02 above
  
- C. Factory Testing:
  - 1. Submit test plans and procedures and scheduled test date for approval at least 20 working days in advance of scheduled test dates. No test results will be accepted prior to receipt and approval of test plans and procedures. Factory test requirements are as follows:
    - a. Circuit breaker tests: In accordance with the requirements of ANSI/IEEE C37.09 and including the following:
      - 1) Design tests:
        - a) Rated maximum voltage.
        - b) Rated voltage range factor.
        - c) Rated frequency.
        - d) Rated continuous current test.
        - e) Short-circuit rating test.
        - f) Rated standard operating duty.
        - g) Rated permissible tripping delay.
        - h) Rated interrupting time.
        - i) Rated dielectric strength.
        - j) Rated control voltage.
        - k) Load current switching.
        - l) Mechanical life.
        - m) Rated transient recovery voltage.
        - n) Rated reclosing time.
      - 2) Production test: All tests in accordance with ANSI/IEEE C37.09.
    - b. Switchgear assembly tests: In accordance with ANSI/IEEE C37.20.2, including the following:
      - 1) Design tests:
        - a) Dielectric tests.
        - b) Rated continuous current test.
        - c) Momentary current test.
        - d) Short-time current withstand test.
        - e) Mechanical endurance test.
        - f) Paint qualification test.
        - g) Flame resistance test for insulation
      - 2) Production tests: All tests in accordance with ANSI/IEEE C37.20.2.
    - c. Instrument and control wiring tests:
      - 1) Check wiring for accuracy, open circuits, short circuits, ground connections and insulation integrity by means of high-potential, continuity and operational tests.
      - 2) Subject wiring to high-potential test of 1,500 volts 60 Hertz to ground for one minute.
      - 3) Verify that wiring is in accordance with manufacturer's wiring diagrams. Check complete wiring, including interconnections of shipping breaks.

## **1.06 DELIVERY, STORAGE AND HANDLING**

- A. Equipment for each facility shall be delivered after its completion in accordance with the delivery dates indicated in Division 1. Arrangement for delivery shall be made in coordination with the Engineer.
- B. Ship each unit securely packaged, braced and labeled for safe handling in shipment and to avoid damage or distortion.
- C. Temporary Bracing: Where necessary, brace switchgear for hoisting lowering and skidding into position. Label temporary internal bracing of switchgear: TEMPORARY-REMOVE BEFORE OPERATION.
- D. Protection Against Concealed Damage: Include within shipping container mechanical impact recorder of rating recommended by manufacturer for shipment by railroad and submit impact record chart with manufacturer's instructions for disposition of damaged material.
- E. Assembly for Shipment:
  - 1. Design enclosures to permit lifting by jacks or slings and moving horizontally on rollers or skidding in any direction.
  - 2. Maximum dimensions of shipping sections to be coordinated with the dimensions of equipment access to ensure shipping dimensions will allow movement of switchgear through structure without damage to equipment or structure or undue difficulty.
  - 3. For shipping split, coil interconnecting wiring on one side of the shipping split with matching terminal block on other side of split. Identify wiring and terminal block points for reconnecting.
  - 4. Drawout relays mounted in their proper cases with moving parts properly secured and packed for shipment.
  - 5. Removable circuit breaker elements packaged separately.
- F. Store switchgear in secure and dry storage facility.

## **PART 2 - PRODUCTS**

### **2.01 MANUFACTURERS**

- A. The switchgear shall be manufactured by one of the following equipment suppliers, or equal:
  - 1. Asea Brown Boveri
  - 2. General Electric
  - 3. Westinghouse
  - 4. Controlled Power Corporation

### **2.02 COMPONENTS**

- A. Circuit breaker:
  - 1. NEMA SG4 and ANSI C37.06 for indoor use.
  - 2. Type: Three-pole, single throw, single interrupter per phase, drawout type, vacuum break, one drawout breaker per cubicle. The circuit breaker shall have its own set of wheels for drawout and shall not require a lifting device for this purpose.
  - 3. Rating on symmetrical basis:
    - a. Nominal voltage class, kV, rms: 13.8.
    - b. Nominal three-phase MVA Class: 750.
    - c. Rated maximum voltage, kV, rms: 15.
    - d. Rated withstand test voltage:

- 1) Low frequency, kV, rms; 36.
  - 2) Impulse, kV: 95.
  - e. Rated continuous current at 60 Hertz, amperes, rms: 1,200.
  - f. Rated interrupting time, cycle: Five maximum.
  - g. Rated permissible tripping delay, sec: Two.
  - h. Rated voltage range factor (K): 1.30.
  - i. Rated short-circuit current at rated maximum kV, Amperes, rms: 28,000.
  - j. Maximum symmetrical interrupting capability, Amperes, rms: 36,000.
  - k. Three-second short time current carrying capability, Amperes, rms: 36,000.
  - l. Closing and latching capability, ampere, rms: 58,000.
4. Electrically powered, spring-charged, stored-energy operating mechanism, with the following additional requirements:
- a. Voltage requirements:
    - 1) Charging of stored-energy operating mechanism: 125 Volts dc.
    - 2) Closing by means of closing release coil capable of operation from 100-140 Volts dc.
    - 3) Tripping by means of shunt trip coil capable of operation from 70-140 Volts dc.
  - b. Mechanically and electrically trip-free.
  - c. Equipped with mechanical devices on front of breaker to actuate closing and tripping operations, in case of failure of control power.
  - d. Compressed spring stored-energy operating mechanism, with sufficient energy storage for opening/closing/ opening operation at rated short-circuit current or at rated required capabilities.
  - e. Stored-energy mechanism automatically charged within 10 seconds following each closing of circuit breaker.
  - f. Stored-energy mechanism suitable for manual charging by means of removable handle in case of failure of control power.
  - g. Mechanical indicator on front. of breaker to indicate that stored-energy closing mechanism is charged.
5. Racking mechanism:
- a. Horizontal drawout breaker: manually-operated mechanism designed to permit racking of breaker with door closed by inserting crank through opening of limited size maximum.
  - b. Racking mechanism gear ratio: To permit one man to rack breaker in and out manually in four minutes maximum.
  - c. When breaker element is in fully lowered or racked out position, circuit breaker, complete with its operating mechanism, capable of being withdrawn from housing and moved on wheels integral with mechanism. Separate handling device for moving circuit breaker, other than transfer truck of fifth-wheel steering bar, is prohibited.
  - d. Positive stops for preventing overtravel and guides for proper alignment of breaker.
6. Grounding:
- a. When breaker is in connected position, case and frame grounded by positive contact with ground bus.
  - b. Breaker ground shoe designed to connect breaker frame to ground bus prior to engagement of primary breaker terminals.
  - c. Ground connection capable of carrying fault current equal to rated short-circuit current and related required capabilities
7. Interlocks:
- a. provide suitable interlocks to perform the following functions:
    - 1) Automatic discharge of stored-energy mechanism of the circuit breaker prior to its racking in or withdrawal from the unit.
    - 2) Prevent racking in and out unless circuit breaker is in OPEN position.

- 3) Prevent either electrical or manual operation of the breaker unless it is in the operating or test position. All circuit breakers to operate in test position and in the test position all remote and interlocking signals inhibited to and from the breaker.
  - 4) Automatically close rectifier cathode circuit breaker (Device 72) when rectifier transformer feeder circuit breaker (Device 52R) is closed, unless the rectifier cathode circuit breaker has been locked out by Device 86.
  - 5) Automatically trip the rectifier cathode circuit breaker (Device 72) when the rectifier transformer feeder breaker trips (Device 52R).
  - 6) Automatically trip and prevent closing the rectifier transformer feeder circuit breaker (Device 52R) and rectifier cathode circuit breaker (Device 72) if the rectifier doors are opened.
  - 7) Electrically interlock the two incoming line circuit breakers and the bus tie circuit breaker so that all three circuit breakers cannot be closed simultaneously. Interlocking scheme shall not prevent closing of one incoming line breaker when the bus tie breaker only is closed and the other incoming line breaker is open.
  - 8) Mode of operation: Normal mode with both incoming line circuit breakers closed and with the bus tie circuit breaker open. Loss of voltage on either incoming line shall initiate automatic transfer of its bus section to the other incoming line provided that the bus section lockout relay has not operated. Re-transfer after restoration of service shall be manual, interlocked for dead transfer.
  - 9) Rectifier Transformer Feeder Breaker key interlocked with Transformer tapboard as specified in Section 16261.
8. Primary Connection:
    - a. Connection between the removable and stationary unit made by male-and-female contacts, with the following additional requirements:
      - 1) Silver-plated, high pressure contacts.
      - 2) Automatic shutter to cover contact orifice when breaker is withdrawn to test position and to uncover orifice when breaker is returned to connected position.
      - 3) Automatic shutters constructed to withstand force of racking mechanism in case shutters fail to open when breaker is racked into positions.
  9. Secondary connection:
    - a. Control, protection, and interlocking circuit connections between stationary and removable elements of switchgear shall be made using device consisting of recessed stationary receptacle and set of self-aligning multiple-contact plugs on removable elements with sufficient number of contacts to accommodate control, protection and interlock circuits, including spares, without resorting to auxiliary relay.
  10. Nonresettable mechanical operation counter registering one count for each circuit breaker closing operation.
  11. Mechanical position indicator, showing breaker as OPEN or CLOSED.
  12. Auxiliary switches:
    - a. Equip each circuit breaker with auxiliary switches, rotary type, operated in both the connected and test position with sufficient number of contacts for operation, indication and interlocking of the breaker together with at least eight spare contacts, four type "a" and four type "b", each wired through secondary disconnect device contacts to accessible terminal blocks.
- B. Potheads and Terminal Connectors
    1. Utility incoming line:

- a. Space and provisions for mounting 3 single-conductor cables terminated in stress cones or slip-on terminators furnished and installed by the appropriate power company. The location, spacing and method of mounting shall be approved by the appropriate power company.
  - b. Provide 2-hole NEMA drilled terminations in switchgear bus to suit appropriate power company's 2-hole lugs and provide cable supports, as required.
  - c. All connections shall be insulated to 95kV BIL.
2. Feeder breakers:
- a. NEMA CC1
    - 1) Long barrel, double indentation compression type with NEMA standard two-hole contact pad for copper conductor. One piece tubular construction formed of tin plated copper.
- C. Buses:
- 1. General requirements:
    - a. Copper or aluminum bus bars of sufficient size to carry specified current without exceeding allowable temperature rise stated in ANSI, NEMA and IEEE Standards. Maximum current density of 800 Amperes per square inch.
    - b. Capable of withstanding the mechanical stresses and heat from maximum short circuit current.
    - c. Bus connections bolted or welded. Contact surfaces of bolted connections silver-plated or tin-plated.
    - d. Each joint having impedance not more than that of bus bar of equal length and clamped to maintain such impedance throughout life of equipment.
  - 2. Power buses:
    - a. Three-phase, three-wire buses fully insulated to 95 kV BIL, with flame-retardant, nonhygroscopic, track-resistant insulation. Provide each bolted connection with minimum of four bolts equipped with palnut or equal and fully insulated.
  - 3. Ground bus:
    - a. Cooper bus, not less than two inches by 1/4 inch provided throughout length of switchgear section. Each unit shall be grounded directly to this bus. A clamp type terminal shall be provided at each end of the ground bus for connection to the station ground.
    - b. In switchgear unit where power cables enter or leave switchgear at top as shown, copper ground bus not less than one inch by 1/8-inch extending from main ground bus to top of unit for grounding of incoming cable ground sheath or shielding tape.
    - c. Joints in ground bus made with tow bolts minimum.
    - d. Mechanical connector provided in each unit for field connection of 4/0 AWG to 500 KCMIL ground cable to switchgear ground bus.
  - 4. Control bus:
    - a. 125 Volt dc bus not less than 6 AWG copper.
    - b. One two-pole knife switch provided in each switchgear cubicle for disconnecting control circuit.
    - c. UL Class J fuses used for control and auxiliary service unfused.
    - d. Closing circuit Fused: tripping circuit unfused.
    - e. White light mounted on control panel to indicate availability of dc control power.
- D. Auxiliary unit:
- 1. Indoor metal cubicle for installing metering transformers furnished by the appropriate power company. The switchgear design shall be in accordance with appropriate

power company's Guide Specification, and shall be coordinated through the Engineer for appropriate power company approval.

2. Separate compartment for mounting two Westinghouse Electric Company Type KIR-11 or equal, 15kV current transformers furnished by appropriate power company with the following additional requirements:
  - a. Current transformer accessible through sealable hinged door. Bolted access plates prohibited.
  - b. Connection between bus and current transformer of same size and current ratings as that of main bus.
  - c. Compartment sized and arranged so that current transformer can be readily removed or replaced after cubicle is installed as integral part of switchgear assembly.
3. Separate compartment in accordance with the latest revision of appropriate power company's guide specification for mounting two Westinghouse Electric Corporation Type VIZ-11 or equal 14,400 -120 Volt potential transformers and a separate drawout fuse carriage for mounting primary fuses furnished by appropriate power company with the following additional requirements:
  - a. Potential Transformer accessible through sealable hinged door. Bolted access plates prohibited. Potential transformers shall be fixed mounted as approved by appropriate power company.
  - b. Fuse clips one inch long, mounted on 12 inch centers for accommodating fuse size 1-9/16 inch diameter ferrules and 12-7/8 inches long.
  - c. Provide silver-plated contact designed to provide adequate contact pressure.
  - d. The fuse drawout carriage for primary fuses shall be designed so that all contacts will be disconnected from the energized circuit and visibly grounded before the fuses become accessible for checking or replacement. This includes the load and line sides of the fuses and the line side of the potential transformer. A 95kV BIL is required in the open position.
    - 1) The fuse drawout carriage shall be grounded in all positions. This may be accomplished by use of a grounding strap. Sliding or rolling ground connections are not acceptable.
    - 2) The fuse drawout carriage shall be sealable in the closed or operating position.
  - e. Details of the design and arrangements of grounding shall be submitted to the Engineer for appropriate power company's specific approval.
4. One 10-inch square by six-inch deep pull box for secondary connection of appropriate power company metering transformers, with the following additional requirements:
  - a. Equipped with two 1-1/2 inch conduits, one to current transformer compartment and the other to potential transformer compartment.
  - b. Provision for installing one 1-1/2 inch conduit from pullbox to appropriate power company metering panel.

E. Current transformers:

1. ANSI C57.13, molded rubber or epoxy construction, wound type complying with ANSI requirements for relaying accuracy classification under burden imposed by devices specified. Mounted in a compartment isolated from the control panel.
2. Current ratio: As specified or as determined by approved coordination study.
  - a. Multi-ratio type MR for incoming feeders and Tie buses.
3. Insulation class:
  - a. 13.8 kV with basic impulse insulation level of 95 kV full-wave.
4. Capable of withstanding thermal and magnetic stresses from flow of current equal to the momentary and interrupting rating of the circuit breaker.
5. Maximum allowable temperature rise under continuous full load above an average ambient temperature of 55°C

- a. By winding resistance: 30°C
    - b. By hottest spot in winding: 40°C
  - 6. Transformer secondary neutral and frame individually grounded by copper wire to switchgear ground bus. Keep each ground connection run as short as possible. Avoid grouping such connections with control or other wiring. Minimum ground wire size: size 8 AWG for secondary and size 6 AWG for frames.
  - 7. Transformer secondary equipped with covers and integral shorting bars. Secondary wiring run to readily identifiable terminal block points with integral shorting bars, in the control compartment.
- F. Potential transformers:
  - 1. ANSI C57.13, molded-rubber or epoxy, of the following configurations:
    - a. Current-limiting primary fuses mounted on integral drawout carriage. Carriage to be pad locked with incoming breaker.
    - b. Drawout transformers with integrally mounted fuses.
  - 2. Connection:
    - a. phase-to-phase for digital power meter and phase to ground for device 27/59.
  - 3. Voltage ratio:
    - a. 14.4kV to 120 Volts.
  - 4. Insulation class:
    - a. 13.8 kV with basic BIL impulse insulation level of 95 kV full-wave.
  - 5. Maximum allowable temperature rise under continuous full load above average ambient temperature of 55°C:
    - a. By winding resistance: 30°C.
    - b. By hottest spot in winding: 40°C.
  - 6. The fuse and PT drawout carriage shall be design so that all contacts will be disconnected from the energized circuit and visibly grounded before the fuses become accessible for checking or replacement. This includes the load and line sides of the fuses and the line side of the potential transformer. A 95 kV BIL is required in the open position.
    - a. The fuse and PT drawout carriage shall be grounded in all positions. This may be accomplished by use of a grounding strap. Sliding or rolling ground connections are not acceptable.
    - b. The fuse and PT drawout carriage shall be sealable in the closed or operating position.
- G. Meters:
  - 1. Ammeters:
    - a. ANSI C39.1 and ANSI C12, switchboard type with 250 or 270 degree scale, approximately seven inches long with plus or minus one percent accuracy:
      - 1) Ammeters:
        - a) Five-ampere, transformer-rated with scale range equal to the associated current transformer primary rating.
      - 2) Voltmeters:
        - a) Rated 0-150 volts for use with 0-18 kV scale.
  - 2. Digital Power Meter:
    - a. ANSI C37.90.1 and ANSI C12.
    - b. A digital power meter, Siemens 4700 or equal, shall be provided to monitor circuits shown on the one-line diagram and specified here. The meter shall measure the real-time RMS values of phase currents, ampere demand, and phase and line voltages plus power measurements including kw, kw demand, kWhours, kVA, kVARS hours. Power factor and frequency shall also be measured. Resettable minimum and maximum values for each measured value shall be recorded in nonvolatile memory. The kW and ampere demand period shall be user programmable from one to sixty minutes. A one volt nominal auxiliary voltage input shall also be provided.

Accuracy of current and voltage measurements shall be .25% and kW, kW hour and other power measurements shall be .50% or better. The power meter shall be capable of high sampling of wave form for power quality analysis and measurement of harmonics in current and voltage wave forms.

- c. The digital power meter shall be listed under UL1244 and meet requirements of applicable ANSI Standards including ANSI C37.90.1 requirements for surge withstand and fast transient tests. All configuration information such as CT ratios, voltage scales, and communications address shall be stored in nonvolatile memory so that it can be set either from the integral display or remotely using the communications module. No batteries shall be required to maintain configuration information indefinitely. The meter shall derive power from a separate 125 V ac or dc source.

- d. Display:

- 1) The digital power meter shall include an integral illuminated display for reading all real-time and min/max measured values as well as programming initial configuration and any relay set-points. The display shall consist of at least twenty 0.4 inch high alphanumeric characters and be operated using clearly labeled sealed membrane keys with stainless steel switch elements for long mechanical life and resistance to atmospheric contamination. The digital power meter with integral display shall be flush mounted on equipment doors or panels. Operation of the power meter to read real-time or min/max measured values or to program configuration and any relay setpoints shall not require opening door or removing panels. A user-defined password shall be required to change configuration, reset min/max log and kW/kVAR hours or change any relay set-points.

- e. Relay:

- 1) Three programmable relay outputs shall be provided to activate and release based on threshold and time-delay values associated with any of the measured parameters. Remote relay operation shall be possible through the communications module. The relay shall be form C rated 10A 120Vac/24Vdc. Activation and release of the relays shall be recorded in a non-volatile log with cause of operation. The log shall record at least the last 50 events. Four discrete inputs shall also be provided to monitor status of NO or NC contacts. One of the discrete inputs shall also be capable of counting state changes. A programmable auxiliary 0 to 1mA or 4 to 20mA analog output shall also be provided.

- f. Communications:

- 1) A communications module shall be provided using an industry standard RS-485 (or RS-232) serial bus to remotely read real-time and min/max measured values, interrogate the event log, reset min/max and kW/kVAR hours and program configuration and any relay setpoints. A means shall be provided to periodically synchronize the meter's internal clock with a master bus clock so that the meter's event and min/max logs are accurately time-stamped within one second. The RS-485 module shall provide at least 500V galvanic isolation between the meter and other devices on the communications bus. Up to 6 channels 0 to 1 or 4 to 20mA dc analog transmission of output data shall also be provided.

- g. Extended memory:

- 1) The power meter shall include extended nonvolatile memory to record at least 100 snapshots of each measured parameter. The interval between snapshots shall be readable using the communications module.

- h. Portable Computer:
  - 1) Portable, Notebook Design with:
    - a) Latest Intel-based Processor,
    - b) 128 MB RAM
    - c) 2 PCMCIA Slots Type II,
    - d) Local Bus Graphics
    - e) Color Active Matrix Screen (256 colors
    - f) 3 Hours Batter w/Charger and AC Adapter,
    - g) 3.5", 1.44 MB Floppy Drive,
    - h) CD Rom,
    - i) 4+GB Hard Drive,
    - j) Built-in Center Trackball and external Mouse
    - k) Internal Fax Modem;56K Baud,
    - l) Carrying Case
  - 2) Provided with the following latest versions of software:
    - a) Latest version of Microsoft Windows Operating System for PC
    - b) Latest version Microsoft word on PC
    - c) Latest Version Microsoft Excel on PC
    - d) Exclusive communication software and 10' cables to interface DPM communication protocol, plus DOS 6.x Operating System

H. Protective relays:

- 1. General requirements:
  - a. Semi-flush mounted, electro-magnetic induction disc adjustable drawout relays, overcurrent and under/over voltage type, each with test switches, except clapper type relays, when used, surface mounted on a fixed portion of the structure. Solid state relays shall not be allowed.
  - b. Rustproof metal rectangular cases finished in dull black.
  - c. With targets, hand reset for targets and seal-in units.
  - d. Contact and adjusting device readily visible, accessible and adjustable from front of relay.
  - e. Designed, constructed and tested in accordance with applicable requirements of ANSI C37.90.
- 2. Overcurrent relay general requirements:
  - a. Select overcurrent relay characteristics, ranges and settings to provide the protection and coordination specified.
- 3. Transformer-rectifier feeder unit overcurrent relays:
  - a. Device 50/51 phase inverse time and instantaneous overcurrent relays, one(1) 50N/51N residual ground inverse time and instantaneous overcurrent relay, three (3) 51-A phase inverse time overcurrent relay and three(3) relays 51B phase inverse time overcurrent relay.
  - b. Relay 51A to protect against overloads beyond the 300 percent, one minute capability of the units.
  - c. Relay 51B to protect against overloads beyond the 450 percent, 15 second capability of the units and coordinated with relay 51A.
  - d. Relays 50/51 and 50N/51N set as low as practicable to provide maximum fault protection and to coordinate with relays 51A and 51B.
  - e. Relays 51A, 50/51 and 50N/51N operating associated lockout relay, to trip the transformer-rectifier feeder breaker.
  - f. Relay 51B equipped with auxiliary relays 51BX to trip all dc track feeder breakers on the associated dc bus.
- 4. Bus tie unit Overcurrent relays.

- a. Device 50/51 phase inverse time and instantaneous overcurrent relays, device 50N/51N residual ground inverse time and instantaneous overcurrent relays.
  - b. Relays 50/51 and 50N/51N operate relay 86BT to trip the bus tie circuit breaker.
  - c. Relays 50/51 and 50N/51N set as low as practicable to provide maximum bus fault protection and to coordinate with transformer-rectifier unit overcurrent relays.
5. Incoming line unit Overcurrent relays
- a. Device 50/51 phase inverse time and instantaneous overcurrent relays, device 50N/51N residual ground inverse time and instantaneous overcurrent relay.
  - b. Relays 50/51 and 50N/51N operate relay 86 to trip incoming line breaker.
  - c. Relays 50/51 and 50N/51N set as low as practicable to provide maximum fault protection and to coordinate with bus tie unit and transformer-rectifier unit overcurrent relays.
  - d. Setting of overcurrent relays to be coordinated with and approved by appropriate power company.
  - e. Current test switch, 10-pole, Westinghouse Style 129A517G01 or equal, provided between current transformer and relay.
6. Voltage relays:
- a. Relays 27/59 undervoltage/overvoltage, single-phase, time voltage relay.
  - b. Relay 27/59 trips incoming line breaker.
  - c. General Electric Company No. 12IAV53K1A, Westinghouse style 289B970A28, or equal. Adjustable range: 55 to 140 Volts or 30 to 120 Volts.
  - d. Potential test switch, 4-pole, Westinghouse Style 129A506G01 or equal, provided between potential transformer and relay.
7. Lockout relays:
- a. Rotary, hand-reset, 125 Volt dc, lockout relay, equipped with green light for indicating reset position, GE HEA or equal.
8. Auxiliary relays:
- a. Provided where required, General Electric Company Type HGA or HFA or equal, mounted inside instrument compartment.
9. Relay test equipment:
- a. One test set for testing all electromagnetic relays furnished.
- I. Switch and Indicating Lights:
- 1. General:
    - a. Rotary type, cam actuated switches with escutcheon and silver to silver contacts rated 20 Amperes. Contacts enclosed in easily removable covers.
  - 2. Circuit breaker control switch:
    - a. Equipped with heavy duty pistol-grip handles and operation targets. Escutcheon engraved "Trip-Close" with spring return to normal. Wired to operate the associated circuit breaker when the Local Remote selector switch is in the Local position. With indicating lights as follows:
      - 1) Red light: Circuit breaker closed, wired to supervise the trip coil.
      - 2) Green light: Circuit breaker is open.
      - 3) Amber light: Circuit breaker is automatically tripped.
  - 3. Circuit breaker supervisory control selector switch:
    - a. Equipped with oval handle. Escutcheon engraved "Local Remote" positions and white indicating light showing switch position in the local mode.
  - 4. Ammeter selector switch:
    - a. Equipped with knurled handle. Escutcheon engraved "OFF-1-2-3".
  - 5. Test switches:

- a. Provided for ammeters and voltmeters and between instrument transformers and the protective relays.
  - 6. Indicating lights:
    - a. LED panel indicator lamp, General Electric Company Type ET-16 or equal.
- J. Control panel:
  - 1. For relays, meters and control equipment, hinged panel of formed steel, with rolled edges, door stop and conveniently located handle for opening.
- K. Line voltage indicators:
  - 1. Neon glow-tube capacitance-coupled high-voltage indicators, Airco Type RS or equal. Glow tube shall be visible without opening the rear door of breaker cubicle.
- L. Surge arresters:
  - 1. Provide station class metal oxide type surge arresters, rated 12.7kV maximum continuous operating voltage (MCOV).
  - 2. Provided at each circuit breaker on incoming lines and rectifier transformer feeders.
- M. Space heaters:
  - 1. Each vertical section unit of switchgear provided with 120-volt, single-phase, 60 hertz heating element to facilitate drying and prevent condensation.
    - a. Two strip heaters shall be installed in each unit. One heater located in the front shall be controlled by a humidistat, adjustable from 60% to 100% relative humidity and set to operate when the relative humidity exceeds 90% or in accordance with manufacturer's recommendations. The other heater located in the rear is to operate continuously. Current for both heaters indicated by an approximate scaled ammeter located in front panel.
    - b. Two 120-volt circuits will be provided. Divide heater load evenly between the two circuits.
  - 2. Heaters enclosed in grill guard with no sharp edges and located so that they are accessible for replacement without requiring de-energization of switchgear bus. Panel ammeter, approximately 2-1/2 inches square, marked to indicate heater load.
  - 3. Power and control circuits to heaters and humidistat connected and protected up to devices and to incoming junction box with 3/4-inch minimum size conduit. Heater power junction box sized four inches square by two inches minimum depth and located at top of switchgear for top entry of minimum 3/4 inch conduit. Remote connection leads to power source labeled: 120V and NEUTRAL.
- N. Instrument and control wiring: Instrument and control wiring including electrical interlocks and intercompartment wiring factory installed in accordance with the following requirements:
  - 1. Wire:
    - a. Copper conductor minimum 14 AWG, insulation rated 600 Volt, type SIS or equal. Use flexible Class C or higher stranded insulated copper wire for wiring across hinged joints. Use twisted, shielded pair wires for overcurrent and voltage relays.
  - 2. Use one continuous length of wire from terminal to terminal without splice or tap. Wire troughs provided for routing wire between devices.
  - 3. Install and connect removable element control wiring in accordance with manufacturer's standard for circuit breaker wiring.
  - 4. Design and install control wiring so that trouble in one main circuit can not be communicated to control wiring of another main circuit.
  - 5. Make connections only at terminals of device, on terminal blocks or on control buses. Make wiring connections using insulated flange fork tongue type terminals.
  - 6. Terminate interconnecting wiring between cubicles and compartments on terminal blocks before wiring to components.
  - 7. Terminal blocks:

- a. With washerhead screw-type terminals, circuit-marking strips for indicating control wire number, phenolic laminated dust cover and 10% minimum spare terminal points.
  - 8. For each wire, use corresponding identification on terminal block marking strips and identify internal wiring at each termination, with same number as that shown on wiring diagram, using plastic sleeve.
  - 9. External wiring:
    - a. External control wiring to enter from top.
    - b. Allow space to route and terminate external single-conductor or multiple-conductor control cable.
    - c. Top entrances provided with removable cover plates for field drilling of conduit and cable entrance holes.
- O. Supervisory Control and Indication:
  - 1. Control: Provisions for closing and tripping each circuit breaker from the remote supervisory control system. Interposing relays for interface having 24 volt dc, 15 VA maximum coils and equipped with arc suppression network. Supervisory control enabled only with Local-Remote switch in Remote position and circuit breaker in the connected position.
  - 2. Indication:
    - a. Contact from each circuit breaker from remote indication circuit breaker position as follows:
      - 1) Closed: Circuit breaker closed and in the connected position.
      - 2) Tripped: Circuit breaker open or in the test or disconnected position.
    - b. Contact from each lockout relay and each incoming line undervoltage relay for remote indication of relay status (Normal-Abnormal).
    - c. Contact requirements:
      - 1) Dry contacts with a maximum load rating of 15 Volt Amperes, a maximum dc current of one Ampere and maximum switching voltage of 250 Volts dc.
      - 2) Contact resistance not to exceed 0.1 ohm in the closed state when operating in a circuit with open-circuit voltage of three Volts dc and closed circuit current of ten milliamperes. Open state resistance greater than 50 megohms.
      - 3) Contact bounce not to exceed five milliseconds.
- P. Maximum Mounting Height of Relays, Instruments, Meters and Devices: 90 inches above finished floor. If necessary, rectifier transformer feeder relays may be mounted on the rectifier.
- Q. Enclosure:
  - 1. Dead-front, free-standing indoor metal enclosure.
  - 2. Steel structure with frame work of welded or bolted structural steel, free from distortion and welding strain and sufficiently rigid to support equipment under normal and short-circuit conditions.
  - 3. Switchgear units equipped with doors as follows:
    - a. 13.8 kV enclosure
      - 1) Front: Hinged front door in accordance with the following:
        - a) Handle and three-point latch to hold door securely closed, with provisions for padlocking.
        - b) Door stop to hold door open.
        - c) Structural reinforcing provided as necessary to prevent sagging of door.
        - d) Circuit breaker compartment door designed not to hinder movement of breaker in and out of compartment when door is open and door-stop set.

- 2) Rear: Hinged door with handle and three-point latch and provisions for padlocking.
    - b. Circuit breaker cubicles to provide for interchangeability of removable circuit breaker elements.
  - 4. Finish: Metallic surfaces degreased, primed and finished with light gray enamel, Color No. 61, ANSI Z55.1 in accordance with reference standard unless other wise specified; two mils minimum dry film thickness.
  - 5. Switchgear assemblies shall include provisions for future extension from either end.
- R. Leveling Channels:
- 1. Steel.
  - 2. Size and configuration as recommended by the switchgear manufacturer.
- S. Additional Circuit Breaker Elements:
- 1. Additional circuit breaker elements as indicated in Section 16051 Table III.
- T. Nameplates:
- 1. Three-ply, laminated plastic plates, engraved through black face to white core and attached by means of stainless steel rivets or screws. Vertical gothic lettering using a round or square cutter. V-shaped groove is prohibited.
  - 2. Provide nameplate on each switchgear showing manufacturer's name and brand designation, the referenced standard, type, class and rating as applicable in accordance with reference standard.
  - 3. Provide additional functional nameplates for each component including relay, terminal block and other devices.
    - a. Each switchgear compartment labeled, front and back, with nameplates 2-1/2 inches by 6-1/2 inches, inscribed in letters 1/2 inch high: INCOMING LINE PRIMARY BREAKER NO. 1, (2); RECTIFIER-TRANSFORMER FEEDER BREAKER NO.1, (2), (3); or AUXILIARY COMPARTMENT NO. 1, (2), as appropriate.
    - b. Each circuit breaker compartment labeled, front only, with nameplate 2-1/2 inches by 6-1/2 inches, inscribed in letters 1/2 inch high with the circuit breaker Supervisory Control Identification Number, as shown in Section 16051 Table II. A typical example of engraving is as follows:  
SUPV CONTROL NO.  
E-D13-11
    - c. In addition to other information normally displayed on equipment, provide nameplate one-inch by length as required, showing in letters 1/2 inch high switch positions, meaning of indicator lamp and other pertinent information.
- U. Major components shall be products of same manufacturer.
- V. Unit Functional Component Listings: Items of equipment required for each switchgear unit shall be as follows as minimum, and as shown on drawings:
- 1. Incoming line unit:
    - a. One - Metal-Clad Stationary Unit
    - b. One - Bus, 3-phase, 1200 Amperes
    - c. One - Circuit Breaker, 1200 Amperes
    - d. One - Provision for Power Company Terminal Connectors.
    - e. Three - Current Transformers, GE Type BP or equal, ratio as required for relaying
    - f. Three - Single Phase Inverse time and Instantaneous Overcurrent Relays, Device 50/51
    - g. One - Residual Ground Inverse Time and Instantaneous Overcurrent Relay, Device 50N/51N
    - h. One - Lockout Relay, Device 86

- i. One - Inverse Time Undervoltage/ Overvoltage Relay, Device 27/59
  - j. One - Digital Power Meter
  - k. One - Test Switch, Westinghouse No. 129A517G01 on line side of overcurrent relays.
  - l. One - Test Switch, Westinghouse No. 129A506G01 on line side of undervoltage/overvoltage relay.
  - m. One - Circuit Breaker Control Switch
  - n. One - Local Remote Selector Switch
  - o. Three - High Voltage Neon Indicating Lights.
  - p. Three - Metal Oxide Surge Arresters.
  - q. Two - Incoming line potential transformers. Connected phase - to - phase with primary and secondary fuses for connecting to Digital Power Meter.
  - r. One - Incoming line potential transformer connected phase - to - ground with primary and secondary fuses for device 27/59.
  - s. One - Humidistat and ammeter for space heaters .
  - t. Two - Space heaters.
2. Bus tie unit:
- a. One - Metal-Clad Stationary Unit
  - b. One - Bus, 3-phase, 1200 Amperes
  - c. One - Circuit Breaker, 1200 Amperes
  - d. Three - Current Transformers, ratio as required for relaying
  - e. Three - Single Phase Inverse Time and Instantaneous Overcurrent Relays, Device 50/51
  - f. One - Residual Ground Inverse Time and Instantaneous Overcurrent Relay, Device 50N/51N
  - g. One - Lockout Relay
  - h. One - Test Switch Westinghouse No. 129A517G01, for protective relays.
  - i. One - Circuit Breaker Control Switch
  - j. One - Auto-Manual Switch
  - k. One - Humidistat and ammeter for space heaters.
  - l. Two - Space heaters.
  - m. One - DPM DP-9 Plug.
3. Rectifier-transformer feeder unit:
- a. One - Metal-Clad Stationary Unit
  - b. One - Bus, 3-phase, 1200 Amperes
  - c. One - Circuit Breaker, 1200 Amperes
  - d. Three - Terminal connections for 1/C # 4/0 cable.
  - e. Three - Current Transformers, ratio as required for relaying, with test switch
  - f. Three - Single Phase Inverse Time and Instantaneous Overcurrent Relays, Device 50/51
  - g. Three - Single Phase Inverse Time Overcurrent Relays, Device 51A.
  - h. Three - Single Phase Inverse Time Overcurrent Relays, Device 51B, with Auxiliary Relays, Device 51BXas required.
  - i. One - Residual Ground Inverse Time and Instantaneous Overcurrent Relay, Device 50N/51N.
  - j. One - Lockout Relay
  - k. One - Ammeter, Suitable Scale, with Test Switch
  - l. One - Ammeter Switch
  - m. One - Test Switch, Westinghouse No. 129A517G01 for protective relays.
  - n. One - Circuit Breaker Control Switch.
  - o. One - Local-Remote Selector Switch.
  - p. One - Kirk key interlock for use with no-load tap changer on rectifier transformer (to be coordinated with supplier of rectifier transformer).
  - q. Three - Metal Oxide Surge Arrestors.
  - r. One - Humidistat and ammeter for space heaters.
  - s. Two - Space heaters.

4. Auxiliary unit:
  - a. One - Metal-Clad Stationary Unit.
  - b. One - Bus 3-phase, 1200 Amperes.
  - c. One - Drawout carriage for primary fuse of two (2) power company metering potential transformers. in conformance with appropriate power company requirements.
  - d. One - Set of Primary Fuses, furnished by appropriate power company, for power company metering potential transformers.
  - e. Provisions for mounting two power company metering current transformers in conformance with appropriate power company requirements.
  - f. One - Humidistat and ammeter for space heaters.
  - g. Two - Space heaters.
5. Leveling Channels:
  - a. Steel.
  - b. Size and configuration as recommended by the switchgear manufacturer.
6. Additional Circuit Breaker Elements:
  - a. Additional circuit breaker elements as indicated in Section 16051 Table III.

### 2.03 ACCESSORIES

- A. There shall be one set of the following accessories for each substation:
  1. One breaker test cabinet with provision for electrical operation of circuit breaker with control switch and provision for other accessories as necessary.
  2. Crank for manually racking circuit breaker in switchgear cubicle.
  3. One circuit breaker maintenance lever with insulated handle.
  4. Fifth wheel provided for moving the circuit breaker outside its enclosure.
  5. One spare set of each type of high-voltage fuse.
  6. One complete set of relay test plugs and relay test switch.
  7. One set of special tool necessary for erection, operation and maintenance of switchgear including those recommended by relay manufacturer and including breaker secondary or control disconnect coupler.
  8. Pegboard: Hardboard, AHA IS 1, tempered, SIS, 1/4 -inch nominal thickness, perforated, sized to accommodate all products specified, framed with one-inch by one-inch hardwood. Frame and hardboard painted color selected by the Engineer. Include hardware for wall mounting and pegboard accessories suited to the products to be mounted. Provide nameplates as specified, one inch high by length as required with accessory names inscribed in 1/2 inch vertical letters.
  9. 13.8 kV grounding, phasing and testing device: (One device located in each traction power substation): Designed to be inserted into the switchgear unit in place of and in the same manner as the circuit breaker removable elements, to permit grounding either the bus or line, or making external connections to either the line for phasing and/or testing purposes with the following additional requirements:
    - a. Momentary and three-second current carrying capacities equal to or greater than those of the circuit breaker removable elements.
    - b. BIL Rating: 95 kV
    - c. Include a power-operated circuit closing device (grounding switch) so arranged with a gang-operated 3-pole selector disconnect switch to

effectively ground either the bus or line when the device is inserted into the unit and closed, with the following additional requirements:

- 1) Closing by means of a portable remote control pushbutton station mounted on the end of a 50-foot, four-conductor, flexible (class C stranding) cable providing common, close trip and ground conductors.
  - 2) Power obtained through the secondary disconnecting device in the switchgear unit.
- d. Grounding device solidly connected to the switchgear ground bus in the operated or grounded position. Make provisions for padlocking in the grounded position.
- e. No automatic tripping provided.
- f. Provide suitable windows or transparent enclosure and barriers to permit visual observation of the position of all selector switch blades before the device is inserted into the stationary housing.
- g. Fabricate steel panels from No. 11 United States Standard gauge steel.
- h. Connect the selector switch hinge end directly to the grounding switch.
- i. Provide insulated covers for bolt heads used to attach insulated panel to the front of the device if not at ground potential.
- j. External connections for testing made by insulated plug connectors for insertion in deep ports or wells accessible at the face of the device. One set of test ports connected directly to the bus. A second set of test ports connected directly to the line terminals. Additional requirements as follow:
  - 1) Mount ports on insulating material and provide closing shutters of like material.
  - 2) Provide separate closing shutter for each set of test ports. Each shutter with provisions for padlocking in closed position.
  - 3) Provide three test plugs or probes for each grounding, phasing and testing device for external connections.
- k. The Contractor is responsible for obtaining approval of shop drawings and submittal including Catalog data from appropriate power company for the grounding, phasing and testing device prior to manufacturing. Submittals shall be made to the Engineer for obtaining appropriate power company approval.

## PART 3- EXECUTION

### 3.01 INSTALLATION

- A. Floor Preparation:
1. Fill floor depression with concrete flush with finish floor. Finish concrete to the tolerances recommended by the switchgear manufacturer. Install leveling channels as recommended by the switchgear manufacturer and as shown on the approved shop drawings.
- B. Install switchgear as shown on drawings, in accordance with approved shop drawings, and as follows:
1. Contractor shall make the bus connections at each shipping split.
  2. The number of shipping splits in ac switchgear for each substation is given below:
- | <u>NAME OF SUBSTATION</u> | <u>No. of shipping Splits</u> |
|---------------------------|-------------------------------|
| [LOCATION-TBD ] TPS       | [ TBD ]                       |
- C. Install conduit and raceways as approved and in accordance with Section 16052.

- D. Make power cable and control wire connections as approved and in accordance with Section 16052.
- E. Make grounding connections as shown on drawings and approved.
- F. Arrange with the power companies for making connections with incoming lines; and for installation of CT, PT, PT fuses, and metering equipment.
- G. Use services of manufacturer's engineering representative for assistance in field assembly and installation in accordance with Section 16051.
- H. Connect space heater circuit to prevent condensation during installation.
- I. Install ac circuit breaker test cabinet and connect it to 125-volt dc supply as shown on drawings.
- J. Install pegboard at location approved by the Engineer. Mount switchgear accessories and associated nameplates on pegboard.

**3.02 FIELD QUALITY CONTROL**

- A. Verify tolerances of concrete floor finish and level of channels.
- B. Switchgear Field Testing and Inspection: In accordance with Section 16051

**END OF SECTION**

## SECTION 16322

### HIGH VOLTAGE AC SWITCH GEAR (34.5 KV) FOR TRACTION POWER

#### PART 1 - GENERAL

##### 1.01 SUMMARY

- A. The scope includes furnishing, delivering, installing 34.5 kV metal-clad switchgear and spare parts.
- B. Compensation for work specified in equipment will be made in the following manner:
  - 1. Equipment For Traction Power Substation: Lump Sum.
  - 2. 34.5 kV AC Circuit Breaker removable element, 1,200 amps: Each.
  - 3. 34.5 kV ground, phase and test device: Each.
- C. Compensation for work specified related to installation will be made in the lump sum installation price for each traction power substation
- D. Related sections:
  - 1. Section 16051 - Scope of Work For Traction Power
  - 2. Section 16052 - Basic Materials and Methods For Traction Power
  - 3. Section 16128 - Wire and Cable For Traction Power
  - 4. Section 16260 -Uninterruptible Power System (Static)
  - 5. Section 16261 - Transformer-Rectifier Units For Traction Power
  - 6. Section 16341 - Metal-Enclosed DC Switchgear For Traction Power
  - 7. Section 16291 - Local Annunciator Panel For Traction Power
  - 8. Section 16292 - Remote Terminal Units (AEMS RTU) For Traction Power

##### 1.02 REFERENCES

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Codes and regulations of jurisdictional authorities.
  - 2. NEC.
  - 3. NEMA: CCI, SG4, SG5.
  - 4. ANSI: C37.06, Z55.1, C39.1, C12.
  - 5. ANSI/IEEE: 141, 242, C37.09, C.37.20.2, C37.90, C37.90.1, C57.13.
  - 6. ANSI, NEMA and IEEE standards as applicable to temperature rise.
  - 7. UL: 1244.
  - 8. AHA: ISI.

##### 1.03 SYSTEM DESCRIPTION

- A. Design Criteria:
  - 1. Floor loading: Switchgear compatible with floor design loading of 250 pounds per square foot.
  - 2. Switchgear suitable for anchoring to a concrete floor steel trowel finished to tolerance level of 1/8 inch in 10 feet.
  - 3. Numbers, types and arrangement of switchgear units as shown on drawings and Table 16051-III.
- B. The switchgear shall be manufactured in accordance with specified standards and shall have prior ANSI/NEMA certification as applicable.

- C. NEMA SG5, ANSI C37.20.2 for indoor use.
- D. Ratings of switchgear:
  - 1. Rated nominal voltage: 34.5 kV.
  - 2. Rated maximum voltage: 38.0 kV.
  - 3. Insulation level, low frequency withstand: 80 kV, rms.
  - 4. Insulation level, impulse withstand: 150 kV.
  - 5. Rated frequency: 60 Hertz.
  - 6. Rated continuous current: 1,200 Amperes
  - 7. Rated momentary current: Corresponding to circuit breaker monetary ratings.
- E. Insulation structure:
  - 1. Material not to support combustion, produce toxic gases, or absorb moisture.
  - 2. When subjected to electric arc, emission of conducting materials from insulating structure limited so as not to interfere with performance of circuit breaker.

#### 1.04 SUBMITTALS

- A. Submit the following for approval in accordance with the Division 1 and with the additional requirements as specified for each:
  - 1. Shop Drawings for installation: In accordance with Table 16051 Table-II.
    - a. Submit drawings showing utility incoming supply cable termination details to Utility Company for approval through the Engineer.
  - 2. Shop Drawings for equipment: In accordance with 16051 Table-II. Additionally, submit five (5) sets of the following to the Engineer for Utility Company approval:
    - a. Drawings showing utility supply cable termination details.
    - b. Incoming line relay ranges and style numbers for 34.5 KV.
    - c. Drawings and catalog cuts of two (2) incoming feeder cubicles and of two (2) auxiliary cubicles including mounting details for metering current and potential transformers.
  - 3. Certification:
    - a. Certify that switchgear complies with floor design loading of 250 pounds per square foot.
    - b. Design test reports or certified copies of design test reports for identical units, performed for each type and rating of circuit breaker as assembled in its complete switchgear unit including bus compartment.
    - c. Certified test reports for specified factory production testing.
    - d. Certificates from manufacturers verifying that equipment conforms to specified requirements.
  - 4. Documentation:
    - a. Submit short-circuit calculations and protective relay coordination study for system protection and selective overcurrent tripping within 150 days of NTP. Submit relay coordination study to the Engineer for approval.
      - 1) In accordance with ANSI/IEEE 141 and ANSI/IEEE 242 for fault calculations and coordinated system protection.
      - 2) Include high-voltage source, relays on high-voltage switchgear, transformer-rectifier units and dc switchgear, and capability curves of rectifiers, rectifier transformers and auxiliary power transformer.
      - 3) Available short-circuit currents based on power company contribution of 1500 MVA for 34.5 kV service.
      - 4) Recommended settings and adjustment of protective devices.
  - 5. Operations and Maintenance Manuals: In accordance with Special Conditions and Section 16053.
  - 6. Spare Parts Lists.

## 1.05 QUALITY ASSURANCE

- A. Qualification:
1. Select a manufacturer who is regularly engaged in production of similar switchgear and has demonstrated a successful record of providing equipment of similar type and rating for extra heavy duty traction service for at least five similar projects.
  2. The proposed switchgear and circuit breaker shall have prior ANSI and NEMA certification.
- B. For Codes, Regulations, Reference Standards and Specifications, refer to Article 1.02 above
- C. Factory Testing: Submit test plans and procedures and scheduled test date for approval at least 20 working days in advance of scheduled test dates. No test results will be accepted prior to receipt and approval of test plans and procedures. Factory test requirements are as follows:
1. Circuit breaker tests: In accordance with the requirements of ANSI/IEEE C37.09 and including the following:
    - a. Design tests:
      - 1) Rated maximum voltage.
      - 2) Rated voltage range factor.
      - 3) Rated frequency.
      - 4) Rated continuous current test
      - 5) Short-circuit rating test.
      - 6) Rated standard operating duty.
      - 7) Rated permissible tripping delay
      - 8) Rated interrupting time.
      - 9) Rated dielectric strength.
      - 10) Rated control voltage.
      - 11) Load current switching.
      - 12) Mechanical life.
      - 13) Rated transient recovery voltage.
      - 14) Rated reclosing time.
    - b. Production test: All tests in accordance with ANSI/IEEE C37.09.
  2. Switchgear assembly tests: In accordance with ANSI/IEEE C37.20.2, including the following:
    - a. Design tests:
      - 1) Dielectric tests.
      - 2) Rated continuous current test.
      - 3) Momentary current test.
      - 4) Short-time current withstand test.
      - 5) Mechanical endurance test.
      - 6) Paint qualification test.
      - 7) Flame resistance test for insulation
    - b. Production tests: All tests in accordance with ANSI/IEEE C37.20.2.
  3. Instrument and control wiring tests:
    - a. Check wiring for accuracy, open circuits, short circuits, ground connections and insulation integrity by means of high-potential, continuity and operational tests.
    - b. Subject wiring to high-potential test of 1,500 volts 60 Hertz to ground for one minute.
    - c. Verify that wiring is in accordance with manufacturer's wiring diagrams. Check complete wiring, including interconnections of shipping breaks.

## 1.06 DELIVERY, STORAGE AND HANDLING

- A. Equipment for each facility shall be delivered after its completion in accordance with the delivery dates indicated in Division 1. Arrangement for delivery shall be made in coordination with the Engineer.
- B. Ship each unit securely packaged, braced and labeled for safe handling in shipment and to avoid damage or distortion.
- C. Temporary Bracing: Where necessary, brace switchgear for hoisting lowering and skidding into position. Label temporary internal bracing of switchgear:
  - 1. TEMPORARY-REMOVE BEFORE OPERATION.
- D. Protection Against Concealed Damage: Include within shipping container mechanical impact recorder of rating recommended by manufacturer for shipment by railroad and submit impact record chart with manufacturer's instructions for disposition of damaged material.
- E. Assembly for Shipment:
  - 1. Design enclosures to permit lifting by jacks or slings and moving horizontally on rollers or skidding in any direction.
  - 2. Maximum dimensions of shipping sections to be coordinated with the dimensions of equipment access to ensure shipping dimensions will allow movement of switchgear through structure without damage to equipment or structure or undue difficulty.
  - 3. For shipping split, coil interconnecting wiring on one side of the shipping split with matching terminal block on other side of split. Identify wiring and terminal block points for reconnecting.
  - 4. Drawout relays mounted in their proper cases with moving parts properly secured and packed for shipment.
  - 5. Removable circuit breaker elements packaged separately.
- F. Store switchgear in secure and dry storage facility.

## **PART 2 - PRODUCTS**

### **2.01 MANUFACTURERS**

- A. The switchgear shall be manufactured by one of the following equipment suppliers, or equal:
  - 1. Asea Brown Boveri
  - 2. General Electric
  - 3. Westinghouse
  - 4. Controlled Power Corporation

### **2.02 COMPONENTS**

- A. Circuit breaker:
  - 1. NEMA SG4 and ANSI C37.06 for indoor use.
  - 2. Type: Three-pole, single throw, single interrupter per phase, drawout type, vacuum break, one drawout breaker per cubicle. The circuit breaker shall have its own set of wheels for drawout and shall not require a lifting device for this purpose.
  - 3. Rating on symmetrical basis:
    - a. Nominal voltage class, kV, rms: 34.5.
    - b. Nominal three-phase MVA Class: 1500.
    - c. Rated maximum voltage, kV, rms: 38.
    - d. Rated withstand test voltage:
      - 1) Low frequency, kV, rms; 80.
      - 2) Impulse, kV: 150.

- e. Rated continuous current at 60 Hertz, amperes, rms: 1,200.
  - f. Rated interrupting time, cycle: Five maximum.
  - g. Rated permissible tripping delay, sec: Two.
  - h. Rated voltage range factor (K): 1.65.
  - i. Rated short-circuit current at rated maximum kV, Amperes, rms: 21,000.
  - j. Maximum symmetrical interrupting capability, Amperes, rms: 35,000.
  - k. Three-second short time current carrying capability, Amperes, rms: 35,000.
  - l. Closing and latching capability, amperes, rms: 56,000.
4. Electrically powered, spring-charged, stored-energy operating mechanism, with the following additional requirements:
- a. Voltage requirements:
    - 1) Charging of stored-energy operating mechanism: 125 Volts dc.
    - 2) Closing by means of closing release coil capable of operation from 100-140 Volts dc.
    - 3) Tripping by means of shunt trip coil capable of operation from 70-140 Volts dc.
  - b. Mechanically and electrically trip-free.
  - c. Equipped with mechanical devices on front of breaker to actuate closing and tripping operations, in case of failure of control power.
  - d. Compressed spring stored-energy operating mechanism, with sufficient energy storage for opening/closing/ opening operation at rated short-circuit current or at rated required capabilities.
  - e. Stored-energy mechanism automatically charged within 10 seconds following each closing of circuit breaker.
  - f. Stored-energy mechanism suitable for manual charging by means of removable handle in case of failure of control power.
  - g. Mechanical indicator on front. of breaker to indicate that stored-energy closing mechanism is charged.
5. Racking mechanism:
- a. Horizontal drawout breaker: manually-operated mechanism designed to permit racking of breaker with door closed by inserting crank through opening of limited size maximum.
  - b. Racking mechanism gear ratio: To permit one man to rack breaker in and out manually in four minutes maximum.
  - c. When breaker element is in racked-out position, circuit breaker, complete with its operating mechanism, capable of being withdrawn from housing and moved on wheels integral with mechanism. Separate handling device for moving circuit breaker, other than transfer truck or fifth-wheel steering bar, is prohibited.
  - d. Positive stops for preventing overtravel and guides for proper alignment of breaker.
6. Grounding:
- a. When breaker is in connected position, case and frame grounded by positive contact with ground bus.
  - b. Breaker ground shoe designed to connect breaker frame to ground bus prior to engagement of primary breaker terminals.
  - c. Ground connection capable of carrying fault current equal to rated short-circuit current and related required capabilities.
7. Interlocks:
- a. provide suitable interlocks to perform the following functions:
    - 1) Automatic discharge of stored-energy mechanism of the circuit breaker prior to its racking in or withdrawal from the unit.
    - 2) Prevent racking in and out unless circuit breaker is in OPEN position.
    - 3) Prevent either electrical or manual operation of the breaker unless it is in the operating or test position. All circuit breakers to operate

- in test position and in the test position all remote and interlocking signals inhibited to and from the breaker.
- 4) Automatically close rectifier cathode circuit breaker (Device 72) when rectifier transformer feeder circuit breaker (Device 52R) is closed, unless the rectifier cathode circuit breaker has been locked out by Device 86.
  - 5) Automatically trip the rectifier cathode circuit breaker (Device 72) when the rectifier transformer feeder breaker trips (Device 52R).
  - 6) Automatically trip and prevent closing the rectifier transformer feeder circuit breaker (Device 52R) and rectifier cathode circuit breaker (Device 72) if the rectifier doors are opened.
  - 7) Electrically interlock the two incoming line circuit breakers and the bus tie circuit breaker so that all three circuit breakers cannot be closed simultaneously. Interlocking scheme shall not prevent closing of one incoming line breaker when the bus tie breaker only is closed and the other incoming line breaker is open.
- b. Mode of operation:
    - 1) Normal mode with both incoming line circuit breakers closed and with the bus tie circuit breaker open. Loss of voltage on either incoming line shall initiate automatic transfer of its bus section to the other incoming line provided that the bus section lockout relay has not operated. Re-transfer after restoration of service shall be manual, interlocked for dead transfer.
8. Primary Connection:
    - a. Connection between the removable and stationary unit made by male-and-female contacts, with the following additional requirements:
      - 1) Silver-plated, high pressure contacts.
      - 2) Automatic shutter to cover contact orifice when breaker is withdrawn to test position and to uncover orifice when breaker is returned to connected position.
      - 3) Automatic shutters constructed to withstand force of racking mechanism in case shutters fail to open when breaker is racked into positions.
  9. Secondary connection:
    - a. Control and interlocking circuit connections between stationary and removable elements of switchgear shall be made using device consisting of recessed stationary receptacle and set of self-aligning multiple-contacts to accommodate control, protection and interlock circuits, including spares, without resorting to auxiliary relays.
  10. Non-resettable mechanical operation counter registering one count for each circuit breaker closing operation.
  11. Mechanical position indicator, showing breaker as OPEN or CLOSED.
  12. Auxiliary switches:
    - a. Equip each circuit breaker with auxiliary switches, rotary type, operated in both the connected and test position with sufficient number of contacts for operation, indication and interlocking of the breaker together with at least eight spare contacts, four type "a" and four type "b", each wired through secondary disconnect device contacts to accessible terminal blocks.
- B. Potheads and Terminal Connectors
    1. Utility incoming line:
      - a. Provisions for mounting one double three-phase pothead or six single phase terminators furnished by Utility Company for incoming loop line connections and grounding.

- b. Short flexible connector installed between each pothead or terminator connecting lugs and rigid bus.
        - c. Pothead or terminator mounted in inverted position with incoming service cable at the top and connecting lugs below unless otherwise shown.
      - 2. Feeder breakers: NEMA CC1
        - a. Long barrel, double indentation compression type with NEMA standard two-hole contact pad for copper conductor. One piece tubular construction formed of tin plated copper.
- C. Buses:
- 1. General requirements:
    - a. Copper or aluminum bus bars of sufficient size to carry specified current without exceeding allowable temperature rise stated in ANSI, NEMA and IEEE Standards.
    - b. Capable of withstanding the mechanical stresses and heat from maximum short circuit current.
    - c. Bus connections bolted or welded. Contact surfaces of bolted connections silver-plated or tin-plated.
    - d. Each joint having impedance not more than that of bus bar of equal length and clamped to maintain such impedance throughout life of equipment.
  - 2. Power buses:
    - a. Three-phase, three-wire buses fully insulated to 150 kV BIL, with flame-retardant, nonhygroscopic, track-resistant insulation. Provide each bolted connection with minimum of four bolts equipped with palnut or equal and fully insulated.
  - 3. Ground bus:
    - a. Copper bus, not less than two inches by 1/4 inch provided throughout length of switchgear section.
    - b. In switchgear unit where power cables enter or leave switchgear at top as shown, copper ground bus not less than one inch by 1/8-inch extending from main ground bus to top of unit for grounding of incoming cable ground sheath or shielding tape.
    - c. Joints in ground bus made with tow bolts minimum.
    - d. Mechanical connector provided in each unit for field connection of 4/0 AWG to 500 KCMIL ground cable to switchgear ground bus.
  - 4. Control bus:
    - a. 125 Volt dc bus not less than 6 AWG copper.
    - b. One two-pole knife switch provided in each switchgear cubicle for disconnecting control circuit.
    - c. UL Class J fuses used for control and auxiliary service unfused.
    - d. Closing circuit fused: tripping circuit unfused.
    - e. White light mounted on control panel to indicate availability of dc control power.
  - 5. Incoming-line bus device for connecting portable ground clam
    - a. Connecting device consisting of copper bracket with 7/16-inch diameter bronze or copper rod positioned horizontally and parallel to rear of switchgear.
    - b. Connecting device mounted near cable termination on each incoming bus.
    - c. Connecting device to provide three-inch length between end supports of rod and minimum 2-1/2 inch radial clearance around rod.
    - d. Connecting device accessible from rear of switchgear following removal of bolted cover or opening of padlocked door.
    - e. 6-inch insulating barriers to be provided on each side of connecting devices or stirrups and extending to rear of switchgear a minimum of six inches all around.

- f. Size, thickness, insulating material and placement of insulating barriers designed to achieve adequate mechanical strength without compromising voltage withstand specified for switchgear.
    - g. Design coordinated and approved by Utility Company.
- D. Auxiliary unit:
  - 1. Indoor metal cubicle for installing potential transformers.
- E. Current transformers:
  - 1. ANSI C57.13, molded rubber or epoxy construction, wound type complying with ANSI requirements for relaying accuracy classification under burden imposed by devices specified. Mounted in a compartment isolated from the control panel.
  - 2. Current ratio: As specified or as determined by approved coordination study
  - 3. Insulation class:
    - a. 34.5 kV with basic impulse insulation level of 150 kV full-wave.
  - 4. Capable of withstanding thermal and magnetic stresses from flow of current equal to the momentary and interrupting rating of the circuit breaker.
  - 5. Maximum allowable temperature rise under continuous full load above an average ambient temperature of 55°C
    - a. By winding resistance: 30°C
    - b. By hottest spot in winding: 40°C
  - 6. Transformer secondary neutral and frame individually grounded by copper wire to switchgear ground bus. Keep each ground connection run as short as possible. Avoid grouping such connections with control or other wiring. Minimum ground wire size: size 8 AWG for secondary and size 6 AWG for frames.
  - 7. Transformer secondary equipped with covers and integral shorting bars. Secondary wiring run to readily identifiable terminal block points with integral shorting bars, in the control compartment.
- F. Potential transformers:
  - 1. ANSI C57.13, molded-rubber or epoxy, of the following configurations:
    - a. Current-limiting primary fuses mounted on drawout carriage.
    - b. Drawout transformers with integrally mounted fuses.
  - 2. Connection: phase-to-phase
  - 3. Voltage ratio: 34.5 kV to 120 Volts.
  - 4. Insulation class: 34.5 kV with basic BIL impulse insulation level of 150 kV full-wave.
  - 5. Maximum allowable temperature rise under continuous full load above average ambient temperature of 55°C:
    - a. By winding resistance: 30°C.
    - b. By hottest spot in winding: 40°C.
  - 6. Fuse grounding contacts: HV terminal of primary fuses grounded with carriage at drawout position.
- G. Meters:
  - 1. Ammeters: ANSI C39.1 and ANSI C12, switchboard type with 250 or 270 degree scale, approximately seven inches long with plus or minus one percent accuracy:
    - a. Ammeters: Five-ampere, transformer-rated with scale range equal to the associated current transformer primary rating.
    - b. Voltmeters: Rated 0-150 volts for use with 0-18 scale
  - 2. Digital Power Meter: ANSI C37.90.1 and ANSI C12.
    - a. A digital power meter, Siemens 4700 or equal, shall be provided to monitor circuits shown on the one-line diagram and specified here. The meter shall measure the real-time RMS values of phase currents, ampere demand, and phase and line voltages plus power measurements including kW, kW demand, kW hours, kVA, kVAR hours. Power factor and frequency shall also be measured. Resettable minimum and maximum values for each

measured value shall be recorded in nonvolatile memory. The kW and ampere demand period shall be user programmable from one to sixty minutes. A one volt nominal auxiliary voltage input shall also be provided. Accuracy of current and voltage measurements shall be 0.25% and kW, kW hour and other power measurements shall be 0.50% or better. The power meter shall be capable of high sampling of wave form for power quality analysis and measurement of harmonics in current and voltage wave forms.

- b. The digital power meter shall be listed under UL1244 and meet requirements of applicable ANSI Standards including ANSI C37.90.1 requirements for surge withstand and fast transient tests. All configuration information such as CT ratios, voltage scales, and communications address shall be stored in nonvolatile memory so that it can be set either from the integral display or remotely using the communications module. No batteries shall be required to maintain configuration information indefinitely. The meter shall derive power from a separate 125 V ac or dc source.
- c. Display: The digital power meter shall include an integral illuminated display for reading all real-time and min/max measured values as well as programming initial configuration and any relay set-points. The display shall consist of at least twenty .4 inch high alphanumeric characters and be operated using clearly labeled sealed membrane keys with stainless steel switch elements for long mechanical life and resistance to atmospheric contamination. The digital power meter with integral display shall be flush mounted on equipment doors or panels. Operation of the power meter to read real-time or min/max measured values or to program configuration and any relay set points shall not require opening door or removing panels. A user-defined password shall be required to change configuration, reset min/max log and kW/kVAR hours or change any relay set-points.
- d. Relay: Three programmable relay outputs shall be provided to activate and release based on threshold and time-delay values associated with any of the measured parameters. Remote relay operation shall be possible through the communications module. The relay shall be form C rated 10A 120Vac/24Vdc. Activation and release of the relays shall be recorded in a non-volatile log with cause of operation. The log shall record at least the last 50 events. Four discrete inputs shall also be provided to monitor status of NO or NC contacts. One of the discrete inputs shall also be capable of counting state changes. A programmable auxiliary 0 to 1mA or 4 to 20mA analog output shall also be provided.
- e. Communications: A communications module shall be provided using an industry standard RS-485 (or RS-232) serial bus to remotely read real-time and min/max measured values, interrogate the event log, reset min/max and kW/kVAR hours and program configuration and any relay setpoints. A means shall be provided to periodically synchronize the meter's internal clock with a master bus clock so that the meter's event and min/max logs are accurately time-stamped within one second. The RS-485 module shall provide at least 500V galvanic isolation between the meter and other devices on the communications bus. Up to 6 channels 0 to 1 or 4 to 20mA dc analog transmission of output data shall also be provided.
- f. Extended memory: The power meter shall include extended nonvolatile memory to record at least 100 snapshots of each measured parameter. The interval between snapshots shall be readable using the communications module.
- g. Portable Computer:
  - 1) Portable, Notebook Design with:
    - a) Latest Intel-based Processor (Pentium III as of year 2000).
    - b) 128 MB RAM

- c) 2 PCMCIA Slots Type II,
  - d) Local Bus Graphics,
  - e) Color Active Matrix Screen (256 colors)
  - f) 3 Hours Batter w/Charger and AC Adapter,
  - g) 3.5", 1.44 MB Floppy Drive,
  - h) CD Rom,
  - i) 4+GB Hard Drive,
  - j) Built-in Center Trackball and external Mouse
  - k) Internal Fax Modem;56K Baud,
  - l) Carrying Case
- 2) Provided with the following latest versions of software:
- a) Latest version of Microsoft Windows Operating System for PC (Windows 98 as of year 2000)
  - b) Latest version Microsoft word on PC
  - c) Latest Version Microsoft Excel on PC
  - d) Exclusive communication software and 10' cables to interface DPM communication protocol, plus DOS 6.x Operating System

H. Protective relays:

1. General requirements:
  - a. Semi-flush mounted, electro-magnetic induction disc adjustable drawout relays, overcurrent and under/over voltage type, each with test switches, except clapper type relays, when used, surface mounted on a fixed portion of the structure. Solid state relays shall not be allowed.
  - b. Rustproof metal rectangular cases finished in dull black.
  - c. With targets, hand reset for targets and seal-in units.
  - d. Contact and adjusting device readily visible, accessible and adjustable from front of relay.
  - e. Designed, constructed and tested in accordance with applicable requirements of ANSI C37.90.
2. Overcurrent relay general requirements: Select overcurrent relay characteristics, ranges and settings to provide the protection and coordination specified.
3. Transformer-rectifier feeder unit overcurrent relays
  - a. Relays 50/51 phase-time and instantaneous overcurrent relays, relays 50N/51N residual ground-time and instantaneous overcurrent relay, relays 51A phase-time overcurrent relay and relays 51B phase-time overcurrent relay.
  - b. Relay 51A to protect against overloads beyond the 300 percent, one minute capability of the units.
  - c. Relay 51B to protect against overloads beyond the 450 percent, 15 second capability of the units and coordinated with relay 51A.
  - d. Relays 50/51 and 50/51N set as low as practicable to provide maximum fault protection and to coordinate with relays 51A and 51B.
  - e. Relays 51A, 50/51 and 50/51N operating associated lockout relay, which in turn trips the unit cathode breaker and the transformer-rectifier feeder breaker.
  - f. Relay 51B equipped with auxiliary relays to trip all dc track feeder breakers on the associated dc bus.
4. Bus tie unit Overcurrent relays.
  - a. Relays 50/51 phase-time and instantaneous overcurrent relays, relays 50N/51N residual ground-time and instantaneous overcurrent relays.
  - b. Relays 50/51 and 50N/51N set as low as practicable to provide maximum bus fault protection and to coordinate with transformer-rectifier unit overcurrent relays.
5. Incoming line unit Overcurrent relays

- a. Relays 50/51 phase-time and instantaneous overcurrent relays, relays 50N/51N residual ground-time and instantaneous overcurrent relays.
    - b. Relays 50/51 and 50N/51N set as low as practicable to provide maximum fault protection and to coordinate with bus tie unit and transformer-rectifier unit overcurrent relays.
  - 6. Voltage relays
    - a. Relays 27/59 undervoltage/overvoltage, single-phase, time voltage relay.
    - b. General Electric Company Type IAV or equal.
  - 7. Lockout relays: Rotary, hand-reset, 125 Volt dc, lockout relay, equipped with green light for indicating reset position.
  - 8. Auxiliary relays: Provided where required, General Electric Company Type HGA or HFA or equal, mounted inside instrument compartment.
- I. Switch and Indicating Lights:
  - 1. General: Rotary type, cam actuated switches with escutcheon and silver to silver contacts rated 20 Amperes. Contacts enclosed in easily removable covers.
  - 2. Circuit breaker control switch: Equipped with heavy duty pistol-grip handles and operation targets. Escutcheon engraved "Trip-Close" with spring return to normal. Wired to operate the associated circuit breaker when the Local Remote selector switch is in the Local position. With indicating lights as follows:
    - a. Red light: Circuit breaker closed, wired to supervise the trip coil.
    - b. Green light: Circuit breaker is open.
    - c. Amber light: Circuit breaker is automatically tripped.
  - 3. Supervisory control selector switch: Equipped with oval handle. Escutcheon engraved "Local Remote". With a white indicating light to indicate when the switch is in the local position.
  - 4. Test switches: Provided between instrument transformers and the protective relays.
  - 5. Indicating lights: LED panel indicator lamp, CPC Part Number 6038-600-1 or equal.
- J. Control panel:
  - 1. For relays, meters and control equipment, hinged panel of formed steel, with rolled edges, door stop and conveniently located handle for opening.
- K. Line voltage indicators: Neon glow-tube capacitance-coupled high-voltage indicators, Airco Type RS or equal. Glow tube shall be visible without opening the rear door of breaker cubicle.
- L. Surge arresters:
  - 1. Provide metal oxide type surge arresters, rated 27kV line to ground, for each circuit breaker (except bus tie breaker) for the suppression of switching surges
- M. Space heaters:
  - 1. Each vertical section unit of switchgear provided with 120-volt, single-phase, 60 hertz heating element to facilitate drying and prevent condensation.
  - 2. Two 120-volt circuits will be provided. Divide heater load evenly between the two circuits.
  - 3. Heaters enclosed in grill guard with no sharp edges and located so that they are accessible for replacement without requiring de-energization of switchgear bus. Heaters controlled by thermostat adjustable from 40F to 80F. Panel ammeter, approximately 2-1/2 inches square, marked to indicate heater load. Thermostat set in accordance with manufacturer's recommendations.
  - 4. Power and control circuits to heaters and thermostat connected and protected up to devices and to incoming junction box with 3/4-inch minimum size conduit. Heater power junction box sized four inches square by two inches minimum depth and located at top of switchgear for top entry of minimum 3/4 inch conduit. Remote connection leads to power source labeled: 120V and NEUTRAL.

- N. Instrument and control wiring:
1. Instrument and control wiring includes electrical interlocks and intercompartment wiring factory installed in accordance with the following requirements:
    - a. Wire: Copper conductor minimum 14 AWG, insulation rated 600 Volt, type SIS or equal. Use flexible Class C or higher stranded insulated copper wire for wiring across hinged joints. Use twisted, shielded pair wires for overcurrent and voltage relays.
    - b. Use one continuous length of wire from terminal to terminal without splice or tap.
    - c. Install and connect removable element control wiring in accordance with manufacturer's standard for circuit breaker wiring.
    - d. Design and install control wiring so that trouble in one main circuit can not be communicated to control wiring of another main circuit.
    - e. Make connections only at terminals of device, on terminal blocks or on control buses. Make wiring connections using insulated flange fork tongue type terminals.
    - f. Terminate interconnecting wiring between cubicles and compartments on terminal blocks before wiring to components.
    - g. Terminal blocks: With washerhead screw-type terminals, circuit-marking strips for indicating control wire number, phenolic laminated dust cover and 10% minimum spare terminal points.
    - h. For each wire, use corresponding identification on terminal block marking strips and identify internal wiring at each termination, with same number as that shown on wiring diagram, using plastic sleeve
    - i. External wiring:
      - 1) External control wiring to enter from top.
      - 2) Allow space to route and terminate external single-conductor or multiple-conductor control cable.
      - 3) Top entrances provided with removable cover plates for field drilling of conduit and cable entrance holes.
- O. Supervisory control and indication:
1. Control:
    - a. Provisions for closing and tripping each circuit breaker from the remote supervisory control system. Interposing relays for interface having 24 volt dc, 15 VA maximum coils and equipped with arc suppression network. Supervisory control enabled only with Local-Remote switch in Remote position and circuit breaker in the connected position.
    - b. Indication:
      - 1) Contact from each circuit breaker from remote indication circuit breaker position as follows:
        - a) Closed: Circuit breaker closed and in the connected position.
        - b) Tripped: Circuit breaker open or in the test or disconnected position.
    - c. Contact from each lockout relay and each incoming line undervoltage relay for remote indication of relay status (Normal-Abnormal).
    - d. Contact requirements:
      - 1) Dry contacts with a maximum load rating of 15 Volt Amperes, a maximum dc current of one Ampere and maximum switching voltage of 250 Volts dc.
      - 2) Contact bounce not to exceed five milliseconds.

- P. Maximum Mounting Height of Relays, Instruments, Meters and Devices shall be 90 inches above finished floor. If necessary, rectifier transformer feeder relays may be mounted on the rectifier.
- Q. Enclosure:
1. Dead-front, free-standing indoor metal enclosure.
  2. Steel structure with frame work of welded or bolted structural steel, free from distortion and welding strain and sufficiently rigid to support equipment under normal and short-circuit conditions.
  3. Switchgear cubicles and circuit breaker compartment equipped as follows:
    - a. 34.5 kV enclosure
      - 1) Front: Hinged door :
      - 2) Rear: Hinged door with provisions for padlocking with the following additional requirements for Utility Company Incoming Cubicles:
      - 3) Rear hinged door capable of 180 degree swing.
    - b. Hinged front door in accordance with the following:
      - 1) Handle and three-point latch to hold door securely closed.
      - 2) Door stop to hold door open.
      - 3) Structural reinforcing provided as necessary to prevent sagging of door.
      - 4) Circuit breaker compartment door designed not to hinder movement of breaker in and out of compartment when door is open and door-stop set.
    - c. Circuit breaker cubicles to provide for interchangeability of removable circuit breaker elements.
  4. Finish: Metallic surfaces degreased, primed and finished with light gray enamel, Color No. 61, ANSI Z55.1 in accordance with reference standard unless other wise specified; two mils minimum dry film thickness.
  5. Switchgear assemblies shall include provisions for future extension from either end.
- R. Nameplates:
1. Three-ply, laminated phenolic plates, engraved through black face to white core and attached by means of stainless steel rivets or screws. Vertical gothic lettering using a round or square cutter. V-shaped groove is prohibited.
  2. Provide nameplate on each switchgear showing manufacturer's name and brand designation, the referenced standard, type, class and rating as applicable in accordance with reference standard.
  3. Provide additional functional nameplates for each component including relay, terminal block and other devices.
    - a. Each switchgear compartment labeled, front and back, with nameplates 2-1/2 inches by 6-1/2 inches, inscribed in letters 1/2 high: INCOMING LINE PRIMARY BREAKER NO. 1,(2); RECTIFIER-TRANSFORMER FEEDER BREAKER NO. 1, (2), (3); or AUXILIARY COMPARTMENT, as appropriate.
    - b. Each circuit breaker compartment labeled, front only, with nameplate 2-1/2 inches by 6-1/2 inches, inscribed in letters 1/2 inch high with the circuit breaker Supervisory Control Identification Number, as shown in Section 16051 Table II. A typical example of engraving is as follows:  
 SUPV CONTROL NO.  
 E-D13-11
    - c. In addition to other information normally displayed on equipment, provide one-inch nameplate showing in letters 1/2 inch high switch positions, meaning of indicator lamp and other pertinent information.
- S. Major components shall be products of same manufacturer.

- T. Unit Functional Component Listings: Items of equipment required for each switchgear unit shall be as follows as minimum, and as shown on drawings:
1. Incoming line unit:
    - a. One - Metal-Clad Stationary Unit
    - b. One - Bus, 3-phase, 1200 Amperes
    - c. One - Circuit Breaker, 1200 Amperes
    - d. One - Provisions for Power Company Cable Terminator
    - e. Three - Current Transformers, ratio as required for relaying
    - f. Three - Phase time and Instantaneous Overcurrent Relays, Device 50/51
    - g. One - Residual Ground Time and Instantaneous Overcurrent Relay, Device 50N/51N
    - h. One - Lockout Relay.
    - i. One - Time Under and Over Voltage Relay, Device 27/59
    - j. One - Digital Power Meter
    - k. One - Test Switch, Westinghouse No. 129A517G01 on line side of overcurrent relays.
    - l. Two - Test Switch, Westinghouse No. 129A517G01 on line side of undervoltage relays and for lockout relays.
    - m. One - Circuit Breaker Control Switch
    - n. One - Supervisory Control Selector Switch
    - o. Three - High Voltage Neon Indicating Lights.
    - p. Three - Metal Oxide Surge Arresters.
  2. Bus tie unit:
    - a. One - Metal-Clad Stationary Unit
    - b. One - Bus, 3-phase, 1200 Amperes
    - c. One - Circuit Breaker, 1200 Amperes
    - d. Three - Current Transformers, ratio as required for relaying
    - e. Three - Phase Time and Instantaneous Overcurrent Relays, Device 50/51
    - f. One - Residual Ground Time and Instantaneous Overcurrent Relay, Device 50N/51N
    - g. One - Lockout Relay
    - h. One - Test Switch Westinghouse No. 129A517G01, for protective relays.
    - i. One - Circuit Breaker Control Switch
    - j. One - Supervisory Control Selector Switch
  3. Rectifier-transformer feeder unit:
    - a. One - Metal-Clad Stationary Unit
    - b. One - Bus, 3-phase, 1200 Amperes
    - c. One - Circuit Breaker, 1200 Amperes
    - d. Three - Terminal connectors for 1/C #1/0 cables.
    - e. Three - Current Transformers, ratio as required for relaying, with test switch
    - f. Three - Phase Time and Instantaneous Overcurrent Relays, Device 50/51
    - g. Three - Phase Time Overcurrent Relays, Device 51A.
    - h. Three - Phase Time Overcurrent Relays, Device 51B, with Auxiliary Relays, Device 51BX, as required.
    - i. One - Residual Ground Time and Instantaneous Overcurrent Relay, Device 50N/51N.
    - j. One - Lockout Relay
    - k. One - Ammeter, Suitable Scale, with Test Switch
    - l. One - Circuit Breaker Control Switch.
    - m. One - Supervisory Control Selector Switch.
    - n. One - Kirk key interlock for use with no-load tap changer on rectifier transformer (to be coordinated with supplier of rectifier transformer).
    - o. Three - Metal Oxide Surge Arresters.
  4. Auxiliary unit:
    - a. One - Metal-Clad Stationary Unit.
    - b. One - Bus 3-phase, 1200 Amperes.

- c. Two - Incoming Line Potential transformers 34.5 kV - 120 volt, with Primary Fuses.
- 5. Leveling Channels:
  - a. Steel.
  - b. Size and configuration as recommended by the switchgear manufacturer.
- 6. Additional Circuit Breaker Elements:
  - a. Additional circuit breaker elements as indicated in Section 16051 Table III.

**2.03 ACCESSORIES**

There shall be one set of the following accessories for each substation:

- A. One breaker test cabinet with provision for electrical operation of circuit breaker with control switch and provision for other accessories as necessary.
- B. Crank for manually racking circuit breaker in switchgear cubicle
- C. One circuit breaker maintenance lever with insulated handle.
- D. One spare set of each type of high-voltage fuse.
- E. One complete set of relay test plugs and relay test switch.
- F. One set of special tool necessary for erection, operation and maintenance of switchgear including those recommended by relay manufacturer and including breaker secondary or control disconnect coupler.
- G. Pegboard: Hardboard, AHA IS 1, tempered, SIS, 1/4 -inch nominal thickness, perforated, sized to accommodate all products specified. Framed with one-inch by one-inch hardwood. Frame and hardboard painted color selected by the Engineer. Include hardware for wall mounting and pegboard accessories suited to the products to be mounted. Provide nameplates as specified, one inch wide with accessory names inscribed in 1/2 inch vertical letters.

**PART 3 - EXECUTION**

**3.01 INSTALLATION**

- A. Floor Preparation:
  - 1. Fill existing floor depression with concrete flush with finish floor. Finish concrete to the tolerances recommended by the switchgear manufacturer. Install leveling channels as recommended by the switchgear manufacturer and as shown on the approved shop drawings.
- B. Install switchgear as shown on drawing, in accordance with approved shop drawings, and as follows:
  - 1. Contractor shall make the bus connections at each shipping split.
  - 2. The number of shipping splits in ac switchgear for each substation is given below:

<u>NAME OF SUBSTATION</u>	<u>No. of shipping Splits</u>
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[LOCATION-TBD ] TPS	[ TBD ]
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- C. Install conduit and raceways as approved and in accordance with Section 16052.

- D. Make power cable and control wire connections as approved and in accordance with Section 16052.
- E. Make grounding connections as shown on drawings and approved.
- F. Arrange with the power companies for making connections with incoming lines; and for installation of CT, PT, PT fuses, and metering equipment.
- G. Use services of manufacturer's engineering representative for assistance in field assembly and installation in accordance with Section 16051.
- H. Connect space heater circuit to prevent condensation during installation.
- I. Install ac circuit breaker test cabinet and connect it to 125-volt dc supply as shown.
- J. Install pegboard at location approved by Engineer. Mount switchgear accessories and associated nameplates on pegboard.

### **3.02 FIELD QUALITY CONTROL**

- A. Verify tolerances of concrete floor finish and level of channels.
- B. Switchgear Field Testing and Inspection: In accordance with Section 16051.

**END OF SECTION**

## SECTION 16341

### METAL-ENCLOSED DC SWITCHGEAR FOR TRACTION POWER

#### PART 1 - GENERAL

##### 1.01 SUMMARY

- A. This section includes
1. furnishing, delivering and installing 700 Volt dc switchgear and spare parts.
- B. Related Sections:
1. Section 16051- Scope of Work For Traction Power
  2. Section 16052 - Basic Materials and Methods For Traction Power
  3. Section 16128 - Wire and Cable For Traction Power
  4. Section 16129 - 2000 Volt Shielded Cable for Traction Power
  5. Section 16261 - Transformer-Rectifier Units For Traction Power
  6. Section 16291 - Local Annunciator Panel For Traction Power
  7. Section 16292 - Remote Terminal Unit (AEMS RTU) For Traction Power
  8. Section 16293 - Mimic Panel-Storage Yard
  9. Section 16321 - High Voltage AC Switchgear (13.8kV) For Traction Power
  10. Section 16322 - High Voltage AC Switchgear (34.5kV) For Traction Power
  11. Section 16441 - Drainage and Negative Switchboard For Traction Power
  12. Section 16451 - Substation Busways For Traction Power
- C. Compensation for work specified in this section related to Equipment will be made in the manner of Lump Sum. In addition, other payment as described below will be paid on a unit basis.
1. 750 Volt DC Cathode Circuit Breaker removable element, 6,000 amps: Each
  2. 750 Volt DC Cathode Circuit Breaker removable element, 8,000 amps: Each
  3. 750 Volt DC Feeder Circuit Breaker removable element, 6,000 amps: Each
  4. 750 Volt DC Positive/Negative Tie Circuit Breaker removable element, 8,000 amps: Each
- D. Compensation for work specified in section associated with installation will be made in the following manner:
1. Included in the lump sum installation cost of each traction power substation and tie-breaker station.

##### 1.02 REFERENCES:

- A. Codes, Regulations and latest editions of the Reference Standards and Specifications:
1. Codes and regulations of jurisdictional authorities.
  2. NEC, NESC.C2.
  3. NEMA: CC1
  4. ANSI/IEEE: C37.100, C37.14, C37.16, C37.16a, C37.17, C37.20.1, C39.1, Z55.1.
  5. ASTM: B187
  6. AHA: IS1.
  7. ISO: 9001

##### 1.03 SYSTEM DESCRIPTION

- A. Design Criteria:
1. Floor loading: Compatible with floor design loading of 250 pounds per square foot.
  2. Switchgear suitable for anchoring to a concrete floor steel float finished to tolerance

- level of 1/8 inch in 10 feet and covered with insulating topping material.
- 3. Numbers, types and arrangements of switchgear units as shown on contract drawings.
- 4. Switchgear design shall be provided with the cable shield monitoring systems, suitable for installation of shielded feeder cables, including termination of cable shields and feeder conductors in the switchgear cubicles.

#### 1.04 SUBMITTALS

Submit the following for approval in accordance with Special Conditions and with the additional requirements as specified for each:

- A. Shop Drawings: In accordance with Section 16051, Table I.
- B. Certification:
  - 1. Design Tests reports or certified copies of test reports for identical units performed for each type and rating of switchgear and circuit breaker as assembled in its complete switchgear unit, furnished under this contract. Test shall have been conducted not more than four (4) years prior to submittal to the Authority. Certified test reports shall be certified by an independent ANSI certified factory in the USA.
  - 2. Certified test reports for specified factory production testing.
  - 3. Certificates from manufacturer verifying that equipment conforms to the specified requirements.
  - 4. Certify switchgear complies with floor design loading of 250 pounds per square foot.
- C. Documentation:
  - 1. Short-circuit calculations and system coordination study in accordance with Section 16051.
- D. Operations, Maintenance Manuals and PMI: In accordance with the following:
  - 1. **Preventive Maintenance Instruction (PMI)**

The O&M Manual provided for contractually furnished or installed equipment shall include a "Preventive Maintenance Instruction" (PMI) section, to ensure the continued safe and reliable operation of the specific system or equipment. This section of the manual shall contain the manufacturer's and/or installer's recommended procedures for periodic inspection and maintenance of the equipment. Training on these procedures shall be included in the contractor provided maintainer training curriculum. If the section contains more than one PMI procedure the section shall begin with a Table Of Contents.

The PMI procedures shall be written in language easily understood by every maintainer skill level of the responsible WMATA maintenance discipline. Prior to acceptance, clarity and effectiveness of each PMI procedure shall be demonstrated in coordination with the maintenance discipline using the recommended minimum number of the lowest skill level maintainers. The maintenance team or individual must be able to understand and successfully perform the draft PMI without coaching from contractors or engineers. Each procedure shall be formatted similar to standard PMI formatting as currently approved by the WMATA maintenance discipline responsible for future maintenance of the equipment, including a standard approval

signature cover sheet. Sample PMIs, as formatting examples, may be obtained from the appropriate maintenance discipline after contract award. Each procedure shall contain:

- a. A recommended performance frequency (interval) that is adjusted to the installed environment and expected level of use
- b. the maintenance crew size and average time for performance of the PMI
- c. the system-specific and/or equipment-specific objectives of the PMI.
- d. lists of:
  - 1). prerequisites
  - 2). required reference documents
  - 3). industry standards or regulations governing the performance of the maintenance action.
  - 4). necessary tools and test equipment
- e. definitions and graphics, as much as practical to clarify instructions
- f. Warnings, Cautions and Safety Notices, plentifully and prominently interspersed to prevent injury, damage or unsafe operating conditions before any procedure step to which they apply
- g. data-sheets and check-lists, for data collection regarding conditions that are measured and to ensure that important steps are not skipped
- h. step-by-step instructions to verify and document that all safety features of the equipment or circuit are operational, functioning properly and .are not being defeated or compromised
- i. step-by-step instructions to verify and document that the tested mechanism or circuit or subsystem functions within design parameters
- j. step-by-step instructions, types of solvents, cleansers and lubricants with intervals for lubrication and cleaning of mechanisms to prevent or minimize grime, corrosion and wear
- k. step-by-step instructions to verify the adjustment of the system, equipment or circuit which will allow it to operate properly (safely, reliably and without causing excessive wear) until the next scheduled PMI

- l. step-by-step instructions to verify the integrity of all fasteners, couplings, electrical connections, etc. which may fail or loosen between scheduled maintenance intervals
- m. step-by-step instructions to document the measured condition of the equipment or circuit, to be used for abatement of deterioration, future failure analyses and in case of catastrophe
- n. step-by-step detailed adjustment instructions for any mechanism or circuit found to be out-of-adjustment

E. Spare Parts Lists.

### 1.05 QUALITY ASSURANCE

- A. Qualification: Select a manufacturer/installation contractor who is regularly engaged in production of similar switchgear and has demonstrated a successful record of providing/installing equipment of similar type and rating for extra heavy duty traction service for at least five similar projects. **The equipment manufacturer will be required to submit documentation to support these qualifications as part of the Pre-Award process.** The equipment manufacturer shall have **as a minimum** ISO 9001 certification.
- B. For codes, Regulation, Reference Standards and Specifications refer to Article 1.02 above.
- C. Factory Testing: Submit test plans and procedures for all production tests and scheduled test date for approval at least **30** working days in advance of scheduled test dates. No test results will be accepted prior to receipt and approval of test plans and procedures. Factory test requirements are as follows:
  - 1. Circuit breaker design and production tests in accordance with the latest edition of ANSI/IEEE C37.14, ANSI/C37.16/16a, including the following as applicable:
  - 2. Design tests:
    - a. Sequence 1:
      - 1) Short-time current test.
      - 2) Continuous current test.
      - 3) Load (low) current switching tests.
      - 4) Endurance test.
      - 5) AC dielectric withstand test at 60%
    - b. Sequence 2:
      - 1) Trip device calibration check test.
      - 2) AC dielectric withstand test
      - 3) Peak current test.
      - 4) Short-circuit current test.
      - 5) Trip device calibration check test.
      - 6) AC dielectric withstand test at 60%.
    - c. Production tests shall include the following:
      - 1) Calibration test.

- 2) Control, secondary wiring, and device check
  - 3) Dielectric withstand voltage test.
  - 4) No-load operation test.
3. Switchgear assembly tests: **Table of compliance for these requirements shall be included, with all laboratory test data, photographs, etc. provided as attachments. For any tests conducted after contract award, notify the Authority Representative prior to testing to allow witnessing of tests. The following tests are required in accordance with the requirements of ANSI C37.20.1.**
- a. Design Tests:
    - 1) Dielectric tests.
    - 2) Rated continuous current test.
    - 3) Momentary current tests.
    - 4) Mechanical endurance tests.
    - 5) Rod entry test.
    - 6) Flame resistance tests for applied insulation.
    - 7) Short time current withstand test.
    - 8) Paint qualification test.
    - 9) Short circuit current withstand test.
  - b. Notify the Engineer not less than **21** days prior to factory testing to allow witnessing of tests.
  - c. Production Tests: All tests in accordance with requirements of ANSI C37.20.1
  - d. Control wiring tests:
    - 1) Check wiring for accuracy, open circuits and short circuits, ground connections, and insulation integrity by means of high-potential, continuity and operational tests.
    - 2) Subject wiring to high-potential test of 1,500 Volts 60 Hertz to ground for one minute.
    - 3) Verify that wiring is in accordance with manufacturer's wiring diagrams.
    - 4) Check wiring complete, including interconnections at shipping breaks.
- D. Major Components: Products of the same manufacturer.
- E. **Components, Limit Switches, Relays, Assemblies and Sub-assemblies: All shall be listed or labeled and be rated for utility or heavy-duty industrial use. All components that are not Listed shall be identified as NOT LISTED in the parts list submitted for approval prior to manufacture. The Authority may direct the manufacturer to use an alternative that is Listed if another comparable Listed device is available.**

#### **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. Equipment for each facility shall be delivered after its completion and in accordance with the facility access dates in Special Condition and shall be coordinated with the Engineer.
- B. Ship each unit securely packaged, braced and labeled for safe handling in shipment and to avoid damage or distortion.

- C. Temporary Bracing: Where necessary, brace switchgear for hoisting, lowering and skidding into position. Label temporary internal bracing: TEMPORARY-REMOVE BEFORE OPERATION
- D. Protection Against Concealed Damage: Include within shipping container mechanical impact recorder of rating recommended by manufacturer for shipment by railroad and submit impact record chart with manufacturer's instructions for disposition of damaged material.
- E. Assembly for Shipment:
  - 1. Design enclosures to permit lifting by jacks or slings and moving horizontally on rollers or skidding in any direction.
  - 2. Maximum dimensions of shipping sections to be coordinated with the dimension of doors and access hatches to ensure shipping dimension will allow movement of switchgear through structure without damage to equipment or structure or undue difficulty.
  - 3. Draw-out relays mounted in their proper cases with moving parts properly secured and packed for shipment.
  - 4. Removable circuit breaker elements packaged separately.
  - 5. For shipping split, interconnecting wiring coiled on one side of the shipping split with matching terminal block on other side of split. Wiring and terminal block points identified for reconnection.
- F. Store switchgear in secure and dry storage facility.
- G. Temporary Bracing: Where necessary, brace switchgear for hoisting, lowering and skidding into position.

## **PART 2 - PRODUCTS**

### **2.01 MANUFACTURERS**

- A. The switchgear shall be manufactured by one of the following or equal:
  - 1. English Electric
  - 2. Whipp & Bourne
  - 3. Control Power Corporation

### **2.02 EQUIPMENT**

- A. DC Switchgear: Metal-enclosed, drawout power circuit breaker switchgear in accordance with the following:
  - 1. The switchgear shall be manufactured in accordance with specified standards and shall have latest ANSI/NEMA/IEEE certification as applicable, prior to award of contract.
  - 2. NEMA SG5 and ANSI C37.20.1 for indoor use.
- B. Ratings:
  - 1. Maximum voltage: 800 Volts, dc.
  - 2. Rated voltage: 750 Volts, dc.
  - 3. Power frequency withstand: 4.2 kV, rms.

- C. Insulation structure:
1. Not to support combustion, produce toxic gases, absorb moisture or track.
  2. When subjected to electric arc, emission of conducting materials from insulating structure limited so as not to interfere with performance of circuit breaker.
- D. Power circuit breakers:
1. NEMA SG5, ANSI/IEEE C37.14, ANSI C37.16/16a, C37.17, single-pole, single-throw, air break, drawout type, **high-speed, with electrically controlled solenoid closing, mechanically latching, and electrically controlled tripping, mechanically** and electrically trip-free, complying with applicable parameters in Table 11 of ANSI C37.16a and with the following additional requirements. For the purposes of this specification, a single-pole breaker constitutes a switching device with a single current path and a single arcing path during current interruption
    - a. Rated voltage: 750 Volts dc.
    - b. Rated maximum voltage: 800 Volts dc.
    - c. Insulation dielectric withstand: **4200** Volts.
    - d. Continuous Current ratings:
      - 1) Cathode circuit breaker: 8,000 Amperes, dc, as indicated, capable of carrying the rated overloads **corresponding to 3000kW extra heavy duty traction rated silicon rectifier.**
      - 2) **Feeder circuit breaker: 6000 ampere dc, as indicated.**
      - 3) Positive and Negative Bus Tie Breakers: Ampere ratings, **8000 ampere.**
    - e. Short-circuit interrupting capacity: **200kA. In addition**, feeder breakers high speed, capable of interrupting the theoretical maximum fault current supplied from silicon rectifier units with a total capacity of 9000 kW. Cathode circuit breakers complying with rated peak current and short-time current ratings in Table 11, ANSI C37.16a.
    - f. Operation counter: Non-resettable with at least four digits for recording trip operations.
    - g. Endurance: Electrical and mechanical endurance performance not less than requirements in ANSI C37.16/16a.
    - h. Control voltage:
      - 1) 125 Volts dc nominal, individually fused
      - 2) Upon loss of control voltage, a DC feeder circuit breaker shall automatically open. The under voltage release mechanism shall be designed and rated to operate at 135V DC without overheating.
    - i. **Racking mechanism: The circuit breaker alignment, shutter mechanism and racking mechanism are considered an integral part of the circuit breaker. There shall be adequate clearance between equipment of the circuit breaker element and all equipment mounted on the switchgear enclosure. The racking mechanism shall be designed and constructed for moving the breaker between three (3) positions : the disconnected, test and connected positions. By rotating the racking mechanism clockwise the breaker moves toward the connected position and when in the fully racked-in connected position the**

racking mechanism turns freely. Rotating counterclockwise the breaker will withdraw from the connected to the test and then to the disconnected position. Use of electro-mechanical toggle device for racking mechanisms shall not be permitted. With connected, test and disconnected positions; manually operated closed-door mechanism by preventing overtravel, guides for alignment of breaker with stationary unit and an indicator to show breaker position within the compartment; racking mechanism gear ratio shall be designed in combination with design of shutters covering main stationary disconnect, such that shutters can withstand the force of racking mechanism if shutters fail to open as breaker is racked in.

- 1) Connected position: Both primary disconnect device and secondary disconnect device in full contact, breaker ready for normal operation.
  - 2) Test position: Primary disconnect device open and separated by a safe distance, secondary disconnect device in full contact.
  - 3) Disconnected position: Both primary disconnect device and secondary disconnect device open and separated by a safe distance.
- j. Primary connection (main disconnects): Connections between the removable and stationary unit made by male-and-female contacts, with the following additional requirements:
- 1) Silver-plated, high pressure contacts.
  - 2) Automatic shutter to cover the contact orifices when the breaker is withdrawn and uncover the orifices when breaker is returned to connected position.
  - 3) Automatic shutters constructed to withstand force of racking mechanism in case shutters fail to open when breaker is racked into connected position or shutter opening visible as breaker is racked into position.
- k. Secondary connection (control and auxiliary disconnects): Control and interlocking circuit connections between stationary and removable elements of switchgear made using device consisting of recessed stationary receptacle and set of self-aligning contacts to accommodate control and interlock circuits, including spares, without resorting to auxiliary relays.
- l. Auxiliary switch contacts: Operated by breaker mechanism in both the connected and test position with sufficient number of contacts for operation, indication and interlocking of the breaker together with at least four spare sets of reversible contacts, each wired through secondary disconnect device contacts to accessible terminal blocks.
- m. Electrically operated, **mechanically latched**, electrically and mechanically trip free, non-pumping, quick make, quick break mechanism insuring full contact pressure until the time of opening with following additional requirements:
- 1) Voltage requirement.
    - a) Closing by means of closing mechanism coil capable of operation from 90-140 Volts dc.
    - b) Tripping by means of tripping mechanism coil capable of operation from 70-140 Volts dc.
  - 2) Equipped with mechanical device on front of breaker, available with door closed, to manually (without electrical power) actuate tripping

operations and with indicator, visible with door closed, to show open or closed condition. Operable in the disconnected, test and connected positions.

- n. Arc chute: Provided to house the main contacts, confine and direct opening arcs until extinguished. **The arc chute shall be comprised of a number of vertical steel arc splitter plates designed to confine and direct the arc and break the arc into a number of smaller arcs which are cooled and extinguished as the arcs move toward the top of the plates. Ceramic plates are not permitted. Proper extinguishing devices are to be included in the metallic splitter plates. Splitter plates are to be insulated at the extremity to ensure that the arcs are extinguished. The arc chute is to be constructed to prevent the escape of arc plasma and the emission of metal from beneath the arc chute. The manufacturer will demonstrate to the satisfaction of the Authority that the design of the switchgear does not result in operation of Energized Structure Relay or Grounded Structure Relay under fault openings, and that a voltage is not impressed on control wiring under fault conditions. The design of the switchgear and associated control and relaying equipment shall ensure against breakdown of insulation to ground for all fault conditions.**
- o. Main contacts: Surfaced with silver, nonwelding silver alloy or equivalent combining high conductivity and necessary arc-resistant properties.
- p. For moving circuit breaker element in and out of cubicle: Breaker carriage mounted on wheels and shall not require use of lifting device.
- q. Removable elements for the same type and rating completely interchangeable. Removable element of different type or rating not interchangeable.

E. Space Heater:

- 1. Each unit of switchgear provided with 120 Volt, single phase, 60 Hertz heating element to facilitate drying and prevent condensation.
- 2. Heaters enclosed in grill guards with no sharp edges and located so that they are easily accessible for replacement without de-energization of switchgear bus and not located close to any equipment which may be adversely affected by their heat.
- 3. Heaters thermostatically controlled. Thermostat adjustable from 40 degree F to 80 degree F. Thermostat set in accordance with manufacturer's recommendation. Panel ammeter approximately 2-1/2 inches square, marked to indicate heater load.
- 4. **Provide ungrounded 120 VAC power circuit from an Isolation Transformer to supply heaters within the DC switchgear assemblies.**

F. Positive Bus Bars:

- 1. General requirements:
  - a. ASTM B187, 98% conductivity bare copper.
  - b. Voltage rating: 1,000 Volts.
  - c. Continuous current rating: **As shown on drawing.**
    - 1) Size sufficient to carry the overloads specified for the silicon rectifiers without exceeding the allowable temperature rise specified in ANSI and NEMA standards. Maximum current density of 800 amperes per square inch.

- d. Capable of withstanding mechanical stresses and heat due to maximum short-circuit current.
- e. Bus contact surface silver-plated or tin-plated at connection.
- f. Each joint having impedance not more than that of bus bar of same length, clamped to maintain that impedance throughout life of equipment and treated to prevent corrosion.
- g. All connections to bus made with cadmium plated, galvanized or similarly coated, high strength steel bolts of sufficient number and size to provide solidly bolted connections. Mounted on barrier type insulation or post type insulators of sufficient strength to withstand without damage or permanent distortion all stresses produced by short-circuit current equal to the interrupting rating of the circuit breakers.
- h. **The bus shall be mounted on barrier type insulation or post type insulators of sufficient strength to withstand without damage or permanent distortion all stresses produced by short-circuit current equal to the interrupting rating of the circuit breakers.**

G. Control Buses:

- 1. Switchgear control bus:
  - a. 125 Volt ungrounded dc bus; copper, #6 AWG minimum with 600 Volt insulation extending the full length of the switchgear assembly. **Terminated on a terminal blocks and marked in each cubicle for connection to individual cubicle for connection to supply source.**
  - b. One two-pole knife switch provided in each switchgear cubicle for disconnecting the control circuit of associated breaker only.
  - c. UL Class J fuses used for control and auxiliary service protection.
  - d. Separate fuses in the closing and tripping circuits of each breaker.
- 2. Switchgear negative bus:
  - a. 1,000 - Volt dc, copper bus, **insulated #6 AWG minimum wire, extended the full length of the switchgear assembly. The bus shall be terminated on terminal blocks in each cubicle for connection to individual cubicle control and metering functions.**
  - b. Substation: Extended the full length of the switchgear assembly and terminated on a terminal block for connection to the Drainage and Negative Switchboard.
  - c. Tie Breaker Station: #6 AWG minimum. Extend negative buses and terminate on terminal blocks for connection to the impedance bond on both trackside.
  - d. Tapped at each circuit breaker unit and extended to the load measuring circuit.

H. Enclosure:

- 1. Dead-front, free-standing, indoor ventilated steel enclosure, high resistance grounded and provided with suitable hardware for insulated anchoring to a concrete floor which has been steel float finished to a tolerance of 1/8 inch in ten feet and covered with an insulating topping
- 2. Steel structure with framework of welded or bolted structural steel, free from distortion and welding strain and sufficiently rigid to support equipment under normal and short-

circuit conditions. Reinforced as required to form a rigid self-supporting structure. All sheet-metal shall be 11-gauge minimum and each cubicle shall have edges formed by appropriate metal brake tooling with joints welded and grounded smooth and having insulated edges. The bottom of the cubicle shall be 1/8" steel plate provided with 1/2 inch steel angle minimum guide the wheels of the circuit breaker carriage.

3. Designed to allow adequate clearance to ground and dissipation of ionized gases from the breaker arc chutes without hazard to personnel or possibility of establishing a conducting path to grounded structure or objects when interrupting rated short circuit current at rated maximum voltage. Include adequate provisions for release of gases from the units by means of suitable stacks, louvered vent openings or vent opening covered with grilles and arranged in such a way that hot gases or other materials cannot be discharged in a manner hazardous to personnel. Ventilation openings on top are not permitted.
4. Switchgear cubicles and circuit breaker compartment equipped with hinged front and rear doors with suitable handle, latch and doorstop.
5. Each power circuit breaker in separate metal-enclosed compartment with a minimum of 24 inches wide, equipped with stationary disconnect device contacts and carriage with integral wheels to permit withdrawal without use of additional lifting device.
6. Circuit breaker compartment door designed not to hinder movement of breaker in and out of compartment when door is open and doorstop set. Capable of being closed with breaker in test or disconnected position.
7. Circuit breaker compartment to provide for interchangeability of removable elements within frames of same size and operating characteristics.
8. Barriers with removable cover plates to separate ionized gases.
9. Control panels: Dead-front, hinged swinging panels mounted on the switchgear frame.
  - a. Support flush and semi-flush devices without distortion from plane surface in any position.
  - b. Supported by hinges allowing the panel to swing open to provide free access to the equipment and wiring behind the panel.
  - c. Secured in the closed position by captive wing-headed bolts, captive knurled knobs or other captive devices capable of being tightened or loosened by hand.
  - d. Equipped with door stop to prevent damage to equipment due to overswing of the panel
10. Mechanical and electrical interlocks:
  - a. Prevent moving the circuit breaker in or out of the connected position with main contacts closed.
  - b. Prevent closing the circuit breaker mechanically unless the breaker is in the test or disconnected position.
  - c. Prevent closing the circuit breaker electrically unless the breaker is in the connected position and the compartment door fully closed and latched, or in the test position.
  - d. Mechanical or electrical interlock to prevent opening the compartment door when the circuit breaker is closed in the connected position.
  - e. Prevent racking in or out with the charging spring in charged position.
11. Key interlocks:
  - a. Prevent the cathode circuit breaker closing unless the rectifier anode disconnect switch is closed.



- for high voltage switchgear meters. Provide current limiting fuses at the connection to shunt.
8. Bus voltage metering: One dc voltmeter, ANSI C39.1 and C12, switchboard type with 250 or 270 degree scale with one percent accuracy complete with zero to 1000 Volt scale with current limiting fuses for each 750 Volt dc positive bus.
  9. Cathode circuit breaker equipped with reverse current trip device: Provided to trip the breaker in the event the current reverses. Reverse current series trip device range 500-2000A (Device 32).
  10. Cathode circuit breaker forward current trip device: Provided and coordinated with dc feeder breakers to trip the breaker upon failure of any feeder breaker to clear a fault (Device 76).
  11. Feeder breaker automatic reclosing equipment (including gap breaker): Provided for each main line feeder circuit breaker and including voltage divider type load measuring relay (Device 182), load measuring resistors, adjustable time delay reclosing relay (Device 183), time delay relays, counters and other devices required to perform the following functions; all assembled in a separate, isolated plug-in housing within the breaker cubicle. All equipment, except load measuring resistor, shall be panel-mounted as draw-out units for ease of removal.
    - a. Operates only when the breaker is in the connected position. Prevents reclosing and disconnects from 700 Volt dc potential when the circuit breaker is in test or disconnected position, or when the circuit breaker is tripped manually, including tripping by the emergency trip circuit, tripping from remote and tripping from the local control switch.
    - b. Closes circuit breaker only (1) if bus or third-rail voltage is above 500 Volts dc or (2) when bus or third-rail voltage is below 500 Vdc, if the load resistance is acceptable. Acceptable level of load resistance shall be adjustable. Provide Setting and calculations for WMATA engineer's approval.
    - c. Load measuring compensates for voltage drop in the track circuit.
    - d. Reclosing circuitry is disconnected if a prolonged closure of the circuit breaker does not occur within a preset time and after four closing attempts after the close signal is received. This automatic disconnection does not lock out the circuit breaker but merely requires an additional manual close signal to reinitiate the automatic reclosing sequence (Device 183).
    - e. All timers and counters are adjustable. Loss of control power is annunciated. Load adjustments shall have calibrated set points over the specified range and the indicators shall be visible from the front panel of the draw-out unit
    - f. The load measuring automatic reclosure circuit shall be designed to permit a breaker reclosure within the preset timeout limit (i.e within 4 attempts), with one chopper type, 8 car train, perched in the track awaiting power restoration after a loss of power.
    - g. The load measuring automatic reclosure equipment shall be designed for ease of calibration with convenient input terminals with either an internal or external calibrator provided for testing entire circuit operation. All calibration instructions shall be fully addressed in the O&M manual. Detailed circuit analysis and operation with corresponding drawings shall be provided for each circuit function, printed circuit board, etc., to permit component level troubleshooting.

- h. Gap breaker reclosure circuitry shall be interlocked with adjacent breakers such that it shall not commence load measuring until adjacent breakers close.
- 12. Feeder breaker and bus tie breaker series trip device: Direct acting, direct release, forward and reverse (bi-directional), series trip device adjustable between 200% and 400% of circuit breaker continuous current rating. Provided for each feeder circuit breaker and bus-tie breaker. Use of control power to accomplish series tripping shall not be permitted. (Device 176).
- 13. **Each feeder and gap breaker shall be equipped with a Rate-of-rise trip device (Device 150) equal to Swartz type 176/150 relays for feeder circuit breakers. The rate-of-rise current detection system shall be as manufacture by SMC Electrical Products or approved equal. Mult-function relays shall be acceptable.** Additional requirements as follows:
  - a. Includes rate of rise sensing circuitry, adjustable rate of rise trip level, adjustable time delay trip and a flag or indicator lamp to verify operation.
  - b. Designed to detect remote short circuit and initiate breaker tripping if the magnitude of short circuit current is below the setting of the breaker direct acting series overcurrent trip device. Capable of discriminating between remote short circuits and train accelerating inrush and insensitive to transients. **Make rate of rise trip device connections through a fused disconnect to a DC current shunt with appropriate device rating.**
- 14. **Surge arrestors for each feeder circuit breaker: dc surge arrester, metal-oxide type suitable for dc transit system distribution, rated 1000 volts maximum permissible line to ground dc voltage and 970 volts dc maximum continuous operating voltage. DC surge arrestors shall be enclosed in a fiberglass enclosures with visible windows, base insulated from switchgear enclosure, the discharge(ground) cable connected to the station ground shall be in a fiberglass conduit..**
- 15. Shunt/Isolation/Amplifier (Voltage Transducer): Provide one voltage transducer in the dc switchgear at each substation. The shunt amplifier shall be a linear amplifier designed to amplify dc shunt millivolt signals. The input shall be from 0-1,000 volt and output shall be 1 milliamp. Provide complete isolation of the input signal. A magnetic amplifier shall be used in the input circuit to isolate the inputs from all other circuits and grounds. The input shall be tested at 4,000 Volts dc for one minute to insure that no breakdown will occur when connected to shunts operating at high voltage above ground. The output shall be a hybrid amplifier operating in the transconductance mode to provide a constant current output. Load resistance variations from 0-10K shall have less than 0.1% effect on the output current to make the amplifier an ideal device for telemetering, scaling and recording applications. The output should be filtered.
  - a. A variation resistor from zero to maximum gain adjustment shall be provided and be accessible through the top cover. Large gain changes should be accomplished by changing the auxiliary gain resistor.
 

1)	Power Requirements	125 Vdc $\pm$ 10% 10VA (Max)
2)	Input Impedance	5000 ohms/Volt
3)	Load Impedance	Any load between 0-10K
4)	Accuracy	$\pm$ 0.5% RO @ 25°C
5)	Temperature Range	-10°C to + 70°C
6)	Temperature Coefficient	+ 0.04% °C

- b. The transducer shall be compatible with the rating of the dc switchgear . Contract.
  - c. The Shunt/Isolation/Amplifier shall be SWARTZ type or equal.
16. Shunt/Isolation/Amplifier (Current Transducer): Provide in each substation switchgear a current transducer for each of the cathode breakers as shown. The shunt amplifier shall be a linear amplifier designed to amplify dc shunt milliamp signals. The input shall be 50mV rated at 20,000 Amps for 8,000 Amps Cathode breaker with 1 milliamp output.
- a. Provide complete isolation of the input signal. A magnetic amplifier shall be used in the input circuit to isolate the inputs from all other circuits and grounds. The input shall be tested at 4,000 Volts dc for one minute to insure that no breakdown will occur when connected to shunts operating at high voltage above ground. The output shall be a hybrid amplifier operating in the transconductance mode to provide a consistent current output. Load resistance variations from 0-10K shall have less than 0.1% effect on the output current to make the amplifier an ideal device for telemetering, scaling and recording applications. The output should be filtered.
  - b. A variable resistor from zero to maximum gain adjustment shall be provided and be accessible through the top cover. Large gain changes should be accomplished by changing the auxiliary gain resistor.
    - 1) Power Requirements 125Vdc  $\pm$  10% 10VA (Max)
    - 2) Input Impedance 5000 ohms/Volt
    - 3) Load Impedance Any load between 0-10K
    - 4) Accuracy  $\pm$  0.5% RO @ 25°C
    - 5) Temperature Range -10°C to + 70°
    - 6) Temperature Coefficient \_\_\_\_\_ + 0.04% °C
  - c. The transducer shall be compatible with the rating of the dc switchgear furnished under the Contract.
17. D.C. Watt transducer: Provide in each substation dc switchgear a dc Watt Transducer for each of the cathode breakers as shown. The dc Watt transducer shall be able to measure direct current watts. The transducer shall be able to convert Digilogic Transducer Input Circuits to accept direct currents. The current input can be direct from a 50mV or 100mV internal shunt. The line-to-line voltage input shall be made for an internal multiplier resistance box for voltages from 600 Vdc to 2,000 Vdc.
- a. Potential Input Nominal 100 Vdc to 2,000 Vdc, for inputs above 600 Vdc, an external Multiplier Resistance Box should be supplied.
  - b. Overload Rated Voltage + 20
  - c. Burden 200 ohms/Volt Nominal
  - d. Current Input From External 50mV source
  - e. Nominal 100mV shunt
  - f. Overload 5 Vdc maximum
  - g. Burden 10.0 mA maximum
  - h. Auxiliary Power 125 Vdc  $\pm$  10%, 6 Watts
  - i. Dielectric Withstand 4,000 Vdc for 1 second
  - j. Temperature Operating Range -20°C to +80°C

	1)	Effects on Accuracy	$\pm 0.15\% / ^\circ\text{C}$
k.		Storage	$-40^\circ\text{C}$ to $+80^\circ\text{C}$
l.		Accuracy	$\pm 0.5\%$ of Rated Output for 100 mV Shunt
m.		Output	0-1 mA dc into 0-10,000 ohms

- 18. Transducer inputs to RTU: **Current, voltage and watt transducer-outputs shall be identified on terminals for connection to analog input modules on DTS/RTU I/O modules.**
- 19. Bus Meter: 0-1000 Volts  $\pm 1\%$

J. Control and indication:

- 1. Control switch: Provided on each circuit breaker for electrical closing and tripping of the breaker.
- 2. Local-Remote selector switch: Provided on each circuit breaker for transferring control from the local control switch to the remote control system.
- 3. Indicating lights: LED panel indicator lamp, General Electric Company Type ET-16 or equal provided on each circuit breaker as follows:
  - a. Red: Breaker closed.
  - b. Green: Breaker open.
  - c. White: Selector switch in local position.

K. Emergency tripping: Means provided on each feeder circuit breaker to electrically trip the breaker from a remote emergency trip system, when the breaker is in the connected position, regardless of Local-Remote selector switch position. The emergency tripping circuits shall be independent and isolated from other tripping circuits of the circuit breakers. **Emergency Trip System activation shall be monitored at the TPSS, TBS Annunciator Panel and MOC(via DTS).**

L. Loss of control power: Means provided on each feeder circuit breaker to automatically trip the breaker on loss of control power. A separate relay shall be provided to monitor loss of control power and provide 2NO and 2NC contacts for connection to annunciator panel.

M. Acceleration gap feeder circuit breaker control: Automatically trips when either adjacent contact rail section dc feeder circuit breakers trip. Allowed to close automatically when both adjacent contact rail section dc feeder circuit breakers are closed. Automatic reclosing should initiate only after both adjacent breakers are closed.

N. Positive and Negative Bus tie breaker control (Storage Yard TPS): Equipped with bi-directional overcurrent series-trip unit (Device 176) and coordinated with adjacent feeder breaker tripping. Negative bus tie breaker shall only operate (close or open) when the positive bus tie breaker is open. Positive bus tie breaker shall only close after the negative bus tie breaker is closed and shall only be opened prior to the negative breaker opening. In the remote mode, both positive and negative tie breakers shall be controlled by one control switch. Electrical interlocks shall be provided to automatically trip the positive breaker if the negative breaker trips, and vice versa.

O. Control and instrument wiring:

- 1. Factory-installed.

2. Insulation rated 2000 Volts as well as 600 volts, Type SIS, 14 AWG minimum copper conductor unless otherwise specified. Flexible Class C or higher stranded insulated copper wire used for wiring across hinged joints.
3. One continuous length of wire used from terminal to terminal without splices or taps.
4. Removable element control wiring installed and connected according to manufacturer's standard for circuit breaker wiring.
5. Control wiring so designed and installed that fault in one main circuit cannot be transferred to control wiring of another main circuit.
6. Connections made at terminals of device, on terminal blocks or on control buses. Wiring connection made using insulated flange fork tongue type terminals.
7. Interconnecting wiring between cubicles and compartments terminated on terminal blocks before being wired to components.
8. Terminal blocks: With screw terminals, circuit marking strips for indicating control wire number, phenolic laminated dust cover and minimum of 10% spare terminal points.
9. For each individual wire, corresponding identification used on terminal block marking strips.
10. Internal wiring identified at each termination, with same number shown on wiring diagram, using suitable plastic sleeve attached within six inches of terminal connections. Terminals shall be color-coated for ready identification of voltage (e.g. 750 Vdc, 125 Vdc, 24 Vdc etc.)
11. External wiring: Provision made for external control wiring to enter from top and with space allowed to terminate external multiple-conductor copper control cable. Top entrances provided with removable cover plates for field drilling of conduit and cable entrance holes.

P. Remote control and indications:

1. Control: Provisions for closing and tripping each circuit breaker except cathode circuit breakers, from the remote control system. Remote control enabled only with Local-Remote switch in Remote position and circuit breaker in connected position. Provide interposing relays for closing and tripping circuits to interface with remote control for each breaker. The relay coils shall be **General Electric Type HGA or HFA, equipped with arc suppression and have** 24 Vdc rating except for those serving Storage Yard and controlled from Yard Control Tower which shall be 125 Vdc rated.
2. Indication:
  - a. Contact from each circuit breaker for remote indication of circuit breaker position as follows:
    - 1) Closed: Circuit breaker closed and in the connected position.
    - 2) Tripped: Circuit breaker open or in the test or disconnected position.
    - 3) Contact bounce not to exceed five milliseconds.

:

3. 125 Volt DC Yard Control cables shall be shielded type cable.

Q. Auto Manual control of Cathode Breaker: An Auto/Manual selector switch shall be provided to control the cathode breakers locally when the selector switch is selected in the Manual position. When Auto Selection is made the cathode breaker shall be controlled by the position of 15 kV or 34.5 kV rectifier breakers described in Section 16321 and 16322.

R. Nameplates:

1. Three-ply, laminated phenolic plates, engraved through black face to white core and attached by means of stainless steel rivets or screws. Vertical gothic lettering using a round or square cutter. V-shaped groove is prohibited.
  2. Nameplate provided on each switchgear showing manufacturer's name and brand designation, the referenced standard, type, class and rating as applicable in accordance with referenced standard.
  3. Additional functional nameplates for each component:
    - a. Each switchgear compartment labeled, front and back, with nameplate 2-1/2 inches by 6-1/2 inches, inscribed in letters 1/2 inch high: CATHODE CIRCUIT BREAKER NO. 2, FEEDER CIRCUIT BREAKER NO. 1, POSITIVE TIE BREAKER, NEGATIVE TIE BREAKER as appropriate.
    - b. Each circuit breaker compartment labeled, front only, with nameplates 2-1/2 inches by 6-1/2 inches, inscribed in letters 1/2 inch high with the circuit breaker Supervisory Control Identification Number, as shown on drawing.
    - c. Provide nameplates for all internal components such as relay, fuse, terminal block, etc.
    - d. In addition to other information normally displayed on equipment, provide one inch nameplates showing, in letters 1/2 inch high, switch positions, meaning of indicator lamp and other pertinent information.
- S. Accessory equipment: One set of the following provided for each substation and tie breaker station:
1. Cranking device to be used for moving the circuit breakers to and from the connected, test and disconnected positions.
  2. Removable closing lever or crank for manually closing the circuit breakers, if required.
  3. A set of test plugs for draw-out relays and instruments.
  4. A set of wrenches for the primary disconnecting devices of the circuit breaker, if required.
  5. Fuse tongs or hook sticks, depending on the requirements.
  6. Twenty-five feet of test cable for each switchgear assembly to permit operating a circuit breaker when completely removed from its compartment. This cable will be required to connect the control circuits of the withdrawn breaker and operate the breaker without the use of the test cabinet.
  7. Test cabinet, suitable for wall mounting, for operating, testing and inspecting the circuit breakers when removed from their compartments. **Include test jumper not less than twenty-five (25) long for connection between the breaker and the test cabinet.**
  8. Set of test jumpers for connecting breaker units to the test cabinet.
  9. Pegboard: Hardboard, AHA IS 1, tempered, SIS, 1/4-inch nominal thickness, perforated, sized to accommodate all products specified. Framed with one-inch by one-inch hardwood. Frame and hardboard painted with color selected by the Engineer. Include hardware for wall mounting and pegboard accessories suited to the products to be mounted. Provide nameplates as specified, one inch high with accessory names inscribed in 1/2-inch vertical letters.
- T. Additional Circuit Breaker Elements: There shall be an additional circuit breaker elements as indicated on drawing.
- U. **Cable Shield Monitoring System: Provide relay to monitor failure or degradation of insulation or jacket of the 1000MCM shielded track feeder cables. The associated relays and devices for this system shall be provided to all DC switchgear line-up.**

The relay shall function to indicate alarm for cable insulation/degradation failure. The cable shield relay and each component shall be isolated from the 750 VDC. The jacket failure alarm and insulation failure alarm shall be designed so as to facilitate cable identification with selective disabling switches in each feeder breaker(s) cubicle. The relay shall include sufficient filtering and adjustable trigger points and time delays to minimize nuisance alarms. The relay shall be manufactured by SMC Electrical Products or approved equal and include, but not be limited to the following:

- a. Provide two cable shield monitoring relays for each DC switchgear assembly containing five (5) feeder breakers or more. For less than five (5) feeder breakers, provide one relay.
- b. Provide and install single knife switches in each feeder breaker cable compartment door to provide means of isolation of single feeder cable. Suitable opening shall be provided in each switch enclosure for control cables to enter from the bottom. The switch shall be rated for 1000V, designed similar to ABB Flexitest switch and mounted as follows:
- c. Relay control wiring connected to the shield wire shall be insulated with minimum of 2kV, 12 AWG minimum copper conductors, Judd Wire or approved equal.
- d. The Contractor shall provide a working model of the cable shield monitoring system and demonstrate operation and submit test results of the same to WMATA engineers for approval before installation.
- e. Move to shield cable
- f. Shield monitoring system shall be connected to the substation annunciator and DTS for local and remote alarm monitoring.

**PART 3 - EXECUTION**

**3.01 INSTALLATION**

- A. Floor Preparation:
  - 1. Finish concrete to the tolerance recommended by the manufacturer.
  - 2. Install insulated floor topping in accordance with Section 16052.
- B. Install switchgear as shown and in accordance with approved shop drawings and as follows.
  - 1. The number of shipping splits at each facility is indicated below. Contractor shall make bus connections in accordance with manufacturer's requirement and connect all control wiring at the appropriate terminal blocks.

Name OF FACILITY	NO. OF SHIPPING SPLITS IN DC SWITCHGEAR	NO. OF PIECES
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[TBD] TBS	[TBD]	[TBD]
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2. Contractor shall furnish and install anchors in insulated floor for DC switchgear at locations indicated by the manufacturers and as shown in typical detail for anchoring DC switchgear to the insulated floor. The required number of anchors at each facility is given below:

NAME OF FACILITY	ANCHOR
[Location - TBD] TPS	[TBD]

- C. Install busways as shown and in accordance with approved shop drawings as Section 16451.
- D. Install conduit, raceways and bus duct as approved and in accordance with Section 16052.
- E. Make power cable and control wire connections as approved and in accordance with Section 16052. The required number of 1000 KCMIL cable lugs shall be furnished by the DC switchgear manufacturer.
- F. Use services of manufacturer's engineering representative for assistance in field assembly and installation of the switchgear in accordance with Section 16051.
- G. Connect space heater circuit to prevent condensation during installation. Connect space heater to 125-volt AC supply as shown.
- H. Install dc circuit breaker test cabinet and connect it to 125-volt dc supply as shown.
- I. **Coordinate installation of all DC Shielded cable terminations with specification section 16129 - 2000 Volt Shielded Cable For Traction Power.**

**END OF SECTION**

## SECTION 16360

### UNIT SUBSTATIONS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing substation equipment for 34.5 kV and 13.8 kV primary service.
- B. Related Work Specified Elsewhere:
  - 1. Wire connection accessories: Section 16125.
  - 2. Grounding and bonding: Section 16060.
  - 3. High-voltage switchgear: Section 16320.
  - 4. Low-voltage switchgear and switchboard: Section 16435.
  - 5. Transformers: Section 16270.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of jurisdictional authorities.
  - 2. NEC.
  - 3. ANSI/IEEE: 141.
  - 4. IEEE: C57.93, C57.94.
- B. Main Components for Substation: Produced for assembly as specified, factory-coordinated and tested before delivery to job site as follows:
  - 1. 34.5 kV or 13.8 kV metal-clad switchgear and 34.5 kV or 13.8 kV to 480Y/277-volt transformer: For in-line assembly.
  - 2. 480-volt switchgear and switchboard: For assembly of various sections as integral unit for in-line assembly with transformer where shown.
- C. Qualifications of Instructor for Operation and Maintenance Training: Qualifications will be considered adequate when either of the following is met:
  - 1. Designer of the system is the instructor and has the ability to communicate facts about the system in understandable terms.
  - 2. Instructor has been trained in teaching methods and is familiarized fully with the subject matter.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings: In accordance with Table 16360-1.
    - a. Submit shop drawings for high-voltage switchgear to electric utility company as applicable for the service area, for coordination and approval by the power company.
    - b. Submit to the Engineer shop drawings approved by the power company as well as shop drawings for complete unit-substation equipment.
  - 2. Certification.
  - 3. Documentation:
    - a. Short-circuit calculations and system coordination study for system protection and selective overcurrent tripping:

- 1) In accordance with ANSI/IEEE 141 for fault calculations and coordinated system protection.
- 2) Include high-voltage source, relays, fuses if used, on high-voltage switchgear, transformer, low-voltage switchgear, molded-case circuit breakers for low-voltage feeders in switchboards, panelboards, motor control centers and motor starters.
- 3) Available short-circuit currents based on power company contribution of 1,500 MVA for 34.5 kV service and 750 MVA for 13.8 kV service and actual motor contribution at low-voltage switchgear but not less than 25 percent of transformer kVA rating for motor contribution if the actual is less.
- 4) Recommended settings and adjustment of protective devices.
- b. Field-test plan and documentation:
  - 1) Submit field-test plan within 60 days after award, with accompanying documentation in the form of test-data recording sheets and list of proposed test equipment.
  - 2) Do not proceed with testing until plan and documentation are approved.
  - 3) Indicate in scope of test plan how equipment will be tested to ensure safe and orderly transition from installation, through initial energizing, to specified field-testing.
  - 4) Accompanying documentation to include standard data-recording sheets as used in manufacturer's in-plant testing of equipment and devices or as used by major utilities or large industrial users of specified equipment. Submit certified copies of test data, indexed by substation, within two weeks after completion of testing.
  - 5) Verify schematic diagrams for proper operation. Submit one complete set of certified yellow-line schematics at time of initial energizing of equipment. Schematic diagrams to indicate verification and tests of functional and protective devices. Indicate each circuitry correction or modification in red-line.
- c. Instructor qualifications: Five copies of resume which outlines each instructor's qualifications and skills not later than 180 calendar days prior to commencement of training.
4. Operations and maintenance training material: Five copies not later than 180 calendar days prior to commencement of training.
5. Operation and Maintenance Manuals: In accordance with Table 16360-2.

#### **1.04 OPERATION AND MAINTENANCE TRAINING:**

- A. Perform operation and maintenance training in accordance with the General Requirements and the following additional requirements for development and performance of operation and maintenance training for unit substation.
- B. Use only instructors who are fully qualified for their presentations as required above under Quality Assurance.
  1. Concept of Training: Design classroom and field instruction to cover in detail the functions of each item of equipment. Cover fault isolation and troubleshooting technique to the extent necessary to permit a technician to diagnose and repair faulty modules. Design instruction to provide Authority maintenance personnel with practical experience in the performance of preventive and corrective maintenance. Provide troubleshooting and fault isolation of simulated faults for each item of equipment in the unit substation.
  2. Develop and provide all operation and maintenance training necessary for Authority-designated personnel to support the power equipment. Have classroom instruction

include not only the anatomy and functioning of the parts under discussion, but the essentials of their routine care, including lubrication schedules, adjustments, limits, test frequency, inspection frequency, troubleshooting, removal and replacement. Have instruction cover theory of operation of the power systems, individual modules and special protective circuits. Use software flow diagrams in order to show sequence of events and timing of system operations.

3. Have the course include hands-on troubleshooting of all subsystems. Allot students adequate time for performing preventive-maintenance operations on the equipment in addition to troubleshooting "bugged" system.
4. In training, assume the Authority's employees have no knowledge of the features of the new equipment. The Authority is permitted to videotape all class presentations.

C. Training Methods and Materials:

1. Develop first-generation reproducible training material.
2. Conduct training using final manuals approved by the Authority and certified by the Contractor as being correct, as-built and reproducible. These materials become the property of the Authority at the end of program.
3. Develop and furnish the following training materials for each course for the Combined Training Program:
  - a. Instructor material for each course.
  - b. Course outline: Course outline with learning objectives. Include a topic outline for each item of equipment. Include in maintenance courses a section devoted to system-fault analysis and troubleshooting. State the learning objectives for each topic.
  - c. Lesson plans: A set of lesson plans for each item of equipment, corresponding to the topic outline, and containing the following information:
    - 1) Lesson title.
    - 2) Time.
    - 3) Objectives.
    - 4) Training aids required.
    - 5) Instruction sequence (outline).
    - 6) Tests.
    - 7) Summary.
  - d. Training aids: For each topic, develop optimum use of visual aids, including transparencies size 8-inch by 10-inch, 35-mm slides, films, and mockups. Provide approved shop drawings in transparency.
  - e. Instructional material: Use the applicable equipment operation and maintenance manuals as the primary source of instructional material. In addition, develop notebooks for each course containing such additional drawings, descriptive information and procedures necessary to ensure that the learning objectives are met in an orderly and timely manner. Arrange notebook material by each item of equipment and sequence according to the topic outline.
  - f. Course topic outlines and schedules: Have the topic outline and schedules for each course contain the following:
    - 1) Description of course including course objectives and type of training, Level One, Level Two or Level Three.
    - 2) Course length and recommended numbers of students per course.
    - 3) List of training materials required including documentation and equipment.
    - 4) For each topic outline for the course, a topic objective and the time allotted to the topic.
    - 5) Schedules listing the major topics and subtopics on a time allocation for each topic.
  - g. Instructor and training aids: Have the instructor guide for each course include:

- 1) Table of contents listing each topic and the time allotted.
  - 2) List of applicable documents.
  - 3) List of training materials.
  - 4) Course learning objectives, course length and recommended number of students.
  - 5) Provide each topic with a cover sheet listing topic, objective, time allotted and training aids required.
  - 6) Include training aids with the instructor guides.
- h. Students handouts: Reproduce diagrams, drawings and procedures from engineering data and manuals and include them in student handout.
- D. Instructional Equipment: Conduct training utilizing installed equipment in normal operating conditions, except use maintenance training-lab equipment for shop and maintenance instruction.
- E. Training Program:
1. Include the following:
    - a. Level One - Equipment-Operating Training Course: Conduct this course for Authority-designated personnel; providing training for equipment operation and troubleshooting, and basic theory of operation of each piece of equipment. In handouts include specific check lists on each piece of power equipment.
    - b. Level Two - Field-Maintenance Training Course: Conduct this course for Authority-designated personnel; emphasizing preventive maintenance, as well as location and correction of faults and equipment failures. Present sufficient training in operation, theory of operation and fault isolation to isolate problems to modules or subassemblies. Stress use of the maintenance manuals to help identify faults.
    - c. Level Three - Shop-Maintenance Training Course: Conduct this course for Authority-designated personnel; providing in-depth training on theory of operation of the systems, individual components, each subassembly (including Contractor-designed, off-the-shelf OEM and other vendor-supplied assemblies), special test equipment; shop test procedures, module and printed circuit board, all replacement and troubleshooting procedures to the circuit-board level, overhaul and testing procedures, operations procedures, and preventive-maintenance procedures. Provide information drawings, including schematics, bills of material and other material required to troubleshoot to the component level.
  2. Supplemental Training: In the event Contractor changes or performs modifications to equipment subsequent to the training that impact form, fit or function; provide supplementary training to the Authority's training instructor on a one-time basis.
- F. Scope: The following number of Authority personnel will attend the training program:

Course Title	Length of Course Hours	Number of Students Per Session	Number of Courses	Number of Course Hours
Field Maint.	80	6	2	160
Shop Maint.	40	8	1	40

1. Provide practical training on equipment for not less than 60 percent of the course duration.
  - a. Location: Conduct training classes at facilities provided by the Authority.
  - b. Times: Set class times at the convenience of the Authority.

2. For Level Two - Field-Maintenance Training Course, the Contractor may propose four courses at 40 hours each in lieu of two courses at 80 hours each subject to approval.
- G. Equipment:
1. Training equipment: Supply and deliver to the Engineer special tools required for maintenance training.
  2. Test equipment: The Field-Level maintenance training requires students to use test equipment provided by the Contractor. The Shop-Level maintenance training requires students to use test equipment provided by the Contractor.
  3. Service equipment: Prior to final turnover to the Authority, furnish and install the following for substation maintenance equipment:
    - a. 72" x 36" x 36" heavy-duty metal storage cabinet with four-shelf arrangement.
    - b. Eight-foot fiberglass step ladder.
    - c. Full set of approved, half-size electrical and equipment shop drawings, bound in stiff cover resistant to oil, water and wear. Make drawings capable of being stored in the metal cabinet.
    - d. Wall-mounted Maintenance Map/Single Line Diagram. Use frame made of metal with lexan or plexiglass. Mount frame as directed.
    - e. 30" x 48" x 34"-high heavy-duty metal work bench with task stool, reinforced steel top, 1/4-inch thick rubber matting covering entire top, and one 12-gauge steel shelf for full width and depth of bench with back turned up two inches.

#### **1.05 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Deliver and handle equipment as specified.
- B. Store equipment in secure and dry storage facility.

### **PART 2 - PRODUCTS**

#### **2.01 PRODUCTS AND MATERIALS:**

- A. High-Voltage Switchgear: Section 16320, kV rating, type and quantity as shown.
- B. Low-Voltage Switchgear and Switchboard: Section 16435, quantity as shown.
- C. Transformers: Section 16270, voltage rating, type and quantity as shown.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION:**

- A. Install substation equipment at location shown in accordance with manufacturer's recommended installation procedure, the NEC and as follows:
  1. Install high-voltage switchgear in accordance with Section 16320, low-voltage switchgear in accordance with Section 16435 and transformers in accordance with Section 16270. Arrange and connect the switchgear and the transformers as shown.
  2. Make power-cable and control-wire connections as shown and in accordance with Section 16125.
  3. Make grounding connections as shown and in accordance with Section 16060.
  4. Interconnect secondary of two substations to form secondary selective network as shown. In combined switchboard room, use bus duct for secondary tie feeder.

5. Arrange with electric utility company for providing primary service to switchgear and coordinate incoming-service termination details.
  6. Apply touch-up paint where necessary.
- B. Manufacturer's Engineering Representative:
1. Arrange for assistance of manufacturer's engineering representative during field-assembly, installation and adjustment of substation equipment.
  2. Initial energizing of each substation to be under guidance of manufacturers' engineering representative who will advise Authority personnel on step-by-step procedure.

### 3.02 FIELD QUALITY CONTROL:

- A. Field-Testing and Inspection:
1. General requirements:
    - a. Conduct field-testing and inspection at each ac-switchboard room to ensure proper operation of equipment provided
    - b. Relays and trip-device setting: The Contractor is responsible for setting protective relays and trip devices in accordance with approved coordination study and their calibration for proper operation during field-testing.
  2. Field inspection:
    - a. Prior to field-testing, check equipment installation in accordance with manufacturer's recommendations and ANSI/IEEE 141 including, but not limited to, verification of the following:
      - 1) Integrity of bus insulation.
      - 2) Tightness of connections.
      - 3) Adequate support of busbars.
      - 4) Correct grounding, anchoring and alignment of switchgear in accordance with manufacturer's drawings.
      - 5) Ease of racking drawout breakers in and out of cubicle.
      - 6) Physical interchangeability of similar circuit breakers.
      - 7) Adjustment of circuit-breaker contact.
      - 8) Functioning of interlock and closing of safety shutter with breaker in disconnect or withdrawn position
      - 9) Transformer installation in accordance with IEEE C57.93 and C57.94.
      - 10) Verify mechanical clearances and proper operation of disconnecting and grounding devices associated with potential transformers.
      - 11) Tightness of bolted bus joints by calibrated torque-wrench method, based on manufacturer's recommended values.
      - 12) Ground-fault system:
        - (a) Inspect for physical damage and compliance with approved shop drawings. Verify location relative to sensors of main neutral-to-ground bus disconnect link and avoidance of multiple ground connections in combined-switchboard rooms.
        - (b) Inspect control-power transformer to ensure adequate capacity for system.
        - (c) Inspect zero-sequence system for symmetrical alignment of core-balance transformers about current-carrying conductors.
        - (d) Verify by device operation, ground-fault device circuit nameplate identification.

- 13) Calibrate protective devices/relays and set them in accordance with approved coordination study.

3. Field-testing:

- a. Furnish equipment required to perform tests.
- b. Provide services of manufacturer's engineering representative and supporting field crew for a period not less than three man-days. Conduct tests in the presence of the Engineer. For each item, submit for approval and perform approved tests including, but not limited to, those specified.
- c. Perform insulation-resistance test of 60-second duration in accordance with the following requirements:

- 1) Test voltage:

Voltage Rating	Test Voltage
150 - 600 volts	1,000 volts
601 - 5,000 volts	2,500 volts
Above 5,000 volts	5,000 volts

- 2) Insulation resistance: kV rating plus one megohm but not less than minimum value recommended by manufacturer.
- 3) Do not perform dielectric-withstand test unless insulation resistance is equal to or greater than minimum value specified.
- d. For high-voltage switchgear, low-voltage switchgear and switchboard:
  - 1) Perform insulation-resistance test between phase-to-phase and phase-to-ground.
  - 2) Test grounding conductors and enclosures for continuity to room ground bus.
  - 3) Test protective relays and trip devices, except power fuses in accordance with ANSI/IEEE 141 procedures, modified as necessary, for compliance with approved coordination study.
  - 4) Test operation of each circuit and control in accordance with approved sequence.
  - 5) Test interlock system as follows:
    - (a) Make closure attempt on locked open devices.
    - (b) Make opening attempt on locked closed devices.
  - 6) Dielectric-withstand tests: Perform dielectric-withstand test of 60-second duration on entire assembled and erected switchgear and switchboard lineup using 60-Hertz voltage level as specified. Perform tests in accordance with reference standards and as follows:
    - (a) 34.5 kV switchgear: 60,000 volts rms.
    - (b) 13.8 kV switchgear: 27,000 volts rms.
    - (c) 480-volt switchgear and switchboard: 2,500 volts rms.
    - (d) Control wiring: 1,500 volts rms.
  - 7) Test current-transformer circuits for polarity, ratio and protective-device operation by secondary-injection method.
  - 8) Test potential transformer ratio and polarity.
  - 9) Perform functional tests on control, interlocking, blocking and supervisory circuits, including verification of interconnections between equipment and interface points which have been installed by others. Verification of these tests to be substantiated by lined-in schematics and signed by the Contractor and the Engineer.
- e. Distribution transformers:
  - 1) Perform insulation-resistance test between winding-to-winding and winding-to-ground. Correct resistance value to temperature.

- 2) Test transformer shell and neutral terminal for continuity to ground bus.
  - 3) Perform ac high-voltage test between high-voltage winding and ground and low-voltage winding and ground. Perform test at 75 percent of factory test voltage for 60-second duration.
  - 4) Test voltage ratio for full-winding and taps. Test result not to deviate more than 0.5 percent from calculated ratio. Set transformer tap as directed.
  - 5) Check polarity or phase relation.
  - 6) Check contacts of dial-type thermometer for indicating normal and overtemperature condition of transformers at remote location and to initiate tripping of associated essential main-feeder breaker or primary breaker as appropriate under abnormal temperature conditions. Set thermometer contacts in consultation with manufacturer, as necessary.
  - 7) Transformer for outdoor use:
    - (a) Test transformer for oil leaks in accordance with IEEE C57.93.
    - (b) Test samples of insulating liquid from top and bottom of tank.
    - (c) Test to verify that dielectric strength is not less than 22 kV for mineral oil.
- f. Substation busway:
- 1) Where directed, test resistance of busway connections. Resistance not to exceed value recommended by manufacturer.
  - 2) Test insulation resistance to ground and between insulated busbar.
  - 3) On busway showing insulation resistance of less than one megohm, perform high-potential test of 60-second duration at 2,200 volts, rms.
  - 4) Check phase rotation and phase crossing on buses when energized from either source.
- g. Ground-fault systems:
- 1) Insulation resistance: Remove neutral-ground disconnect link and measure system neutral insulation resistance to ensure that no shunt ground paths exist. System neutral insulation to be 10,000 ohms minimum, preferably one megohm or greater. Reinstall link.
  - 2) Determine relay pickup current by primary injection at sensor and operation of circuit interrupting device. Pickup current to be within ten percent of device setting.
  - 3) Test relay timing by injecting 150 percent and 300 percent of pickup current into sensor. Relay timing to be within manufacturer's published time-current characteristic curve
- h. Proof of compliance:
- 1) If testing indicates failure to comply with specified requirements, replace, correct or modify equipment so that it does comply.
  - 2) Conduct additional tests witnessed by the Engineer to prove compliance with specified requirements.

**B. Field-Testing Personnel:**

1. Provide services of qualified manufacturer's engineering representatives to perform specified field-testing program.
2. When more than one representative is involved, the Contractor is responsible for coordination of testing effort.
3. Provide engineers, technicians and journeymen as necessary to set up and implement testing.

C. Authority Tests:

1. The Authority reserves the right to require the Contractor to conduct acceptance tests of sound level on each transformer unit at each passenger station within one year after installation.
2. In order to perform sound-level tests, the Contractor may recreate test conditions of applicable standards to the extent possible without disturbing existing structure or installed equipment or materials.

**THIS SPACE NOT USED.**

D. Submit certified test reports.

<b>TABLE 16360-1</b>			
<b>SCHEDULE OF SHOP DRAWINGS REQUIREMENTS</b>			
<b>Item</b>	<b>Requirements</b>	<b>Submit (a)</b>	<b>Within Days (b)</b>
1.	Outline dimensions, including weights and foundation requirements for equipment furnished.	X	90 (c)
2.	Front views, floor plans, and mounting details for equipment furnished.	X	90 (c)
3.	One-line diagrams	X	120 (c)
4.	List of standard symbols and nomenclature.	X	120 (c)
5.	Elementary diagrams with description of each circuit.	X	120 (c)

**TABLE 16360-1 (Cont.)****SCHEDULE OF SHOP DRAWINGS REQUIREMENTS**

Item	Requirements	Submit (a)	Within Days (b)
6.	Interconnection wiring diagrams.	X	120 ©)
7.	Wiring diagrams, showing internal wiring of equipment furnished.	X	150 (c)
8.	Wiring diagram, showing interconnection between shipping breaks.	X	150 ©)
9.	Cross sections showing internal construction of equipment.	X	120 ©)
10.	Physical details of connections to transformers.	X	90 (c)

**TABLE 16360-1 (Cont.)**

**SCHEDULE OF SHOP DRAWINGS REQUIREMENTS**

Item	Requirements	Submit (a)	Within Days (b)
11.	Physical details of bus connections.	X	90 (c)
12.	Certified test reports.	-	30 (d)
13.	Transformer data, including:  a. Excitation current. b. Impedance, percent based on rated kVA. c. Reactance, percent based on rated kVA. d. Resistance, percent based on rated kVA. e. Full-load and half-load efficiency. f. No load loss. g. Weights: (1) Core and coils. (2) Tank and fittings. (3) Insulating liquid. (4) Total.	X	45 (c)

**TABLE 16360-1 (Cont.)**

**SCHEDULE OF SHOP DRAWINGS REQUIREMENTS**

Item	Requirements	Submit (a)	Within Days (b)
14.	AC-Switchgear data, including:  a. Circuit breaker duty-cycles before required maintenance: (1) No-load operation. (2) Full-load operation. (3) Rated fault operation. b. Weight of circuit breaker only.	X	45 (c)
15.	Control-power data for each substation, Including:  a. Continuous 125-volt dc load. b. Continuous 120-volt ac load. c. Closing and tripping loads of: (1) 480-volt circuit breakers, for each rating. (2) 34.5 kV circuit breakers. (3) 13.8 kV circuit breakers. d. Trip setting for dc control-power feeder breaker.	X	120 (c)

<b>TABLE 16360-1 (Cont.)</b>			
<b>SCHEDULE OF SHOP DRAWINGS REQUIREMENTS</b>			
Item	Requirements	Submit (a)	Within Days (b)
16.	Clearing time-current curves of relays, circuit breakers and fuses, if used, including unlatched time of circuit breakers.	X	120 (c)
17.	Short-circuit calculations and system coordination study for system protection and selective overcurrent tripping including time-current fault-clearing curves of protective devices.	X	120 (c)
18.	Detailed equipment arrangement drawing for each substation.	X	120 (c)

**THIS SPACE NOT USED.**

<b>TABLE 16360-1 (Cont.)</b>	
<b>SCHEDULE OF SHOP DRAWINGS REQUIREMENTS</b>	
<b>NOTES AND LEGEND</b>	
(a)	Initial submittal for approval. Unless otherwise shown, in accordance with General Requirements.
(b)	Approved final drawings or certified data.
(c)	After receipt of Notice to Proceed.
(d)	After completion of test.
X	Submittal required.
-	Submittal not required.

**THIS SPACE NOT USED.**

**TABLE 16360-2**

**SCHEDULE OF OPERATIONS AND MAINTENANCE REQUIREMENTS**

Item	Requirements	Submit (a)	Within Days (b)
1.	Shipping and handling data: Instructions and drawings for unloading, handling erection and installation.	-	120 (c)
2.	Bills of Material, with reference to components showing original manufacturer's part numbers.	-	30 (c)
3.	Operation and Maintenance Manuals, complete, including separate manuals for ac switchgear, transformer, switchboard and busways, with information on each type of equipment and device furnished, shop drawings from Table 16360-1, excluding manufacturing details and Items 1. and 2. above.	(d)	(d)
4.	Operation and Maintenance Training.	180 (e)	30 (e)

<b>TABLE 16360-2 (Cont.)</b>	
<b>SCHEDULE OF OPERATIONS AND MAINTENANCE REQUIREMENTS</b>	
<b>NOTES AND LEGEND</b>	
1.02	Initial submittal for approval.
1.03	Approved final document.
1.04	Before shipment.
1.05	See General Requirements.
1.06	Prior to commencement of training.
-	Submittal not required.

**END OF SECTION**

## SECTION 16425

### MOTOR STARTERS AND CONTROL CENTERS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing motor starters and control centers.
- B. Related Work Specified Elsewhere:
  - 1. Grounding and bonding: Section 16060.
  - 2. Circuit breakers, panelboards and load centers: Section 16440.
  - 3. Motors: Section 16225.
  - 4. Wire connection accessories: Section 16125.
  - 5. Raceways, boxes and cabinets: Section 16130.
  - 6. Unit substation: Section 16360.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of jurisdictional authorities.
  - 2. NEC.
  - 3. NEMA AB1, ICS-2, ICS-2.3, 250.
  - 4. ANSI: Z55.1.
  - 5. ASTM: A47, A653, B187.
  - 6. UL: 845, Electrical Construction Materials Directory
  - 7. ITS: Directory of ITS Listed Products.
- B. The following items to be listed or labeled per referenced UL or ETL directory.
  - 1. Motor starter.
  - 2. Combination starters.
  - 3. Motor circuit protectors.
  - 4. Motor control centers.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Interconnection wiring diagrams.
  - 2. Certification.
  - 3. Operation and Maintenance Manuals.
  - 4. Short-circuit calculations and coordination study in accordance with Section 16360.

##### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.
- B. Store motor starters and control centers in secure and dry storage facility.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. General Requirements for Motor Starters:
1. Interchangeability: Equipment of same type, size, rating, functional characteristics and make is to be interchangeable.
  2. NEMA ICS-2, ac general-purpose, Class A.
  3. Rating: Continuous-current rating suitable for associated motor as shown.
  4. Type:
    - a. Up to and including ½ HP: Manual starter operable on 120-volt, single-phase, 60 Hertz supply unless otherwise shown.
    - b. From above ½ HP up to and including 50 HP: Across-the-line magnetic starter operable on 480-volt, three-phase, 60 Hertz supply.
    - c. Above 50 HP: Closed-transition autotransformer starter operable on 480-volt, three-phase, 60 Hertz supply.
  5. Provide ground-fault protection with five-ampere pick-up in each motor starter for fans in fan shafts and pumps in drainage-pumping stations.
  6. Enclosure:
    - a. Type:
      - 1) For aboveground indoor locations and electrical rooms: NEMA 250, Type 1.
      - 2) For tunnel areas and underground locations except electrical rooms: NEMA 250, Type 12.
      - 3) For outdoor locations: NEMA 250, Type 3R.
    - b. Materials:
      - 1) Zinc-coated steel sheet: ASTM A653, coating designation G90, minimum thickness 14 gauge.
      - 2) Malleable iron: ASTM A47.
    - c. Finish: Metallic surface cleaned, degreased, primed with zinc primer and finished with light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.
  7. Nameplate:
    - a. Nameplate provided on each motor starter and control center in accordance with NEMA ICS, showing manufacturer's name and brand designation, the referenced standard, type, class and rating as applicable.
    - b. Additional functional nameplates for each component as follows:
      - 1) Three-ply, laminated phenolic plates, engraved through black face to white core and attached by means of stainless-steel rivets or screws.
      - 2) Lettering to be vertical gothic using a round or square cutter. V-shaped groove not acceptable.
      - 3) Each starter labeled with one-inch wide nameplate showing starter's designation and function in ½-inch high characters.
- B. Manual Starters: Quick-make/quick-break toggle mechanism, manual-reset thermal-overload device, position indicator showing ON/OFF/TRIPPED positions, red indicating light showing closed position.
- C. Across-The-Line Magnetic Starter:
1. Reversing or nonreversing as shown.
  2. NEMA size: As shown, not smaller than NEMA 1.
  3. 480-volt primary to 120-volt secondary control transformer with fuse in the primary circuit
  4. Manual-reset overload relay, one per phase, with the following additional requirements:
    - a. In starter for motors in fan shafts: Magnetic-type sensitive to current.
    - b. In starters for motors in other locations: Thermal-type.
  5. Two NO contacts with provision for addition of two NO or NC contacts.
  6. Nonreversing-type: START/STOP pushbutton mounted on door.

7. Reversing-type: FORWARD/REVERSE/STOP pushbutton mounted on door.
  8. HAND/OFF/AUTO selector switch provided when specified.
- D. Autotransformer Starter:
1. Reversing or nonreversing closed-transition type as shown.
  2. NEMA size: As shown.
  3. Adjustable taps for 50, 65 and 80 percent of line voltage.
  4. 480-volt primary to 120-volt secondary control transformer with fuse in primary circuit.
  5. Manual-reset overload relay, one per phase.
    - a. In starter for motors in fan shafts: Magnetic-type sensitive to current.
    - b. In starters for motors in other locations: Thermal-type.
  6. One pneumatic adjustable timing relay.
  7. Two NO contacts with provision for addition of two NO or NC contacts.
  8. Nonreversing-type: START/STOP pushbutton mounted on door.
  9. Reversing-type: FORWARD/REVERSE/STOP pushbutton mounted on door.
  10. HAND/OFF/AUTO selector switch provided when specified.
- E. Motor Circuit Protectors (MCP):
1. NEMA AB1, molded-case, quick-make/quick-break, mechanically trip-free switching mechanism with adjustable magnetic trip for instantaneous short-circuit protection.
  2. Rating:
    - a. Number of poles: Three.
    - b. Continuous-current rating: As shown, not less than full-load current of motor.
    - c. Voltage: 480-volt, three-phase, 60 Hertz.
    - d. Interrupting rating: As shown.
    - e. Trip range: As necessary to provide maximum protection to associated motor.
  3. Where shown or necessary, individually removable current limiter, internally mounted on load side of MCP, with the following additional requirements:
    - a. Limiter current rating and time-current limiting characteristics coordinated with time-current characteristics of MCP to provide the following:
      - 1) Interruption by MCP under fault-current level up to interrupting capacity of MCP.
      - 2) Interruption by current limiter in conjunction with the MCP of fault-current level above interrupting capacity of MCP.
      - 3) Where necessary to protect associated motor starter. Limit fault-current below withstand capability of the starter.
      - 4) Where necessary to protect associated motor-circuit conductors. Limit fault-current below withstand capability of cable insulation.
    - b. Current-limiter housing interlocked with MCP tripping mechanism so that breaker will trip upon removal of cover.
    - c. Equipped with common trip mechanism for tripping all poles simultaneously on blowing of current limiter to prevent single phasing.
    - d. Capable of interrupting minimum fault-current up to 100,000 rms symmetrical amperes at 480 volts ac.
- F. Combination Starter:
1. NEMA ICS-2, rated 480 volts, three-phase, 60 Hertz.
  2. Motor starter: Across-the-line magnetic or autotransformer starter as shown and specified.
  3. One 480-volt, three-pole MCP.
  4. Externally mounted operating handle with position indicator showing ON/OFF/TRIPPED condition of MCP. Operating handle interlocked for preventing

opening and closing of door when MCP is in ON position. Defeater provided to bypass interlock. Provision for padlocking in OFF position.

- G. Motor Control Centers:
1. NEMA ICS-2.3, Class 1, Type B, rated 480-volt, three-phase, 60 Hertz, totally enclosed, deadfront, free-standing, modular assembly having vertical and horizontal buses, wireways, compartments equipped with circuit breakers, MCP and starters as shown.
  2. Enclosure: Modular assembly allowing maximum of six compartment units in one vertical assembly and units' layout in any combination without structural interference, with the following additional requirements:
    - a. Type:
      - 1) Above ground indoor locations and electrical rooms: NEMA 250, Type 1.
      - 2) Tunnel areas and underground, except electrical rooms: NEMA 250, Type 12.
      - 3) Outdoor locations: NEMA 250, Type 3R.
    - b. Each unit compartment provided with individual door having concealed hinges. Unit door mechanically interlocked with unit circuit breaker to prevent opening or closing when the circuit breaker is in the ON position. Defeater provided to bypass interlock. Provision for padlocking in OFF position.
    - c. Horizontal wireway with removable coverplate provided at top and bottom for wiring between sections, incoming conduit and cable, motor and control wiring. Top trough separated by barrier from main horizontal bus.
    - d. Vertical wireway, with its own door, provided adjacent to each vertical assembly and accessible to two adjacent vertical assemblies when applicable.
    - e. Reinforced with adequate steel framework to form rigid structure with smooth outer surface free of burrs, ridges or other blemishes.
    - f. Zinc-coated steel sheet: ASTM A653 coating designation G90, minimum thickness 14 gauge
    - g. Finish: Metallic surface cleaned, degreased, primed with zinc primer and finished with light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.
  3. Horizontal and vertical buses: Main horizontal buses provided at top of structure. Vertical buses for feeding power to each compartment provided in each vertical assembly and securely bolted to main buses.
    - a. Busbar: ASTM B187, 98-percent-conductivity copper, contact surfaces tin-plated, fully insulated by extruded sleeve or wound tape.
    - b. Each horizontal and vertical bus rated for a minimum of 600 amperes and 300 amperes, respectively, with current density not to exceed 1,000 amperes psi or to meet ANSI temperature of 50-degree rise unless otherwise shown.
    - c. Each bus rigidly held by bus supports which have high-dielectric qualities, are moisture-resistant, noncarbonizing and nontracking and have vertical creepage surfaces to prevent faults due to buildup of conductive dirt.
    - d. Bus assembly braced to withstand short-circuit rating of 22,000 symmetrical amperes, rms or available short circuit determined by short-circuit calculations, whichever is greater.
    - e. Unit guides provided in unit compartment for aligning starter stubs.
    - f. Continuous bare-copper ground bus, 1/4-inch by two-inch cross-section, provided throughout length of control center.
  4. Motor starter: Across-the-line magnetic or autotransformer starter, as shown and specified, with tin-plated stub assembly for connecting to vertical buses in unit compartment.

5. Circuit breaker:
  - a. Main circuit breaker: One 480-volt, three-pole, rating as shown and in accordance with Section 16440.
  - b. Branch circuit breaker: One 480-volt, three-pole MCP for each unit compartment.
6. Indicator light: One red light mounted on each unit compartment showing ON position of circuit breaker.
7. Nameplate: As specified under General Requirements for motor starters, with the following additional requirement:
  - a. Each motor control center labeled with 1-1/2 inch wide nameplate showing designation in one-inch high characters.
  - b. Each compartment labeled with one-inch wide nameplate showing function and number of the motor controlled in 1/2-inch high characters.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION:**

- A. Embed iron sills for anchoring motor control center flush with raised concrete pad as shown.
- B. Install motor starters and control centers as shown in accordance with manufacturer's recommendations.
- C. Install conduit in accordance with Section 16130 and the NEC.
- D. Connect power cable and control wire as recommended by manufacturers and as follows:
  1. Make power-cable and control-cable connections to manual starters, across-the-line magnetic starters and autotransformer starters by means of integral mechanical connectors. If such items are not furnished with integral mechanical connectors, make connections using compression connectors in accordance with Section 16125.
- E. Install motor starters and control centers as shown and in accordance with the NEC and Section 16225.
- F. Ground motor starter, complete motor control center in accordance with Section 16060.
- G. Apply touch-up paint as necessary.

#### **3.02 TESTING:**

- A. Furnish necessary equipment and perform the following tests:
  1. Test circuits for connections in accordance with wiring diagram.
  2. Test to ensure that insulation resistance to ground of nongrounded conductor is in accordance with Section 16060.
  3. Test equipment enclosures for continuity to grounding system.
  4. Test operation of circuits and controls.
- B. Submit certified test reports.

**END SECTION**

## SECTION 16435

### LOW-VOLTAGE SWITCHGEAR AND SWITCHBOARD

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing 480-volt switchgear and switchboard.
- B. Related Work Specified Elsewhere:
  - 1. Raceways, boxes, and cabinets: Section 16130.
  - 2. Wire connection accessories: Section 16125.
  - 3. Grounding and bonding: Section 16060.
  - 4. Circuit breakers, panelboards, and load centers: Section 16440.
  - 5. Unit substations: Section 16360.
  - 6. Uninterruptible power system: Section 16260.
- C. Design Criteria:
  - 1. Floor loading: Compatible with floor design loading of 250 pounds per square foot.
  - 2. Switchgear and switchboard suitable for anchoring to a concrete floor steel trowel finished to a tolerance level of 1/8 inch in 10 feet.

##### 1.02 QUALITY ASSURANCE:

- A. Qualifications:
  - 1. Select manufacturer regularly engaged in production of switchgears and switchboards.
  - 2. Furnish low-voltage switchgear, switchboard, and their main components from one manufacturer.
- B. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of jurisdictional authorities.
  - 2. NEC.
  - 3. NEMA: PB2.
  - 4. ANSI: C37.16, C37.17, C37.50, Z55.1.
  - 5. UL: 891.
  - 6. ASTM: B187.
  - 7. ANSI/IEEE: C37.13, C37.20.1, C57.13.
- C. Factory Testing: Submit design tests or certified copies of test reports on identical units performed for each type and rating of circuit breakers as assembled in its complete switchgear or switchboard unit including bus compartment.
  - 1. Circuit breaker tests in accordance with requirements of ANSI C37.50 and including the following:
    - a. Design test:
      - 1) Trip-device calibration-check test.
      - 2) AC dielectric withstand-voltage test.
      - 3) Continuous-current test.
      - 4) Overload-switching test.
      - 5) Endurance tests.
      - 6) Short-circuit current tests.
      - 7) Short-time current test.
    - b. Production tests: All applicable tests in accordance with the requirements

- of ANSI C37.50.
2. Switchgear assembly tests: In accordance with the requirements of ANSI/IEEE C37.20.1 and including the following:
    - a. Design tests:
      - 1) Dielectric tests.
      - 2) Rated continuous-current tests.
      - 3) Short-time current withstand tests.
      - 4) Short-circuit current withstand tests.
      - 5) Mechanical endurance tests.
      - 6) Flame-resistance tests.
      - 7) Rod entry test.
      - 8) Paint qualification test.
    - b. Production tests: All applicable tests in accordance with requirements of ANSI/IEEE C37.20.1.
  3. Switchboard assembly tests: In accordance with the requirements of NEMA PB2 and UL 891 and including the following:
    - a. Design tests:
      - 1) Temperature-rise tests.
      - 2) Short-circuit current tests.
      - 3) Enclosure tests.
      - 4) Dielectric test.
    - b. Production tests: All applicable tests in accordance with requirements of NEMA PB2 and UL 891.

### **1.03 SUBMITTALS:**

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  1. Shop Drawings: In accordance with Section 16360.
  2. Certification: Certified test reports for specified factory testing.
  3. Documentation:
    - a. Short-circuit calculations and system coordination study: In accordance with Section 16360.
    - b. Field-testing plan: In accordance with Section 16360.
  4. Operation and Maintenance Manuals: In accordance with Section 16360.

### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Ship each unit securely packaged, braced and labeled for safe handling in shipment and to avoid damage and distortion.
- B. Temporary Bracing: Where necessary brace switchgear for hoisting, lowering and skidding into position. Label temporary internal bracing: TEMPORARY - REMOVE BEFORE OPERATION.
- C. Protection Against Concealed Damage: Include within shipping container mechanical impact recorder of rating recommended by manufacturer for shipment by railroad and submit impact-record chart with manufacturer's instruction for disposition for damaged material.
- D. Assembly for Shipment:
  1. Design enclosures to permit lifting by jacks or slings and moving horizontally on rollers or skidding in any direction.
  2. Maximum dimensions of shipping sections to be coordinated with dimensions of access hatches, corridors and doors to ensure shipping dimensions will allow movement of switchgear through structure without damage to equipment or structure

- or undue difficulty.
- 3. Draw-out relays mounted in their proper cases with moving parts properly secured and packed for shipment.
- 4. Removable circuit-breaker elements packaged separately.
- 5. For shipping split, interconnecting wiring coiled on one side of shipping split with matching terminal block on other side of split. Wiring and terminal block points identified for reconnection.

E. Store switchgear in secure and dry storage facility.

## 1.05 OPERATIONS AND MAINTENANCE TRAINING:

A. In accordance with the General Requirements and Section 16360.

## PART 2 - PRODUCTS

### 2.01 PRODUCTS AND MATERIALS:

- A. General Requirements for Switchgear:
1. ANSI/IEEE C37.20.1, for indoor use.
  2. Ratings:
    - a. Maximum voltage: 508 volts.
    - b. Frequency: 60 Hertz.
    - c. Insulation level: Low-frequency withstand: 2.2 kV.
    - d. Continuous current: As shown and in accordance with reference standards.
    - e. Short-time current: In accordance with reference standards and approved coordination study.
  3. Insulation structure:
    - a. Not to support combustion, produce toxic gases, absorb moisture or track.
    - b. When subjected to electric arc, emission of conducting materials from insulating structure limited so as not to interfere with performance of circuit breaker.
  4. Power circuit breakers:
    - a. ANSI/IEEE C37.13, ANSI C37.16, three-pole, single-throw, air-break drawout-type, with manually or electrically controlled closing and electrically controlled tripping, mechanically and electrically trip-free, with the following additional requirements:
      - 1) System nominal voltage: 480 volts.
      - 2) Rated maximum voltage: 508 volts.
      - 3) Rated frequency: 60 Hertz.
      - 4) Insulation dielectric-withstand: 2,200 volts.
      - 5) Three-phase short-circuit current rating (symmetrical amperes): As shown and in accordance with reference standards and approved coordination study.
      - 6) Frame size (amperes):
        - (a) Secondary main circuit breaker: Minimum frame size suitable to carry continuous forced-air cooling rating of its distribution transformer.
        - (b) Essential main and secondary tie circuit breakers: Minimum frame size as shown.
      - 7) Equip each power circuit breaker with a solid-state tripping system consisting of three current sensors, microprocessor-based controlled-phase overcurrent trip device, time coordinated ground fault protection and flux-transfer shunt trip. Provide trip device complying with ANSI C37.16, and C37.17, with adjustable long-time

and short-time elements, communication interface, power metering and non-volatile memory for protective settings, Cutler Hammer Digitrip RMS 810, Siemens Static Trip III CP, or equal. Range of trip-device current rating in amperes and setting as shown and in accordance with approved coordination study. True RMS sensing protection to be achieved by analyzing the secondary current signals from the circuit breaker current sensors and initiating trip signals to the circuit breaker. Protective settings, metering values and stored data to be accessible from the data communication network interface and locally from a digital alpha-numeric display unit mounted on the trip unit or breaker. Additional features to include:

- (a) Provide the trip unit with an information system that provides LED's to indicate mode of trip following an automatic-trip operation. The indication of the mode to be retained after an automatic trip. Provide a trip reset button to turn off the LED indication after automatic trip.
  - (b) Provide the trip unit with a front panel display that indicates the protection-function settings. Have the unit continuously self-checking and provide a visual indication that the internal circuitry is being monitored and is fully operational.
  - (c) Provide the trip unit with a portable secondary current test set with matching connector plug or with an integral test panel, either of which enables the user to select the values of test currents within the range of available settings; with the basic protective settings not affected during testing operations.
  - (d) Provide an alpha-numeric display to indicate cause of trip, instantaneous value of maximum phase current and level of fault current that initiated an automatic-trip operation.
  - (e) Have the trip unit include a potential transformer module (PTM), suitable for operation up to 600 volts, 60 Hz; the primary of the PTM connected internally to the load side of the circuit breaker through a dielectric disconnect plug.
  - (f) Equip the trip unit with an energy-monitoring function processor to provide at a minimum; Phase Current (amps), Peak Demand (kilowatts), Present Demand (kilowatts), and Energy Consumption (kilowatt-hours).
  - (g) Equip the trip unit with a communication interface via a network twisted pair for remote monitoring and control.
  - (h) Provide the unit with an external power supply if voltage source is different than that provided to control the breaker; the main supply to the power supply to be 125 volts dc.
- 8) Operation counter.
  - 9) Endurance: Electrical and mechanical-endurance performance not less than requirements in reference standard.
  - 10) Control voltage: 125 volts dc nominal, individually fused.
  - 11) Racking mechanism: With connected, test and disconnected positions; manually operated closed-door mechanism by insertion of crank through small opening in door; positive stops for preventing overtravel and guides for alignment of breaker with stationary unit; racking- mechanism gear ratio and design such that in combination with design of shutters covering main stationary disconnect, force required to puncture or damage shutters or breaker disconnect will become sufficiently large and readily apparent to protect against failure of shutters to open as breaker is racked in.

- 12) Primary connection (main disconnects): Connection between the removable and stationary unit made by male-and-female contacts, with the following additional requirements:
  - (a) Silver-plated high-pressure contacts.
  - (b) Automatic shutter to cover the contact orifices when the breaker is withdrawn and uncover orifices when breaker is returned to connected position.
  - (c) Automatic shutters constructed to withstand force of racking mechanism in case shutters fail to open when breaker is racked into position or shutter opening visible as breaker is racked into position.
- 13) Secondary connection (control and auxiliary disconnects): Control and interlocking-circuit connections between stationary and removable elements of switchgear made using device consisting of recessed stationary receptacle and set of self-aligning multiple-contact plugs on removable elements with sufficient number of contacts to accommodate control and interlock circuits, including spares, without resorting to auxiliary relays.
- 14) Spare auxiliary contacts for DTS: As shown to indicate closed and open positions for circuit breaker at remote location. Dry-type minimum of one NC and one NO rated 15 voltamperes, 250 volts dc, five milliseconds contact-bounce maximum and not more than 0.10-ohm contact resistance. Wired through secondary contacts to terminal blocks.
- 15) Shunt trip device.
- 16) For electrically operated breakers: Electrically powered, spring-charged, stored-energy operating mechanism, with following additional requirements:
  - (a) Voltage requirement:
    - (1) Charging of stored-energy operating mechanism: 125 volts dc.
    - (2) Closing by means of closing release coil capable of operation from 100 - 140 volts dc.
    - (3) Tripping by means of shunt trip coil capable of operation from 70 - 140 volts dc.
  - (b) Closing release coil energized by means of pushbutton, control switch or automatically by interlocking/control signal.
  - (c) Shunt trip coil energized manually by pushbutton, control switch or automatically by interlocking/control signal.
  - (d) Equipped with mechanical devices on front of breaker to actuate closing and tripping operations in case of failure of control power.
  - (e) Compressed-spring stored-energy mechanism with energy storage sufficient for closing-opening operation at rated short-circuit current or at related required capabilities.
  - (f) Stored-energy mechanism automatically charged within 10 seconds following each closing of circuit breaker.
    - (1) Stored-energy mechanism suitable for manual charging by means of removable or built-in handle in case of failure of control power.
    - (2) Automatic discharge of stored-energy mechanism prior to circuit-breaker withdrawal.
  - (g) White indicating light or flag provided on escutcheon of each circuit-breaker unit to indicate that stored-energy closing mechanism is charged.

- 17) For manually operated breakers: Manually, spring-charged, stored-energy mechanism, with the following additional requirements:
    - (a) Built-in spring charging handle in front of breaker with indicator on escutcheon to indicate that stored-energy closing mechanism is charged.
    - (b) Closing by means of releasing stored energy by pushbutton or charging handle itself.
    - (c) Tripping by means of shunt trip coil capable of operation from 70 - 140 volts dc and by mechanical device on front of breaker.
    - (d) Compressed-spring stored-energy mechanism with energy storage sufficient for closing-opening operation at rated short circuit current or at related required capabilities.
    - (e) Automatic discharge of stored-energy mechanism prior to circuit-breaker withdrawal.
  - 18) Electrically controlled closing: On tie breakers only.
5. Space heater:
- a. Each vertical section of switchgear provided with 120-volt, single-phase, 60 Hertz heating element to facilitate drying and prevent condensation.
  - b. Heaters enclosed in grille guards with no sharp edges and located so that they are easily accessible for replacement without de-energization of switchgear bus. Heaters thermostatically controlled. Thermostat adjustable from 40F to 80F. Thermostat set in accordance with manufacturer's recommendation. Panel ammeter approximately 2-1/2 inches square, marked to indicate heater load.
6. Bus bars:
- a. General requirements:
    - 1) ASTM B187, 98-percent-conductivity copper.
    - 2) Current rating:
      - (a) Size sufficient to carry specified current and complying with applicable requirements of UL, ANSI, NEMA, IEEE and NEC.
      - (b) Bus rating for secondary main-breaker unit and bus connection to transformer sized for continuous forced-cooling rating of transformer.
    - 3) Capable of withstanding mechanical stresses and heat due to maximum short-circuit current.
    - 4) Bus contact surface silver-plated or tin-plated at connection.
    - 5) Each joint having impedance not more than that of bus bar of same length and clamped to maintain that impedance throughout life of equipment.
    - 6) Connection coordinated for proper mating with adjacent equipment terminals and enclosures. At transformer connection, flexible joint and access plate provided for assembly and inspection of such joints.
  - b. Power buses: Three-phase, four-wire copper buses, neutral bus of same rating as that of phase bus. Each bolted connection with four bolts minimum.
  - c. Ground bus:
    - 1) Copper bus, not less than two inches by 1/4 inch provided throughout length of switchgear section.
    - 2) In switchgear unit where power cables enter or leave switchgear at top, copper ground bus not less than one inch by 1/8 inch extended from main ground bus to top of unit.
    - 3) Joints in ground bus made with four bolts and overlap of four inches.

- 4) Mechanical connector provided in each unit for field connection of 4/0 through 500 kcmil ground cable to switchgear ground bus.
- d. Ground-to-neutral link provided at each ac switchgear in accordance with NEC for grounding of neutral. For services in same ac-switchboard room, single-grounding electrode connection to tie-point of neutral from each power source is permitted.
- e. Control bus:
  - 1) 125-volt dc bus; copper, No. 6 AWG minimum.
  - 2) One two-pole knife switch provided in switchgear cubicle for disconnecting the control circuit.
  - 3) UL Class J or RK-5 fuses used for control and auxiliary-service protection.
  - 4) Closing circuit fused; tripping circuit unfused.
  - 5) White light to indicate availability of dc control power.
- 7. Control and instrument wiring:
  - a. Factory-installed.
  - b. Insulation-rated, 600 volts, Type SIS, No. 14 AWG minimum copper conductor. Flexible Class C or higher stranded insulated copper wire used for wiring across hinged joints.
  - c. One continuous length of wire used from terminal to terminal without splices or taps.
  - d. Removable-element control wiring installed and connected according to manufacturer's standard for circuit-breaker wiring.
  - e. Control wiring so designed and installed that fault in one main circuit cannot be transferred to control wiring of another main circuit.
  - f. Connections made at terminals of device, on terminal blocks or on control buses. Wiring connection made using insulated-shank ring-type terminals.
  - g. Interconnecting wiring between cubicles and compartments terminated on terminal blocks before being wired to components.
  - h. Terminal blocks: With screw terminals, circuit-marking strips for indicating control wire number, phenolic-laminated dust cover and minimum of 10-percent spare terminal points.
  - i. For each individual wire, corresponding identification used on the wiring diagrams.
  - j. Internal wiring identified at each termination, with same number shown on wiring diagram, using suitable plastic sleeve attached within six inches of terminal connections.
  - k. External wiring: Provision made for external control wiring to enter from bottom or top and with space allowed to terminate external multiple-conductor copper control cable. Top entrances provided with removable coverplates for field-drilling of conduit and cable entrance holes.
  - l. Testing:
    - 1) Check wiring for accuracy, open circuits and short-circuits, ground connections and insulation integrity by means of high-potential, continuity and operational tests.
    - 2) Subject wiring to high-potential test of 1,500 volts to ground for one minute or as recommended by the manufacturer.
    - 3) Verify that wiring is in accordance with manufacturer's wiring diagrams.
    - 4) Check wiring completely, including interconnections at shipping breaks.
- 8. Fuses: Current-limiting fuse installed in each control circuit except tripping circuit. Tripping control circuit to include green and red indicating lights to monitor availability of trip power with the red light in series with the trip coil to also monitor continuity of trip coil.
- 9. Enclosure:

- a. Dead-front, free-standing, indoor steel enclosure designed for line up with 13.8 kV to 480Y/277-volt transformer.
  - b. Steel structure with framework of welded or bolted structural steel, free from distortion and welding strain and sufficiently rigid to support equipment under normal and short-circuit conditions.
  - c. Switchgear cubicles and circuit-breaker compartment equipped with hinged front door and either hinged rear door or bolted rear covers. Bolted covers furnished with alignment studs and keyhole slots for positioning prior to bolting.
  - d. Each power circuit breaker in separate metal-enclosed compartment.
  - e. Circuit-breaker compartment door designed not to hinder movement of breaker in and out of compartment when door is open and doorstop set.
  - f. Barriers provided in bus compartment to separate bus section as follows:
    - 1) Main bus from tie bus.
    - 2) Main bus from essential bus.
  - g. Transition compartment sized as necessary with front and rear bolted covers to line up and coordinate with transformer.
  - h. Circuit-breaker compartment to provide for interchangeability of removable elements within frames of same size and operating characteristics.
  - i. Finish: Metallic surfaces degreased and finished with light-gray enamel, ANSI Z55.1, Color 61 in accordance with ANSI/IEEE C37.20.1 two mils minimum DFT.
10. Nameplate:
- a. Nameplate provided on each switchgear showing manufacturer's name and brand designation, the referenced standard, type, class and rating as applicable in accordance with reference standard.
  - b. Additional functional nameplates for each component, relay, meter, terminal block, etc. with the following requirements:
    - 1) Three-ply, laminated phenolic plates; engraved through black face to white core and attached by means of stainless-steel rivets or screws, provide on each switchgear and its components.
    - 2) Lettering: Vertical gothic using round or square cutter. V-shaped groove not acceptable.
    - 3) Each switchgear section labeled with nameplate one-inch high bearing the following inscription in letters ½-inch high: 480-VOLT SWITCHGEAR.
    - 4) Each switchgear compartment labeled with nameplate ½-inch high bearing, as appropriate one of the following inscriptions in letters 1/4-inch high: SECONDARY MAIN BREAKER, SECONDARY TIE BREAKER.
    - 5) In addition to other information normally displayed on equipment, provide nameplate to show switch positions, meaning of indicator lamp and other pertinent information.
11. Ground-fault protection system:
- a. Time coordinated and with solid-state microprocessor based trip unit with the following additional requirements:
    - 1) Current-adjustment range: 100 to 1,200 amperes, with three calibration marks minimum.
    - 2) Time-adjustment band: Instantaneous and six- and 12-cycle calibration marks.
    - 3) Setting: As shown and as necessary to maximize protection and proper coordination in accordance with approved coordination study.

B. Low-Voltage Switchgear:

- 1. Secondary main and tie cubicle: Equipped with the following:

- a. Secondary main circuit breaker: Power circuit breaker with microprocessor-based phase-overcurrent trip device, shunt trip device, ground-fault protection, position-indicating lights, spare auxiliary contacts for DTS, accessories and interlocks.
- b. Secondary tie circuit breaker: Power circuit breaker with microprocessor-based phase-overcurrent trip device, shunt trip device, electrical closing device, ground-fault protection, spare auxiliary contacts for DTS, position-indicating lights, accessories and interlocks. One or two tie breakers provided as shown.
- c. Current transformers:
  - 1) ANSI/IEEE C57.13, window-type with polarity markers to operate digital power metering.
  - 2) Quantity: Three.
  - 3) Current ratio: As necessary for forced-cooling rating of distribution transformer with five-ampere secondary.
  - 4) Insulation class: 600 volts with basic-impulse insulation level of 10 kV full-wave.
  - 5) Maximum allowable temperature rise under continuous full-load above average ambient temperature of 55C.
    - (a) By winding resistance: 30C.
    - (b) By hottest spot in winding: 40C.
  - 6) Accuracy class: 0.6B - 0.5 or better.
- d. Potential transformer:
  - 1) ANSI/IEEE C57.13, wound-type with polarity markers to operate voltage relay and meters.
  - 2) Quantity: Three.
  - 3) Voltage ratio: 480 volts primary to 120 volts secondary.
  - 4) Insulation class: 600 volts with basic impulse-insulation level of 10 kV full-wave.
  - 5) Maximum allowable temperature rise under continuous full-load above average ambient temperature of 55C.
    - (a) By winding resistance: 30C.
    - (b) By hottest spot in winding: 40C.
  - 6) Accuracy class: 0.6 W or X.
  - 7) Transformers connected WYE-WYE with three-phase and neutral potential bus.
- e. Power metering and communication interface:
  - 1) Each switchgear equipped with a digital power meter, Cutler Hammer IQ Data Plus II, Siemen 4700. Voltage inputs provided from potential transformers (PTs) connected to the main secondary 480-volt bus. Current inputs provided from external- mounted current transformers with five-amp secondary output, mounted to measure currents on the secondary main bus. CT and PT ratios to be field selective. Provide a communications option tied into the communication network.
  - 2) Each breaker equipped with a microprocessor-based trip device provided with a data communication interface tied into a local-area communication network.
  - 3) Each switchgear provided with a two-wire local-area network tied into a central monitoring system, Cutler Hammer Assemblies Electronic Monitor II (AEM II), Siemens Power Monitor. Have the monitor provide local status of all breakers, load data, metering parameters, cause of trip, min./max. values, etc. Install the local area network to mitigate problems associated from electrical fields and electromagnetic interference.
  - 4) Provide a separate RS-232 (DB-9) plug and network

interface/translator, panel mounted with protective dust cover, for customer interface from a Notebook- type computer (IBM Compatible). Provide networking software and any special network interface board/PCMCIA for use with Authority-furnished notebook-type computer. The user interface software to be a Windows version, providing data access to all device parameters and metering values.

- 5) Power Supply: All metering equipment control power or its external power supply(s) to be powered from 125-volt DC control power or 120-volt ac, 60 Hz provided from one of the following sources:
    - (a) Emergency panel.
    - (b) Load side of secondary breaker.
    - (c) Line side of secondary main breaker with necessary equipment including auxiliary relays to ensure that control power is available after operation of transfer scheme.
  - f. Test switches: Provided between instrument transformers, meters and relays as listed below:
    - 1) ABB Style FT-1.
  2. Feeder main cubicle: Equipped with the following:
    - a. Feeder circuit breakers: Each circuit breaker with microprocessor-based phase- overcurrent trip device, shunt trip, ground-fault protection, position-indicating lights and necessary accessories and interlocks.
- C. Electrical Interlocks: Provide interlocks and coordination with primary-service switchgear, as applicable, for performing the following functions:
1. Modes of operation: Normal, automatic throwover, manual restoration and maintenance throwover as follows:
    - a. Normal: All power circuit breakers, except tie breaker, are closed. Tie breaker is normally open.
    - b. Automatic throwover: Automatic throwover operation occurs only when an undervoltage condition occurs in one of the primary feeders and when other secondary main breaker is closed.
      - 1) Where primary service is through 13.8 kV metal-clad switchgear, tripping of primary breaker caused by undervoltage condition automatically trips secondary main breaker and initiates closing of secondary tie breaker. Automatic throwover operation is blocked if secondary main breaker or primary breaker has tripped because of overcurrent or ground-fault condition.
    - c. Manual restoration: When proper-voltage condition has been restored, substation may be retransferred to normal mode. After primary breaker has been closed or after primary voltage has been re-established as evidenced by return to normal of transformer secondary voltage, both tie breakers are tripped first from a common tie breaker trip switch, followed by closing of secondary main breaker, all manually.
    - d. Maintenance throwover: Same as automatic but initiated manually by simulating undervoltage condition at potential test switch followed by manual restoration as specified.
  2. To prevent paralleling two sources and to prevent feedback through transformer into primary lines.
  3. To trip secondary main breaker when primary breaker trips. Tripping of secondary main breaker does not trip primary breaker.
  4. To operate simultaneously two tie breakers in passenger stations having two separate ac-switchboard rooms.
  5. To allow each drawout circuit breaker in test position to be closed or tripped by local operation and to inhibit interlocking/control signals to or from breaker when in such position.

6. To provide time coordinated ground-fault protection. In addition, ground-fault protection for secondary main and tie circuit breakers to provide reliable operation under any operating condition without nuisance tripping because of partial cancellation of stray currents flowing in neutral.
  7. In combined ac switchboard room: Ground-fault protection on secondary main and tie breakers designed to trip secondary main breaker associated with fault and to prevent nuisance tripping of other secondary main breaker.
  8. Interconnecting control wiring between two remotely located unit substations to be designed for installation in a two-inch conduit minimum.
- D. General Requirements for Switchboards:
1. NEMA PB2, UL 891.
  2. Ratings:
    - a. Normal voltage: 480 volts.
    - b. Frequency: 60 Hertz.
    - c. Rated continuous current: As shown.
    - d. Short-circuit rating: As shown.
  3. Molded-case circuit breakers: Section 16440.
  4. UL listed.
  5. Bus:
    - a. ASTM B187, 98-percent-conductivity copper.
    - b. Continuous-current rating: As shown.
    - c. Capable of withstanding mechanical stresses and heat due to maximum short-circuit current.
    - d. Bus contact surfaces: Silver-plated or tin-plated at connection.
    - e. Neutral bus rating: Same as that of phase bus.
    - f. Control bus: 125-volt dc; copper, No. 6 AWG minimum; with UL Class J or RK-5 fuses for each compartment where necessary.
    - g. Ground bus secured to each vertical-section structure and extending entire length of switchboard.
  6. Control wiring:
    - a. Insulation rated 600 volts, Type SIS, copper, No. 14 AWG minimum. Flexible, Class C or higher, stranded wire used for wiring across hinged joints.
    - b. One continuous length of wire used between terminals without splices or taps.
    - c. Connections made at terminal of device, on terminal blocks or at control bus, using tinned copper-ring compression terminals with insulated sleeve.
    - d. Interconnect wiring between compartments terminated on terminal blocks before being wired to components.
    - e. Terminal blocks: With screw-type terminals, circuit-marking strips for indicating wire number, phenolic-laminated dustcover and 10-percent minimum spare terminal points.
    - f. For each individual wire, same identification used on each terminal block marking strip.
  7. Ground-fault protection system:
    - a. Time coordinated ground fault protection system with solid state adjustable tripping device.
      - 1) Solid-state, adjustable.
      - 2) Current adjustable range: As per manufacturer
      - 3) Time adjustment band: As per manufacturer.
      - 4) Setting: As shown or as necessary to maximize protection and coordination.
  8. Enclosure:
    - a. Dead-front, free-standing indoor steel enclosure designed for lineup with 480-volt switchgear, where applicable.

- b. Steel structure with framework of welded or bolted structural steel, free from distortion and welding strain and sufficiently rigid to support equipment under normal and short-circuit conditions.
  - c. Each breaker compartment equipped with hinged door or bolted cover in front and bolted rear cover. Bolted covers furnished with headed studs and keyhole slots for hanging in position before bolting.
  - d. Vertical barrier provided between feeder main cubicle and the essential switchboard.
  - e. Individually mounted feeder breakers externally operable. Highest breaker handle not more than six-feet six-inches above floor.
  - f. Interconnections between feeder-main cubicle bus and switchboard bus shall be provided by using internal busbar and rated, segregated and braced in accordance with applicable reference standards.
  - g. Spaces for future breakers to include necessary bus connections and device supports.
  - h. Finish: Metallic surfaces degreased and finished with light-gray enamel, ANSI Z55.1, Color 61, in accordance with ANSI/IEEE C37.20.1, two mils minimum DFT.
  - i. Adjustable breaker lifting device mounted on top of switchgear.
9. Nameplates:
- a. Nameplate provided on each switchboard and its components in accordance with reference standards.
  - b. Three-ply, laminated phenolic plates, engraved through black face to white core and attached by means of stainless-steel rivets or screws, provided on each switchboard and its components.
  - c. Lettering: Vertical gothic using round or square cutter. V-shaped groove not acceptable.
  - d. Each switchboard cubicle labeled with nameplate one-inch high bearing, as appropriate, one of the following inscription in letters ½-inch high: SWITCHBOARD or CHILLER PLANT SWITCHBOARD.
  - e. In addition to other information normally displayed on equipment, provide nameplate to show breaker handle positions, meaning of indicator lamp and other pertinent information.
- E. Switchboards:
- 1. Equipped with individually mounted circuit breaker, each with solid state trip device, with integral time coordinated ground-fault protection and space heater.
  - 2. Adjustable instantaneous (magnetic) trip settings: As necessary for coordination.
  - 3. Bus bars on load side extending to rear of cubicle.
  - 4. Phase, neutral and ground buses and 125-volt dc control bus.
  - 5. Suitable for service entrance.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION:**

- A. Install switchgear in position as shown and in accordance with the NEC.
- B. Install conduits and raceways as shown and in accordance with the Section 16130.
- C. Make power-cable and control-wire connections as shown and as follows:
  - 1. Make power-cable and control-wire connections to circuit breakers, current-limiting circuit breakers and integrally fused circuit breakers by means of integral mechanical connectors. If such items are not furnished with integral mechanical connectors, make connections using compression connectors in accordance with Section 16125.

D. Make grounding connections as shown and in accordance with Section 16060.

**3.02 FIELD QUALITY CONTROL:**

A. In accordance with Section 16360.

**END OF SECTION**

## SECTION 16440

### CIRCUIT BREAKERS, PANELBOARDS AND LOAD CENTERS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies furnishing, installing, connecting and testing of circuit breakers, panelboards and load centers.
- B. Related Work Specified Elsewhere:
  - 1. Raceways, boxes and cabinets: Section 16130.
  - 2. Wire, cable and busways: Section 16120.
  - 3. Wire connection accessories: Section 16125.
  - 4. Grounding and bonding: Section 16060.
  - 5. Field painting: Section 09920.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. NEC.
  - 3. NEMA: AB1, PB1, ST20, 250.
  - 4. ANSI: Z55.1.
  - 5. UL: 50, 67, 198C, 489, 891, Electrical Construction Materials Directory.
  - 6. ASTM: A276, B187.
  - 7. ITS: Directory of ITS Listed Products.
- B. Source Quality Control:
  - 1. Each item listed per referenced UL or ITS directory.

##### 1.02 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings.
  - 2. Certification.

##### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Mark each circuit breaker, panelboard and transformer in accordance with applicable reference standard.
- B. Ship each unit securely packaged and labeled for safe handling and to avoid damage or distortion.
- C. Store products in secure and dry storage facility.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. General Requirements:

1. Interchangeability: Components of the same type, size, rating, functional characteristics and make are to be interchangeable.
  2. Finish for enclosures for enclosed circuit breakers, panelboards, emergency-service panelboards and load centers:
    - a. Clean and degrease metallic surfaces.
    - b. Prime with zinc primer.
    - c. Finish with one coat of light-gray enamel, ANSI Z55.1, Color 61. Minimum dry-film thickness: Two mils.
- B. Circuit Breaker: NEMA AB1, UL 489, molded-case, bolt-on, quick-make/quick-break, mechanically trip-free switching mechanism, with thermal trip for inverse time-delay overcurrent protection and magnetic trip for instantaneous short-circuit protection. Shunt-trip device for tripping by ground-fault relay as shown. Frame size 225 amperes and above equipped with interchangeable thermal trip and adjustable magnetic-trip unit. Designed to carry continuous rating in ambient temperature of 40C with the following parameters as shown:
1. Number of poles.
  2. Rated voltage.
  3. Rated interrupting current.
  4. Trip setting.
  5. Frame size.
- C. Integrally Fused Circuit Breaker:
1. NEMA AB1, molded-case, quick-make/quick-break, mechanically trip-free switching mechanism.
  2. Thermal trip for inverse time-delay overload and magnetic trip for instantaneous short-circuit protection. Shunt-trip device for tripping by ground-fault relay as shown. Frame size 400 amperes and above equipped with interchangeable thermal and adjustable magnetic trips.
  3. Individually removable current limiter, internally mounted on load side of circuit breaker, with rating and time current limiting characteristics that coordinate with time current-tripping characteristics of circuit breakers to provide the following:
    - a. Interruption of circuit breaker under fault-current level up to interrupting capacity of circuit breaker.
    - b. Interruption by current limiter in conjunction with circuit breaker under fault-current level above interrupting capacity of circuit breaker.
    - c. Where necessary to protect downstream panelboard, limit fault current at branch circuit breakers below their interrupting capacity.
    - d. Where necessary to protect associated feeder/branch circuits, limit fault current below short-circuit current withstand capability of cable.
  4. Removable cover provided over current-limiter section of circuit breaker with interlock for tripping of breaker upon removal of cover and to prevent turning circuit breaker to ON position with cover removed.
  5. Equipped with common trip mechanism for tripping all breaker poles simultaneously on blowing of current limiter to prevent single phasing.
  6. Capable of interrupting minimum fault current of 100,000-rms symmetrical amperes at 480 volts ac.
  7. Circuit breaker rating:
    - a. Number of poles: As shown.
    - b. Frame size: As shown.
    - c. Voltage rating: 480 volts.
    - d. Interrupting capacity: As necessary to coordinate with current limiter.
    - e. Trip setting: As shown.
- D. Enclosed Circuit Breaker:
1. NEMA AB1.

2. Circuit breaker: As shown and as specified. Overcurrent trip device coordinated to provide selective tripping under overload conditions.
3. Enclosure:
  - a. Galvanized steel, surface-mounted, unless otherwise shown.
  - b. Type:
    - 1) Above-ground indoor locations and electrical rooms: NEMA 250, Type 1.
    - 2) Tunnel areas and underground locations, except electrical rooms: NEMA 250, Type 12.
    - 3) Outdoor locations: NEMA 250, Type 3R.

E. Panelboard:

1. NEMA PB1, UL 67.
2. Enclosure:
  - a. UL 50.
  - b. Galvanized steel, surface-mounted unless otherwise shown.
  - c. Type:
    - 1) Aboveground indoor locations and electrical rooms: NEMA 250, Type 1.
    - 2) Tunnel areas and underground locations, except electrical rooms: NEMA 250, Type 12.
    - 3) Outdoor locations: NEMA 250, Type 3R.
  - d. Gutter size:

Main Bus Rating Amperes	Minimum Top and Bottom Gutter Size in Inches	Minimum Side Gutter Size in Inches
100 and below	4	4
225	6	4
400 and over	8	4

- e. Interior components mounted on backplate of reinforced steel for rigid support and accurate alignment.
- f. Provide latch and handle in accordance with UL 50; screw fastenings will not be accepted in lieu of latch.
- g. Provision for enclosure grounding.
3. Busbars:
  - a. ASTM B187.
  - b. 98-percent-conductivity copper.
  - c. Contact surface silver-plated or tin-plated.
  - d. Rating of neutral and ground bus: Equal to that of phase bus.
  - e. Neutral bus mounted on insulating block.
  - f. Neutral and ground busbars equipped with integral mechanical connectors.
4. AC panelboards:
  - a. Type of service: Three-phase, four-wire, 277/480 volt or 120/208 volt or as shown.
  - b. Type of main: Main lugs or circuit breakers or integrally fused circuit breakers as shown, conforming to requirements specified, located at top or bottom as necessary
  - c. Branch circuit: Circuit breakers or integrally fused circuit breakers as shown, conforming to requirements specified, number of circuits as shown.
  - d. Circuit breaker: Trip device coordinated with that of upstream circuit breakers to provide selective tripping.
  - e. Suitable for service entrance where necessary.

5. DC Panelboard:
  - a. Type of service: 125-volt dc, two-wire.
  - b. Type of main: Two-pole circuit breaker, 100-ampere frame, 100-ampere trip and 10,000-ampere interrupting capacity, unless otherwise shown.
  - c. Branch circuit: Two-pole circuit breakers, 100-ampere frame and 10,000-ampere interrupting capacity, in accordance with specified requirements, quantities as follows unless otherwise shown:
    - 1) With 20-ampere trip: Two minimum.
    - 2) With 30-ampere trip: Two minimum.
    - 3) With 50-ampere trip: Two minimum.
  - d. Enclosure finish: As specified under General Requirements for this section, except color to be OSHA red as specified in Section 09920.
6. Emergency-power panelboard:
  - a. NEMA PB1, UL 67, fused-switch.
  - b. Enclosure:
    - 1) Galvanized steel, surface-mounted unless otherwise shown.
    - 2) Type:
      - a) Above-ground indoor locations and electrical rooms: NEMA 250, Type 1.
      - b) Tunnel areas and underground locations, except electrical rooms and tunnel areas: NEMA 250, Type 12.
      - c) Outdoor locations: NEMA 250, Type 3R.
    - 3) Minimum of four inches side gutter and six inches top and bottom gutter.
    - 4) Mounting channel drilled and tapped to accommodate any combination of fused switch.
  - c. Busbar:
    - 1) ASTM B187.
    - 2) 98-percent-conductivity copper.
    - 3) Contact surface silver-plated or tin-plated.
    - 4) Rating of neutral and ground bus: Equal to that of phase bus.
    - 5) Neutral bus mounted on insulating block.
    - 6) Drilled and tapped to accommodate any combination of fused switch unit.
    - 7) Neutral and ground bus equipped with integral mechanical connectors.
  - d. Type of service: As shown.
  - e. Type of mains: Main lugs or fused switch unit as shown, located at top or bottom as necessary.
  - f. Branch circuit: Equipped with fused switch unit, number of circuits as shown.
  - g. Fused switch unit:
    - 1) Individually enclosed, quick-make/quick-break switching mechanism.
    - 2) Equipped with the following:
      - a) Silver-alloy contacts.
      - b) External operating handle capable of being padlocked in ON or OFF position.
    - 3) Defeatable door interlock to prevent opening the door when operating handle is in ON position.
    - 4) Pressure-type fuse with Class J cartridge fuse conforming to UL 198C.
    - 5) Current rating and number of poles: As shown; maximum rating, 30 amperes.
    - 6) Use two-pole or three-pole switch unit if single-pole switch unit is not available.

7. Fuse time-current characteristic coordinated with upstream fuse time-current characteristic to provide selective overcurrent tripping.
- F. Nameplates:
1. Three-ply, laminated phenolic plates, engraved through black face to white core and attached by stainless-steel rivets or screws.
  2. Lettering: Vertical gothic using round or square cutter. V-shape groove is prohibited.
  3. Each panelboard labeled with nameplate one-inch high bearing ½-inch high inscriptions as appropriate.
  4. Nameplate for emergency-power panelboard to bear inscription EMERGENCY POWER.
- G. Load Centers:
1. Enclosure:
    - a. UL 891, stainless steel, ASTM A276, Type 304, or approved equal.
    - b. Type:
      - 1) Above-ground indoor locations and electrical rooms: Non-ventilated indoor.
      - 2) Underground locations, except electrical rooms and tunnel areas: Non-ventilated outdoor.
      - 3) Outdoor locations and tunnel areas: Non-ventilated outdoor.
  2. Transformer:
    - a. NEMA ST20, dry, self-cooled, epoxy-encapsulated, double-wound with insulated copper conductor with 185C-insulation system capable of withstanding full-wave impulse voltage of 10KV.
    - b. Five kVa load center: Single-phase, 60 Hertz, 480 volts primary to 120/240 volts secondary.
    - c. Nine kVa load center: Three-phase, 60 Hertz, 480 volts primary to 120/208Y volts secondary.
    - d. Fifteen kVa load center: Three-phase, 60 Hertz, 480 volts primary to 120/208Y volts secondary.
    - e. Maximum allowable temperature rise under continuous full load above ambient temperature of 30C and 40C maximum:
      - 1) By winding resistance: 115C.
      - 2) By hottest spot in winding: 145C.
  3. Circuit breaker:
    - a. Bolt-on or plug-in, as specified.
    - b. Primary circuit breaker: 480 volts, bolt-on, 14,000-rms symmetrical amperes interrupting capacity, 100-ampere frame, with the following additional requirements:
      - 1) For five kVa load center: Two-pole breaker with 20-ampere trip setting.
      - 2) For nine kVa load center: Three-pole breaker with 25-ampere trip setting.
      - 3) For 15 kVa load center: Three-pole breaker with 40-ampere trip setting.
    - c. Secondary main circuit breaker:
      - 1) Bolt-on, two or three poles as shown, 240 volts, 10,000-rms symmetrical amperes interrupting capacity with trip setting as follows:
        - a) For five kVa load center: 25 amperes.
        - b) For nine kVa load center: 30 amperes.
        - c) For 15 kVa load center: 50 amperes.
    - d. Branch circuit breaker:

- 1) Single-pole, plug-in, 120 volts, 10,000-rms symmetrical amperes interrupting capacity.
    - a) For five kVa load center: Four breakers, each with 20-ampere trip setting.
    - b) For nine kVa load center: Six breakers, each with 20-ampere trip setting.
    - c) For 15 kVa load center: Twelve breakers, each with 20-ampere trip setting.
  - e. Nameplate: Laminated plastic, one-inch high, attached by means of stainless-steel rivets or screws, showing load-center number in 1/2-inch high white characters engraved on black background.
  4. Neutral and ground bus bar equipped with mechanical connectors.
- H. Current-Limiting Circuit Breaker:
1. NEMA AB1, UL 489, molded-case, quick-make/quick-break, mechanically trip-free switching mechanism.
  2. Thermal trip for inverse time-delay overcurrent protection and magnetic trip for instantaneous short-circuit protection. Shunt trip device for tripping by ground-fault relay as shown.
  3. Limit the fault current, without the use of fusible element, to provide the following:
    - a. Protect associated cable by limiting the fault let-through energy to a value below the short-circuit withstand capability of the cable.
    - b. Protect downstream panelboard by limiting fault current at branch circuit breakers within their interrupting capabilities.
  4. Circuit-breaker rating:
    - a. Number of poles: As shown.
    - b. Frame size: As shown.
    - c. Voltage rating: 480 volts.
    - d. Interrupting capacity: Minimum 100,000-symmetrical RMS amperes.
    - e. Trip setting: As shown.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION:**

- A. Install panelboards at locations shown, with bottom not less than 12 inches above floor. Use multiple-section panelboards to meet such spacings if necessary.
- B. Mount panelboards and load centers with front straight and plumb.
- C. When feeder serves more than one panelboard or panelboard section, install separate junction box or provide adequate gutter area for termination of feeders and bus taps.
- D. Install single and/or multiple-conductor cable in accordance with Section 16120. Connect branch circuit wires as shown. Connect neutral wire of branch circuit to neutral bar in panelboard.
- E. Install load centers where shown.
- F. Make conduit connections in accordance with Section 16130.
- G. Make power cable connections to circuit breakers, integrally fused circuit breakers, fused switch units, neutral and ground bus bars in panelboard and load centers and enclosed circuit breakers by means of integral mechanical connectors. If such items are not furnished with

integral mechanical connectors, make connections using compression connectors in accordance with Section 16125.

- H. Ground panelboards, load centers and enclosed circuit-breaker enclosures in accordance with Section 16060 and the NEC.
- I. Apply matching touch-up paint where necessary.

**3.02 DIRECTORY OF CIRCUITS:**

- A. Furnish each panelboard and load center with legibly printed circuit directory located on inside of enclosure.

**3.03 FIELD QUALITY CONTROL:**

- A. Furnish necessary equipment and perform the following tests:
  1. Molded-case circuit breakers: Perform pole-to-pole and pole-to-ground insulation resistance tests with 1,000V dc megger. Insulation resistance to be 50 megohms minimum.
  2. Panel boards and load centers: Perform insulation-resistance tests of each bus section phase-to-phase and phase-to-ground for one minute using 1,000V megger. Insulation resistance to be not less than manufacturer's recommended minimum or two megohms minimum.
  3. Test circuit connections in accordance with wiring diagram.
  4. Test panelboard and load-center enclosures for continuity to grounding system.
  5. Check cable connections to circuit breakers and fused switch unit for tightness.
  6. Check setting of adjustable magnetic trips for compliance with approved coordination study.
- B. Submit certified test reports.

**END OF SECTION**

## SECTION 16441

### DRAINAGE AND NEGATIVE SWITCHBOARD FOR TRACTION POWER

#### PART 1 - GENERAL

##### 1.01 SUMMARY

- A. This scope includes:
  - 1. Furnishing drainage and negative switchboard and spare parts
  - 2. Installation of drainage and negative switchboards
- B. Related sections:
  - 1. Section 16051 - Scope of Work For Traction Power
  - 2. Section 16052 - Basic Materials and Methods For Traction Power
  - 3. Section 16128 - Wire and Cable For Traction Power
  - 4. Section 16261 - Transformer-Rectifier Units For Traction Power
  - 5. Section 16341 - Metal-Enclosed DC Switchgear For Traction Power
  - 6. Section 16451 - Substation Busways For Traction Power
- C. Payment and Measurement Basis:
  - 1. Compensation for work specified in this section associated with equipment in traction power substations will be made in the lump sum manner.
  - 2. Compensation for work specified in this section associated with installation will be made in the Lump Sum Installation cost of each traction power substation.

##### 1.02 REFERENCES

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Codes and regulations of jurisdictional authorities.
  - 2. NEC
  - 3. ANSI Z55.1
  - 4. NEMA CCI

##### 1.03 SUBMITTALS

- A. Submit the following for approval in accordance with the Division 1 and with additional requirements as specified for each:
  - 1. Shop Drawings: In accordance with Section 16051, Table II.
  - 2. Certification:
    - a. Certified test reports for specified factory testing.
    - b. Certificates from manufacturer verifying that equipment conforms to specified requirements.
  - 3. Operations and Maintenance Manuals: In accordance with Division 1.
  - 4. Spare Parts Lists.

##### 1.04 QUALITY ASSURANCE

- A. Qualifications: Select a manufacturer who is regularly engaged in production/installation of similar equipment and has demonstrated a successful record of providing equipment of similar type and rating for extra heavy duty traction service for at least five similar projects.
- B. Factory Testing: Submit test plans and procedures and scheduled test date for approval at least 20 working days in advance of scheduled test date. No test results will be accepted prior to receipt and approval of test plans and procedures. Factory test requirements are as

follows:

1. Switchboard dielectric withstand test: Test all live parts of the switchboard, completely assembled, except without reverse current switches at a voltage level of 2800 Volts, rms, 60 Hertz at 4100 Volts dc for 60 seconds.
- C. For Codes, Regulations, References, Standards and Specifications, refer to Article 1.02.

## **1.05 DELIVERY, STORAGE, AND HANDLING**

- A. Equipment for each facility shall be delivered in accordance with the access dates in Division 1.
- B. Ship each unit securely packaged and labeled for safe handling, lowering and skidding into positions. Label temporary internal bracing: TEMPORARY-REMOVE BEFORE OPERATION.
- C. Temporary Bracing: Where necessary, brace for hoisting, lowering and skidding into position. Label temporary internal bracing: TEMPORARY-REMOVE BEFORE OPERATION.
- D. Store in secure and dry storage facility.

## **PART 2 - PRODUCTS**

### **2.01 EQUIPMENT**

- A. Drainage and Negative Switchboard:
1. Free standing, metal enclosed, suitable for indoor service and including the following equipment:
    - a. Negative switches.
    - b. DC negative bus and bus connections.
    - c. Stray current corrosion control equipment.
    - d. Drainage bus and bus connections to stray current corrosion control equipment.
    - e. Negative return cable terminal connectors.
    - f. Negative bus-tie circuit breaker in accordance with Section 16341.
  2. Enclosure:
    - a. Metal-enclosed, rigid, self-supporting, self-contained, ventilated steel structure, assembled as one unit, switchboard construction.
    - b. Designed and arranged to provide convenient access to all components for normal operation and maintenance.
    - c. Terminal connectors provided for connecting the switchboard metal enclosure to the substation ground bus.
    - d. Access opening for future negative bus extension covered by a removable metal cover.
    - e. Finish: Metallic surfaces degreased, primed and finished with light gray enamel, Color No. 61, ANSI Z55.1 in accordance with referenced standard; two mils minimum dry film thickness.
  3. Negative Switches
    - a. Description:
      - 1) No-load break, single pole unfused, enclosed knife switches, connected to the negative bus mounted in compartments in the switchboard with danger signs provided at each switch. Signs made of 20 gauge steel, seven inches by ten inches with corner mounting holes and worded to say NO LOAD BREAK SWITCHES - OPEN ALL RECTIFIER DC CATHODE CIRCUIT BREAKERS

- BEFORE OPENING THESE SWITCHES.
- 2) Back connected with provisions for connecting 1000 KCMIL negative return cables from the running rails as shown.
  - 3) All current carrying components electrically isolated from the switchboard enclosure.
  - 4) Designed so as to allow for the compartment doors to close with the negative switch in the open position.
- b. Rating: 750 Volts, 4,000 Amperes dc continuous and capable of withstanding short-circuit currents imposed by parallel silicon rectifier units of 9000 kW total capacity.
  - c. Connectors: Terminal connectors of the long barrel, double indentation compression type with two hole contact pad and of one piece tubular construction formed of pure electrolytic copper and tin-plated to resist corrosion. Terminal connectors in accordance with NEMA CC1. Number of connectors in accordance with Section 16051, Table III.
4. DC Negative Bus and Bus Connections:
- a. Material and rating: High quality copper or aluminum, electrical conductivity, 750 Volts dc, rated dc continuous current as shown. Size based on a maximum current density of 800 Amperes per square inch.
  - b. Insulation: Bare, except where close clearances may make insulation necessary. Bus bars mounted on barrier type insulation or post type insulators of sufficient strength to withstand, without damage or permanent distortion, all stresses produced by specified short-circuit currents.
  - c. Bus Connections:
    - 1) Connection surfaces silver or tin plated.
    - 2) Joints treated to prevent corrosion. Each joint having a conductivity at least equal to that of the bus bar.
    - 3) Bolted with cadmium plated, galvanized or similarly coated high-strength steel bolts of sufficient number and size to provide solidly bolted connection.
    - 4) Include provisions for possible future connector of dc negative bus to substation ground bus.
    - 5) Terminate negative bus on a terminal block for connection to the negative bus of the DC switchgear - size will be as shown on contract drawings.
5. Stray Current Corrosion Control Equipment
- a. Each stray current corrosion drainage circuit, number as indicated, consists of the following:
    - 1) Cable connector.
    - 2) Fuseholder and current limiting fuse.
    - 3) Shunt.
    - 4) Variable resistor.
    - 5) Reverse current switch.
    - 6) Disconnect switch.
    - 7) Connection to drainage bus.
  - b. Cable connector: Long barrel, double indentation compression type of one piece tubular construction, formed of pure electrolytic copper and tin plated to resist corrosion, for 250 KCMIL cable. In accordance with NEMA CC1 except contact pads may be one hole.
  - c. Fuseholders and fuses: Rated 1000 Volts dc.
  - d. Fuses; Current limiting, nonventing, rated and coordinated with the withstand capability of the drainage disconnect switches. Bolt-on, 60 Ampere, Chase-Shawmut Form 101, Catalog No. A100P60 or equal.
  - e. Shunts for test usage: Copper, rated to produce one millivolt drop per Ampere, 100 Ampere capacity, installed in each stray current control circuit
  - f. Disconnect switches:

- 1) Installed between the incoming stray current control cable and the substation negative bus as shown.
  - 2) Single-pole, load break, knife blade switch rated at 60 Amperes continuous at 600 Volts dc. Coordinate switch rating with current limiting fuse to provide adequate withstand capability under fault conditions.
  - 3) Mounted on an insulating base with adequate clearances to increase strike and creepage voltage levels to 750 Volts dc minimum.
- g. Reverse current switch: Low threshold solid state reverse current switch (diode) rated 60 Amperes, 200 Volts dc peak inverse voltage, 20 to 80 millivolt threshold voltage, complete with two 4/0 connectors. Specifically designed and tested for use as a stray current control device. Provide adequate ventilation for switch, associated protective devices, wiring and terminals.
- h. Variable Resistor: Rated 1.1 Ohms, 11 to 104 Amperes, 620 to 820 Watts heat dissipation per unit, cylindrical core type and furnished with an adjustable clamp type terminal.
6. Drainage Bus and Bus Connections:
- a. Description and rating: High quality copper or aluminum, electrical conductivity, rated 400 amperes dc continuous and 750 Volts dc.
  - b. Insulation: Bus bars mounted on barrier type insulation or post type insulators. Bare, except where close clearances may make insulation necessary.
  - c. Bus Connections:
    - 1) Connection surfaces silver or tin plated.
    - 2) Joints treated to prevent corrosion. Each joint having a conductivity at least equal to that of the bus bar.
    - 3) Bolted with cadmium plated, galvanized or similarly coated, high-strength steel bolts of sufficient number and size to provide solidly bolted connection.
    - 4) Drainage bus solidly connected to the dc negative bus.
  - d. Bus Compartment: Isolated from the stray current corrosion control equipment compartments. Includes drainage bus work, connection bars, bus supports, cable connections and cable supports.
- B. Negative Switchboard:
1. Free-standing, metal-enclosed, suitable for indoor installation and including the following equipment:
    - a. DC negative bus and bus connections in accordance with item 2.01.A.4 above.
    - b. Negative cable terminal enclosures in accordance with item 2.01.A.2.
    - c. Negative return cable terminal connections.
    - d. Negative bus tie circuit breaker and switchgear cubicle in accordance with Section 16341 and Section 16051, Table III, for number and ratings.
- C. Nameplates:
1. Three-ply, laminated phenolic plates, engraved through black face to white core and attached by means of stainless steel rivets or screws. Vertical gothic lettering using a round or square cutter.
  2. Provide nameplate on each switchboard showing manufacturer's name and brand designation, the referenced standard, type, class and rating as applicable in accordance with referenced standard.
  3. Provide additional functional nameplates for each component
  4. Each enclosure labeled, front and back, with nameplate 2-1/2 inches by 6-1/2 inches, inscribed in letters 1/2 inch high: "DRAINAGE AND NEGATIVE SWITCHBOARD" or "NEGATIVE SWITCHBOARD" as appropriate.

5. In addition to other information normally displayed on equipment, provide one-inch nameplate showing in letters 1/2 inch high switch positions, meaning of indicator lamp and other pertinent information.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. Install Drainage and Negative Switchboard and in accordance with approved shop drawings.
- B. Install conduit and raceway in accordance with approved shop drawings and Section 16052 (Basic Materials and Methods).
- B. Install negative bus duct as shown and in accordance with approved shop drawings and Section 16451 (Substation Busways).
- C. Make cable connection in accordance with approved shop drawings and Section 16052 (Basic Materials and Methods).
- D. Use services of manufacturer's engineering representative for assistance in field assembly and installation of the equipment in accordance with Section 16051.

#### **3.02 FIELD QUALITY CONTROL**

- A. Field Testing and Inspection is as specified in Section 16051 (Scope of Work).

**END OF SECTION**

## SECTION 16451

### SUBSTATION BUSWAYS FOR TRACTION POWER

#### PART 1 - GENERAL

##### 1.01 SUMMARY

- A. This section specifies:
  - 1. Furnishing and delivering to the job site substation busways (bus ducts)
  - 2. Installation of substation busways (bus ducts)
- B. Related work specified elsewhere
  - 1. Section 16051- Scope of Work For Traction Power
  - 2. Section 16261 - Transformer-Rectifier Units For Traction Power
  - 3. Section 16341 - Metal-Enclosed DC Switchgear For Traction Power
  - 4. Section 16441 - Drainage and Negative Switchboard For Traction Power.
- C. Payment and measurement basis:
  - 1. Compensation for work specified in this section associated with installation will be made in the lump sum installation cost of each traction power substation.
  - 2. Compensation for work specified in this section associated with equipment will be made in the manner of lump sum per each traction power substation.
  - 3.

##### 1.02 REFERENCES

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Codes and regulations of Jurisdictional authorities
  - 2. NEC
  - 3. NEMA BU1
  - 4. ANSI C37.23, Z55-1
  - 5. L 857

##### 1.03 SUBMITTALS

- A. Submit the following for approval in accordance with Division 1 and with the additional requirements specified for each:
  - 1. Shop Drawings: In accordance with Table 16051, Table I.
  - 2. Calculations: Surge suppression capacitor ratings.
  - 3. Certification:
    - a. Certified test reports or certified copies of test reports for identical units for specified factory testing.
    - b. Certificates from manufacturer verifying that equipment conforms to the specified requirements.
  - 4. Operations and Maintenance Manuals: In accordance with Division 1.

##### 1.04 QUALITY ASSURANCE

- A. Qualifications: Select a manufacturer who is regularly engaged in production of similar busway and has supplied for at least five similar projects.
- B. Factory Testing:
  - 1. Dielectric withstand test: Perform a 60 second dielectric withstand test on the busways as follows:

- a. Anode (ac) bus duct: Test between phases and phases to enclosure by applying 2200 volts, rms, 60 Hertz, or 3100 volts, dc.
  - b. Cathode bus duct: Test between live parts and enclosure by applying 3700 volts, rms, 60 Hertz or 5200 volts, dc.
  - c. Negative bus duct: Test between live parts and enclosure by applying 3700 volts, rms, 60 Hertz or 5200 volts, dc.
  - 2. Continuous current test: Perform tests to demonstrate that bus assembly meets the temperature rise limitations per ANSI C37.23.
  - 3. Short-circuit withstand test: To determine the electrical, thermal and mechanical adequacy of buses and connections under short-circuit conditions.
- C. For Codes, Regulation, References and Specifications, refer to Article 1.02.

## **1.05 DELIVERY, STORAGE, AND HANDLING**

- A. Equipment for each facility shall be delivered after its completion and in accordance with the access dates indicated in Division 1 and in coordination with the Authority and the Installation Contractor.
- B. Ship each unit securely packaged, braced and labeled for safe handling in shipment and to avoid damage or distortion.
- C. Temporary Bracing: Where necessary, brace for hoisting, lowering and skidding into position. Label temporary internal bracing: TEMPORARY-REMOVE BEFORE OPERATION.
- D. Store in secure and dry storage facility.

## **PART 2 - PRODUCTS**

### **2.01 EQUIPMENT**

- A. General Requirements:
  - 1. In accordance with ANSI C37.23, NEMA BU1 and UL 857.
  - 2. Bus bars:
    - a. Electrical conductor, high quality copper of 98% electrical conductivity, having all joint and connection surfaces silver or tin plated and supported on insulators or self-extinguishing material. All bus connections bolted with cadmium plated, galvanized, or similarly coated, high strength steel bolts of sufficient number and size to provide solidly bolted connections.
    - b. Sizes shall be based on current density (800 Amperes per square inch maximum), maximum allowable temperature rise per NEMA/ANSI/IEEE Standards and as stated under Transformer-Rectifier unit design test in Section 16261 and short circuit stress withstand capability due to a bolted fault at the bus connection.
  - 3. Enclosure: Totally enclosed, non-ventilated type. All bus-bolted connections accessible through removable, gasketed covers.
  - 4. Finish: Metallic surfaces degreased, primed and finished with light gray enamel, Color No. 61, ANSI Z55.1 in accordance with referenced standard. Two mils minimum dry film thickness.
- B. AC Bus Duct:
  - 1. Three phase, designed for connecting transformer secondary terminals to rectifier.
  - 2. Rating: 1,000 Volts ac Amperes as indicated in power one line diagram or Section 16051 Table III, capable of carrying the rectifier loadings specified and capable of withstanding stresses due to a bolted short circuit at the ac bus connection in the

- rectifier with a fault level of 750 MVA for the 13.8 kV switchgear bus and 1500 MVA for the 34.5 kV switchgear bus
3. Connection: Flexible connectors of the braided or laminated type provided for connecting bus conductors to the transformer terminals.
  4. Surge suppression capacitors: Voltage surge suppression capacitors, connected between each of the bus bars and the ground bus within the bus duct enclosure. Capacitor sizes and ratings determined by the Contractor. Capacitors shall be fused with blown fuse indicators visible from the outside of rectifier enclosure.
  5. Strip heaters: Provide 120 V, 60Hz strip heaters, extending the entire length, mounted on the bottom, without thermostat and monitored by an ammeter located on the rectifier enclosure and with wiring terminated on a suitable molded case circuit breaker located in the rectifier enclosure.
  6. Enclosure:
    - a. Designed for flange bolting over the transformer secondary terminals and to the rectifier.
    - b. Electrically insulated from the rectifier enclosure as specified.
    - c. Equipped with a removable gasketed cover at the transformer connections for ease of maintenance and testing.
  7. Ground Bus:
    - a. Copper, rated at twenty-five percent of the main bus capacity provided for connecting the sections to form one continuous length without bridging the insulated section at the rectifier.
  8. Outdoor Construction: (For outdoor transformers) Provide 120V, 60 Hz. strip heaters, extending the entire length, mounted on the bottom, without thermostat and monitored by an ammeter located on the rectifier cubicle and with wiring terminated on a suitable molded case circuit breaker located in the rectifier cubicle.
- C. Cathode Bus Duct:
1. Positive bus, designed for connecting the positive bus of the rectifier to the cathode circuit breaker.
  2. Rating: 1,000 Volts dc ratings Ampere as indicated in power one line diagram or Section 16051 Table III, capable of carrying the rectifier loadings specified and capable of withstanding stresses due to short circuit currents.
  3. Enclosure:
    - a. Electrically insulated from the rectifier enclosure and dc switchgear enclosure as specified in Sections 16261 and 16341.
    - b. Equipped with a removable gasketed cover at the rectifier connection for ease of maintenance and testing.
    - c. Insulated from all supports to 1000 Volts.
- D. Negative Bus Duct:
1. Designed for connecting negative bus of the rectifier to the negative switchboard bus.
  2. Rating: 750 Volts dc, Amperes continuous, as shown in power one line diagram or as indicated in Table 16051-III, capable of carrying the rectifier loadings specified and capable of withstanding stresses due to short circuit currents.
  3. Enclosure:
    - a. Electrically insulated from the rectifier enclosure by an insulating gasket of suitable material and thickness.
    - b. Solidly tied to the drainage and negative switchboard enclosure.
    - c. Equipped with a removable gasketed cover at the rectifier connection for ease of maintenance and testing.

### **PART 3 - EXECUTION**

**3.01 INSTALLATION**

- A. Install bus duct in accordance with approved shop drawings. Provide bracing of bus ducts to prevent movement due to short circuit forces in accordance with manufacturer's recommendations. Submit calculations for forces exerted on bus ducts based on layout shown on approved shop drawings.
- B. Use services of manufacturer's engineering representative for assistance in field assembly and installation of the equipment in accordance with Section 16051.
- C. The Contractor shall make bolted bus connections at each shipping split indicated below in accordance with manufacturer's instructions.
  - 1. [As an example], the bus ducts will have the following number of shipping splits:

Name of SUBSTATION	NO. OF SPLITS	NO. OF PIECES
[Location - TBD]	[TBD]	[TBD]

**3.02 FIELD QUALITY CONTROL**

- A. Field Testing and Inspection: As specified in Section 16051 (Scope of Work).

**END OF SECTION**

## SECTION 16525

### LIGHTING FIXTURES AND MOUNTING POLES

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing lighting fixtures and mounting poles.
- B. Related Work Specified Elsewhere:
  - 1. Grading, excavation and backfilling: Section 02320.
  - 2. Concrete formwork: Section 03100
  - 3. Concrete reinforcement: Section 03200.
  - 4. Cast-in-place structural concrete: Section 03300.
  - 5. Field painting: Section 09920.
  - 6. Grounding and bonding: Section 16060.
  - 7. Wire, cable and busways: Section 16120.
  - 8. Wire connection accessories: Section 16125.
  - 9. Raceways, boxes and cabinets: Section 16130.
  - 10. Wiring and control devices: Section 16145.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of jurisdictional authorities.
  - 2. NEC.
  - 3. UL: 496, 542, 1029, 1570, 1571, 1572, Electrical Construction Materials Directory.
  - 4. FS: FF-B-588, FF-P-395, FF-S-325C.
  - 5. MS: MIL-C-450.
  - 6. FED STD: 595.
  - 7. PEI: 1001.
  - 8. SSPC: SP-8, SP-10.
  - 9. ASTM: A53, A167, A276, A123, A507, A575, B26, B85, B117, B136, B137, B209, B221, B244, D635, D1056, D1400, D2240.
  - 10. AASHTO: M314, LTS-3.
  - 11. ITS: Directory of ITS Listed Products.
  - 12. AA: Standard finishes as designated by the Aluminum Association and referenced in NAAMM Metal Finishes Manual.
  - 13. ANSI/IEEE: C62.41.
  - 14. IEEE Publication 587.
  - 15. ANSI Standards.
  - 16. FCC Rules and Regulations, Part 15, Part 18.
  - 17. NEMA 1
  - 18. AISI.
  - 19. IES: RP-20
- B. Each lighting fixture to be labeled or listed per referenced UL or ITS directory.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Include photometric curves.

2. Samples: One of each type of fixture.
3. Certification:
  - a. Verification that each fixture is in compliance with applicable codes, regulations, reference standards and specifications for the location at which it is to be used. Indicate requirements that each fixture meets.
  - b. Calculations: Submit calculations by a professional engineer registered in the jurisdiction where material is to be installed certifying that assemblies of foundation, anchor bolts, pole, arms and luminaire will withstand specified wind pressure, wind speed, stress, deflection, vibration and fatigue.

#### **1.04 PRODUCT DELIVERY, STORAGE, AND HANDLING:**

- A. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.
- B. Store lighting fixtures and mounting poles in secure and dry storage facility.

#### **1.05 WARRANTY:**

- A. Globes and Diffusers: In addition to warranty requirements of the General Provisions, furnish warranty against discoloration and distortion for a total of four years.
- B. Lamps: Warrant the life of lamps for periods specified.

### **PART 2 - PRODUCTS**

#### **2.01 PRODUCTS AND MATERIALS:**

- A. General Requirements for Lighting Fixtures:
  1. Interchangeability: Components of same type, size, rating, functional characteristics and make are to be interchangeable.
  2. In accordance with UL 1570, UL 1571 and UL 1572.
  3. Materials:
    - a. Steel:
      - 1) Sheet: ASTM A507, 22-gauge minimum.
      - 2) Bar: ASTM A575.
    - b. Steel pipe: ASTM A53, Type S.
    - c. Stainless steel:
      - 1) Sheet: ASTM A167, 22-gauge minimum.
      - 2) Bar: ASTM A276, Type 316.
      - 3) Finish: AISI Alloy S30400, NAAMM Finish No. 4, unless otherwise shown.
    - d. Aluminum: Alloy as recommended by manufacturer, unless otherwise shown or specified.
      - 1) Sheet and plate: ASTM B209.
      - 2) Extrusion: ASTM B221, 0.109-inch minimum thickness, unless otherwise shown.
      - 3) Cast:
        - a) Die cast: ASTM B85, 0.1875-inch minimum thickness, unless otherwise shown.
        - b) Sand cast: ASTM B26, 0.1875-inch minimum thickness, unless otherwise shown.
        - c) Color-anodized cast: Kalcator Casting Alloy No. 2 or equal.
4. Lamps:
  - a. In accordance with applicable ANSI Standards.

- b. Incandescent:
  - 1) Wattage: As shown or specified.
  - 2) Finish: Inside frosted unless otherwise shown.
  - 3) Base:
    - a) Up to 200 watts: Medium screw base
    - b) Above 200 watts: Mogul screw base.
  - 4) Operating voltage: 120 volts, 60 Hertz.
  - 5) Rated life: 2,500 hours.
  - 6) Bulb size: As shown.
- c. Mercury vapor:
  - 1) Watt rating: As shown.
  - 2) Color: Deluxe white.
  - 3) Finish: As shown.
  - 4) Base:
    - a) Up to 100 watts: Medium screw base.
    - b) Above 100 watts: Mogul screw base.
  - 5) Rated life: 24,000 hours.
  - 6) Bulb size: As shown.
- d. Fluorescent:
  - 1) Wattage and size: As shown or specified.
  - 2) Color: Warm white.
  - 3) Type:
    - a) PL7 compact, PL13 compact.
    - b) F6T5/CW and F20T12WW, Preheat start.
    - c) F32T8/WW, F48T12/WW/SHO, F72T12/WW/SHO, and F96T12/WW/SHO: Rapid start.
  - 4) Rated life:
    - a) Super-high output (SHO), very-high output (VHO) and high output (HO) lamps: 12,000 hours.
    - b) F32T8/WW: 20,000 hours.
    - c) PL compact lamps: 10,000 hours.
  - 5) Base:
    - a) Super-high output (SHO), very-high output (VHO) and high output (HO) lamps: Recessed double contact.
    - b) F32T8/WW: Medium bi-pin.
    - c) PL7 medium.
- e. Tungsten-halogen:
  - 1) Wattage: As shown.
  - 2) Size: T-3.
  - 3) Base: Recessed single contact.
  - 4) Rated life: 4,000 hrs.
  - 5) Operating voltage:
    - a) 1,500-watt lamps: 277 volts, 60 Hertz.
    - b) All other lamps: 120 volts, 60 Hertz.
- f. Metal-halide:
  - 1) Wattage: As shown.
  - 2) Size: As shown.
  - 3) Color: Clear unless otherwise noted.
  - 4) Lamp operating position: As shown.
  - 5) Base: Mogul.
  - 6) Rated life:
    - a) 175 watt: 7,500 hours.
    - b) 400 watt: 15,000 hours.
    - c) 1,000 watt: 10,000 hours.
- g. High-pressure sodium:
  - 1) Wattage: As shown.

- 2) Size: As shown.
  - 3) Coating: Clear, unless otherwise shown or specified.
  - 4) Base: Medium or mogul.
  - 5) Rated life: 24,000 hours.
5. Lampholders:
- a. Incandescent, mercury vapor, metal halide and high-pressure sodium:
    - 1) In accordance with UL 496.
    - 2) Black or white thermosetting phenolic compound, glazed-porcelain or neoprene base and body as shown. Neoprene unit molded in one-piece, weatherproof, oil-resistant, with vibration-absorbing socket construction.
    - 3) Incandescent: Rated 660 watts, 250 volts for medium screw base.
    - 4) Mercury vapor, high-pressure sodium and metal halide:
      - a) Rated 660 watts, 600 volts: Medium screw base.
      - b) Rated 1,500 watts, 600 volts: Mogul screw base.
    - 5) Provide mechanical self-retaining neoprene gasket for dust and moisture proof seal between lamp and lampholder.
    - 6) Provide vibration proof feature to prevent incandescent lamp from loosening in lampholder in S-1 fixture
  - b. Fluorescent:
    - 1) In accordance with UL 542.
    - 2) Rated 660 watts, 600 volts.
    - 3) Integral starter holder for preheat-type lamps, with starter.
    - 4) White, thermosetting phenolic-compound base and body, silver-plated phosphorous-bronze contacts, self-aligning neoprene gasket face.
  - c. Tungsten-halogen: Porcelain with silver-plated contacts, to suit RSC lamp base.
6. Ballasts:
- a. Mercury-vapor lamps, high-pressure sodium lamps and metal-halide lamps:
    - 1) UL 1029, high-power-factor type.
    - 2) Operable on 120-volt or 277-volt, 60 Hertz as shown or necessary, type and rating suitable for associated lamp.
    - 3) Capable of starting lamp at ambient temperature of minus 20F and above.
    - 4) Equip with individual fuse protection installed in ballast compartment of fixture.
  - b. Fluorescent lamps:
    - 1) FCC part 15 subpart J, UL listed Class P.
    - 2) Operable on 120-volt or 277-volt, 60 Hertz, as shown or necessary, type and load rating suitable for associated lamps.
    - 3) Capable of starting lamps at ambient temperature as follows:
      - a) F32T8/WW lamps: Zero degree F.
      - b) F48T12/WW/SHO, F72T12/WW/SHO, and F96T12/WW/SHO lamps: Minus 20F.
    - 4) Sound rating:
      - a) For use with F32T8/WW lamps installed in office areas: A.
      - b) For use with F32T8/WW lamps installed in ancillary areas: B or better.
      - c) For use with F48T12/WW/SHO, F72T12/WW/SHO, and F96T12/WW/SHO lamps: D or better.
    - 5) Maximum utilization of two-lamp ballasts in public-area lighting fixtures.
    - 6) Equipped with individual fuse protection, installed in the fixture wiring channel.
7. Fixture body and housing: Shape, size and material as shown.

8. Reflector: Shape, size and material as shown. Aluminum or stainless steel polished to mirror finish unless otherwise shown. Minimum thickness 22 gauge unless otherwise shown.
9. Diffusers:
  - a. Shape and size as shown, one-piece molded or extruded clear virgin acrylic or polycarbonate plastic having the following properties:
    - 1) Interior diffusing with smooth exterior surface.
    - 2) Self-extinguishing, in accordance with ASTM D635.
    - 3) No material color change when used with 4500K fluorescent lamp.
    - 4) No apparent yellowing after 500 hours exposure to fluorescent-lamp source under conditions similar to those existing in the lighting fixture.
    - 5) No alteration to optical properties of the fixture when finished diffuser treated with anti-static wax.
  - b. Formed by carefully controlled processes so that the finished piece retains its design contours and dimensions at normal operating temperature.
  - c. Resistance to shrinking, warping, crazing, cracking, or discoloring, either in service or when stored in the manufacturer's standard shipping containers under normal conditions.
10. Globes:
  - a. Clear seamless polycarbonate or high-impact heat-resistant glass as shown.
  - b. Shape and size: As shown.
  - c. Minimum thickness: 0.125 inch, surface free from visible mold seam.
  - d. Reduction in strength: 10-percent maximum after five years.
  - e. Maximum haze: Two percent.
  - f. Minimum light transmittance: 88 percent.
11. Lenses:
  - a. Plastic lenses: Clear polycarbonate as shown, minimum thickness 0.06 inch.
  - b. Glass lenses: 1/4-inch tempered glass, laminated glass, or 1/8-inch double-strength clear glass as shown, capable of absorbing ultraviolet rays when used with mercury-vapor or metal-halide lamps.
  - c. Refracted lenses: Heat-resistant, annealed, clear borosilicate glass, with the following additional requirements:
    - 1) Initial lumen distribution on horizontal plane evenly from zero to 90 degrees: 55 to 60 percent.
    - 2) Minimum efficiency: 85 percent.
12. Fixture wire: Section 16120.
13. Gasket:
  - a. Keyed gasket: One-piece, extruded solid neoprene having Type A durometer hardness of 30 plus-or-minus five when tested in accordance with ASTM D2240.
  - b. Self-retaining gasket:
    - 1) One-piece, closed-cell sponge neoprene, soft or medium density.
    - 2) Resistant to aging, heat, ultra-violet light, water, oil, weathering and setting as determined by ASTM D1056.
    - 3) Cemented to component with resilient neoprene sealing compound compatible with finish. Adhesive not applied to diffuser.
  - c. Silicone gasket equal to neoprene, at Contractor's option.
14. Hardware:
  - a. Latches, catches, release mechanisms, hinges, screws, bolts, studs, nuts, rivets, washers and springs. Heavy-duty stainless steel or bronze, as shown.
  - b. Latches and catches: Captive-type.
  - c. Operating hardware: Self-retaining type.
15. Construction:

- a. Fixture body, reflectors, wiring channels, end caps and castings formed so as to prevent buckling or distortion.
  - b. Minimum of two wire clips provided in wiring channel to support wiring. Self-cleaning air filter provided on breather ports.
  - c. Seams and joints continuously welded and ground smooth.
  - d. When aluminum will be in contact with dissimilar metal, separate contact surfaces with gasket, nonabsorptive tape, or coating to prevent corrosion.
16. Finish:
- a. Baked enamel: Nonspecular finish consisting of six-stage hot-cleaning wash, phosphate coat, prime coat, and finish coat of sprayed white or other color acrylic enamel as shown, baked at 350F for a minimum of 30 minutes, with the following additional requirements:
    - 1) Dry-film thickness (DFT) per ASTM D1400: 1.25 mils minimum.
    - 2) Undercutting of enamel film from scored line after exposing to 10-percent salt spray for 1,500 hours, per ASTM B117: 0.067-inch maximum.
    - 3) Baked white enamel after 100 hours exposure to fadeometer: 86-percent minimum reflectance factors, no appreciable visual color change.
    - 4) Bronze color: FED STD 595, Color No. 20040.
  - b. Porcelain enamel: Opaque, fused vitreous surface finish, 88-percent average reflectance factor, in accordance with the following standards:
    - 1) On steel: PEI 1001.
    - 2) On aluminum alloy: PEI 1001.
  - c. Specular anodized coating: 14-stage process for permanently sealed specular or semispecular finish, as shown, in accordance with patented electrolytic process, Alzak or equal. When shown dark-bronze color, match Duranodic 313 Dark Bronze.
  - d. Clear anodic coating: AA-M22C22-A41, minimum coating thickness 0.8 mil, coating weight 35 milligrams per square inch, hot-water seal overall, tested in accordance with the following requirements:
    - 1) Coating weight: ASTM B137.
    - 2) Coating thickness: ASTM B244.
    - 3) Sealing test: ASTM B136.
    - 4) Undercutting of anodic film from scored line after exposing to 10-percent salt spray for 1,500 hours, in accordance with ASTM B117: 0.067-inch maximum.
  - e. Color-anodized finish: NAAMM AA-M22-C22A42, minimum coating thickness 0.8 mil, coating weight 35 milligrams per square inch, hot-water seal overall, tested in accordance with the following requirements:
    - 1) Coating weight: ASTM B137.
    - 2) Coating thickness: ASTM B244.
    - 3) Sealing test: ASTM B136.
    - 4) Color: Dark Bronze. Kaiser Aluminum Color, Statuary Bronze; Alcoa Color, Dark Bronze, Duranodic 313.
  - f. Zinc coating: ASTM A123.
  - g. Factory-painting: Prepare surfaces by pickling in accordance with SSPC SP-8. Apply coating of 7.0-mil total DFT as follows:
    - 1) First coat: Inorganic zinc-silicate primer, 2.5-mil DFT.
    - 2) Second coat: High-build epoxy primer, 3.0-mil DFT.
    - 3) Third coat: Aliphatic polyurethane, 1.5-mil DFT, FED STD 595, Color No. 20040.
  - h. Field painting: Section 09920.
  - i. Electrostatic-powder coating: Prepare surfaces by sandblast cleaning complying with SSPC SP-10 near-white blast cleaning, applying coating promptly after cleaning. Ground material to be coated. Apply coating as

- electrostatically-charged dry powder using electrostatic spray gun to produce DFT of six mils plus-or-minus two mils. Cure by heat treatment.
17. Mark each fixture and its components in accordance with applicable reference standard.
  18. Conduit: Section 16130.
  19. Connectors: Section 16125.
  20. Fasteners: Size and type shown or best suited to use.
    - a. Expansion anchors: FS FF-S-325C, Group II, Type 3, Class 1, stainless steel, Type 303.
    - b. Toggle bolts: FS FF-B-588.
    - c. Powder-actuated: FS FF-P-395.
    - d. Finish: Where exposed, custom finish exposed parts to match surface being fastened.
  21. Anchor bolts, nuts and washers:
    - a. AASHTO M314, hot-dip galvanized.
    - b. Bolts hooked, unless otherwise shown or recommended by manufacturer of pole or structure being anchored.
    - c. Two nuts and one washer for each anchor bolt for plumbing pole or leveling structure.
    - d. Finish: Where exposed, custom finish exposed parts to match surface being fastened.
  22. Mounting poles:
    - a. Steel or aluminum, straight or tapered as shown. Complete assembly of anchor bolts, pole, arms and luminaire designed to withstand wind pressure (P) developed by wind speed (V) of 80 MPH in accordance with AASHTO LTS-3. Pole assembly to fully comply with AASHTO requirements for permissible stresses, deflection, vibration and fatigue. Ratio of deflection to pole height under action of applicable static loading not to exceed 1/60.<sup>\*1</sup>  
OR
    - b. Steel, straight or tapered as shown. Complete assembly of anchor bolts, pole, arms and luminaire designed to withstand wind pressure (P) developed by wind speed (V) of 80 MPH in accordance with AASHTO LTS-3. Pole assembly to fully comply with AASHTO requirements for permissible stresses, deflection, vibration and fatigue. Ratio of deflection to pole height under action of applicable static loading not to exceed 1/60.<sup>\*2</sup>
    - c. Size and shape: As shown.
    - d. Base assembly: Steel base plate, designed to withstand full-bending movement of shaft and welded to shaft; anchor bolts; and base cover.
    - e. Handhole size: As shown, with 12-gauge steel sheet coverplate.
    - f. Polygonal-shaped poles fabricated with sharp bends.
    - g. Longitudinally welded with welds continuous and ground smooth.
  23. Grout: Section 03300, nonshrink. Where recommended by manufacturer, prime surfaces to be grouted.
  24. Concrete base, including forms and reinforcement: Division 3, Sections 03100, 03200, and 03300.
  25. Bituminous coating: MS MIL-C-450.
  26. Photoelectric control: Section 16145.

## 2.02 LIGHTING FIXTURES:

- A. Tunnel and Ancillary-Space Lighting Fixtures: Types as shown and as follows:
  1. Type 1 fixture:
    - a. Open, industrial-type, fluorescent.
    - b. Lamps: Two 32-watt F32T8/WW.

- c. Body: Aluminum or 20-gauge steel channel-shaped body, end plates, cover and reflector. Knockouts in body and end plates as shown. Attach end plates to body with noncorrosive screws. Double-strength construction for steel channel.
  - d. Finish:
    - 1) Channel, end plates, and cover:
      - a) Steel: White baked enamel.
      - b) Aluminum: Clear anodic coating.
    - 2) Reflector: White baked enamel for aluminum and steel.
2. Type 2 fixture: Same as Type 1, except fixture equipped with one-piece acrylic-plastic diffuser in extruded aluminum or steel frame; with octolens surface.
3. Type 3 fixture:
- a. Open, strip-type, fluorescent.
  - b. Lamps: Two 20-watt F20T12/WW.
  - c. Body: Aluminum or 20-gauge steel channel, end plates and cover. Knockouts in body and end plates as shown. End plates attached to body with noncorrosive screws. Double-strength construction for steel channel.
  - d. Finish:
    - 1) Steel: White baked enamel, interior and exterior.
    - 2) Aluminum: Clear anodic coating.
4. Type 4 fixture:
- a. Enclosed, watertight, fluorescent, for mounting on channel inserts.
  - b. Lamp: One 32-watt F32T8/WW.
  - c. Enclosure:
    - 1) Body: Extruded-aluminum housing with die-cast aluminum end caps, flanged to provide solid seat for gasket between body and door frame.
    - 2) Door frame: Extruded aluminum, minimum of three hinges riveted to door and housing, 0.2-inch diameter stainless-steel hinge pins and minimum of three door-fastening screws.
    - 3) Door-fastening screws: Quick-turn, slotted, pan-head, captive, corrosion-resistant, location to provide uniform pressure on door gaskets.
    - 4) Diffuser: Clear, inside-ribbed polycarbonate plastic.
    - 5) Reflector: Aluminum, three-part, with portion concealing ballast flush-hinged to permit wiring connections and ballast replacement.
  - d. Finish:
    - 1) Enclosure: Clear anodic coating.
    - 2) Reflector: White baked enamel.
5. Type 4A fixture: Two tandem-mounted Type 4 fixtures, with two lamp ballasts, as shown.
6. Type 5 fixture:
- a. Enclosed fluorescent fixture.
  - b. Lamp: One 32-watt F32T8/WW.
  - c. Enclosure: Steel housing and end plates. Knockouts where shown. End plates attached to housing with noncorrosive screws. Diffuser: Clear acrylic plastic.
  - d. Finish:
    - 1) Enclosure: White baked enamel.
    - 2) Reflector: White baked enamel.
7. Type 6A fixture:
- a. Enclosed, vapor-tight, compact fluorescent, for pendant mounting.
  - b. Housing: Cast aluminum, with threaded hub for 3/4-inch conduit, and cast-aluminum guard.
  - c. Globe: Clear glass with high-impact resistance.
  - d. Finish: Clear anodic coating.

- e. Fluorescent lamp: One PL13 compact.
- 8. Type 6B fixture: Same as Type 6A, except for mounting on outlet box.
- 9. Type 6C fixture: Same as Type 6A, except bracket-type for mounting on wall.
- 10. Type 6D fixture: Same as Type 6C, except complete with outlet box.
- 11. Type 7A fixture:
  - a. Enclosed, vapor-tight, high-pressure sodium for ceiling mounting.
  - b. Housing: Cast aluminum, with ballast compartment cast aluminum, guard.
  - c. Globe: Clear glass with high-impact resistance.
  - d. Finish: Two coats of gray epoxy enamel.
  - e. Lamp: One 50-watt, clear, BT-25, high-pressure sodium.
- 12. Type 7B fixture: Same as 7A, except wall-mounted.
- 13. Type 7C fixture: Same as 7A, except pendant-mounted. Center topped and integrally counter-weighted so fixture hangs plumb.
- 14. Type 8 Fixture:
  - a. Enclosed, weatherproof high-pressure sodium for wall mounting, UL-listed "Suitable for Outdoor and Wet Locations".
  - b. Housing: Die-cast aluminum luminaire, integral ballast housing and grid guard, with tamper-resistant stainless-steel hardware.
  - c. Refractor: Pressed, clear, prismatic, single-piece, thermal/shock-resistant, borosilicate glass or polycarbonate.
  - d. Finish: Electrostatic powder-coated, FED STD 595 Color No. 20040.
  - e. Lamp: One clear, high-pressure sodium, wattage as shown.
- 15. Type 9 Fixture: Emergency trip station light:
  - a. Enclosed and gasketed weatherproof, mercury-vapor fixture mounted on steel channel and tube as shown, UL-listed as Suitable for Outdoor and Wet Locations.
  - b. Housing: Die-cast copper-free aluminum luminaire with 90-degree arm for wall mounting, integral ballast housing, grid guard and threaded globe seat, with tamper-resistant stainless steel hardware.
  - c. Globe: Thermal shock-resistant and impact-resistant blue, tempered glass with threads to ensure secure fit to housing.
  - d. Finish: Natural.
  - e. Lamp: Mercury-vapor, 40-watt B-17.
  - f. Ballast: H45 type, Class H insulated, capable of starting 40-watt mercury-vapor lamp at ambient temperature of minus 20F and above, suitable for remote mounting.
  - g. Remote ballast enclosure: Fiberglass or aluminum with polyester powder paint finish, front access, weathertight construction, 3/4-inch conduit entry and exit knockouts, with mounting lugs suitable for mounting on channel inserts or on wall as shown.
  - h. Source: Hubbell catalog number VMWX-5050C-R, or approved equal.
- 16. Type X fixture:
  - a. Exit sign for top, side, back or pendant-mounting, as shown. With directional arrows where shown. Color of lettering and arrows to comply with jurisdictional requirements.
  - b. Lamps: Ultra-long-life light-emitting diodes (LED) mounted on a circuit board to operate on 120V or 277V, single phase, 60-Hz supply. Have LED's protected by a clear panel and special optical diffuser.
  - c. Housing: Die-cast aluminum, 0.125-inch minimum wall thickness. Concealed hinges and latching mechanism.
  - d. Door: Die-cast aluminum, 0.125-inch minimum thickness; open-face with phosphorescent-glass panel and six-inch high letters; color of letters and field as required by the jurisdictional authority, using fired-on ceramic colors.
  - e. Finish: Clear-satin anodic coating, unless otherwise shown.

B. Station Kiosk Lighting:

1. Lighting Fixtures; Station Kiosk: UL 1570, and the following additional requirements:
  - a. Type K-4 lighting fixture: Open compact fluorescent downlight fixture, Prescolite Catalog Number CFR813EBDM-B572-MTR-120V/208V/240V/277V - RIF1 or approved equal, for recess mounting in the ceiling of the kiosk with the following additional requirements
    - 1) Two 13-watt compact fluorescent twin tube lamps with four-pin 2GX7 lamp base compatible with fixture lampholder and suitable for dimming application using electronic ballast.
    - 2) Encased and potted Class P electronic ballast capable of producing flicker-free light output range from five percent to 100 percent of rated output.
    - 3) Clear Alzak reflector with lower black baffle to provide 50° optical cutoff and maximum spacing to mounting height ratio of 1.1.
    - 4) Diecast aluminum trim ring with baked enamel finish, FS 595, Color No. 36586.
    - 5) Dimensions:
      - a) Nominal aperture size: 8 inches.
      - b) Maximum height: 8 inches.
      - c) Maximum overall dimensions of housing, including accessories, in vertical view above ceiling plane: 16 inches by 20 inches.
    - 6) Integral junction box approved for 90°C through wiring.
    - 7) Suitable for damp location.
    - 8) Radio interference filter for suppressing radio interference noise.
    - 9) Lighting fixture, dimming ballast and associated controls designed and manufactured for compatibility by a single manufacturer.
  - b. Ballast: Dimming compact fluorescent electronic ballast, Prescolite Model No. PUV-20RSD or approved equal, for mounting on the housing of the Type K-4 lighting fixture and with the following additional requirements:
    - 1) Capable of operating four-pin, 13-watt compact fluorescent lamps with circuitry that constantly monitors lamp conditions to provide constant light output regardless of voltage fluctuations.
    - 2) Equipped with a soft start/rapid start function which preheats cathode filaments and then ignites the lamp for maximum lamp life.
    - 3) Capable of dimming continuously from 100 percent to five percent of rated light output.
    - 4) Capable of maintaining full filament heat throughout the dimming range for long lamp life.
    - 5) Dimming circuitry UL Class 2 and fully isolated from ballast input power.
    - 6) Compatible with low voltage (2.5-12 volts dc) dimming systems.
    - 7) Compatible with phase controlled dimmers by utilizing a dimming interface box to provide the interface between the phase controlled ac output and the 2.5-12 volts dc signal required by the ballast.
    - 8) Equipped with push-in wire connections suitable for No.18 AWG solid copper wire.
    - 9) Input voltage universal and suitable for operation on 120-volt system.
    - 10) Maximum lamp current crest factor of 1.414.
    - 11) Power factor of 0.95 or higher.
    - 12) Input current total harmonic distortion not to exceed 10 percent.
    - 13) Operating frequency exceeding 30 kilohertz.
    - 14) Maximum control input current of 2 milliamperes at 12 volts dc output.
    - 15) Sound level not exceeding Class A ambient noise levels.
    - 16) Minimum starting temperature of 0°F.

- 17) Capable of withstanding line transients as defined in IEEE Publication 587, Category A, ANSI/IEEE C62.41, Category A.
  - 18) Capable of maintaining cathode filament voltage within ANSI standards.
  - 19) Meet requirements of FCC Rules and Regulations, Part 18.
  - 20) UL-listed, Class P, Type 1 Outdoor.
2. Lighting Control System; Station Kiosk: Lighting control system consisting of dimming interface box and dimmer switch as follows:
- a. Dimming interface box: Dimming interface box, Prescolite Model No. CIB or approved equal, to provide the interface between electronic dimming ballasts and the phase controlled wallbox dimmer and with the following additional requirements:
    - 1) Compatible with fluorescent wallbox dimmers and with lamp types used with electronic dimming ballasts.
    - 2) Dimming interface box to convert the dimmed (phase controlled) ac output from a wallbox dimmer to the 2.5-12 volts dc signal required by the electronic ballast. Lowest dimming level shall correspond to a 3 volts dc signal and maximum light output shall correspond to a 12 volts dc signal.
    - 3) DC control output to be isolated from the switched ac and dimmed ac inputs and protected internally from short circuits.
    - 4) Capable of operating from one to 100 electronic dimming ballasts.
    - 5) Input voltage autoranging and suitable for operation on 120-volt system.
    - 6) Constructed in a steel NEMA 1 enclosure with nominal 6-inch by 8-inch by 4-inch dimensions.
    - 7) UL-listed.
  - b. Dimmer switch: Commercial grade linear slide, phase controlled wallbox dimmer, Prescolite Model No. P6F-BR or approved equal, to provide the dimmed/phase controlled ac output to the dimming interface box and with the following additional requirements:
    - 1) Single pole, 120 volts for controlling up to 12 fluorescent lamps.
    - 2) Vertical slide intensity control with on/off illuminated switch.
    - 3) Soft start electronic circuit with voltage compensation to minimize flicker resulting from line voltage fluctuations.
    - 4) Toroidal radio frequency interference (RFI) filter to minimize radio and intercom interferences.
    - 5) Adjustable low-end trim to permit user to determine minimum light level based on particular ballast and lamp combinations.
    - 6) Cover finished with brown or bronze color.
    - 7) UL-listed.
- C. Parking Structure Lighting Fixtures: The low glare fixture shall comply with the latest IES Specifications, RP-20 (Lighting for Parking Facilities). The electrical components will carry a five year minimum warranty, with other components covered by a two(2) year warranty.
- 1. Housing: A die cast housing integrating the high power factor ballast and wiring splices. The wiring shall be rated for 90°C.
  - 2. Ballast: High power factor with multitap power feature 120/277V, 60HZ. UL listed and capable for starting at -20°F
  - 3. Lamp: 150 W, High Pressure Sodium, Medium base, clear . Average life of 24,000 hours.
  - 4. Fixture shall be fused, totally sealed and UL listed for wet location.
- D. Other Lighting Fixtures: Types as shown, with materials and finishes shown and specified

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION:**

- A. Install lighting fixtures of types shown at locations shown as follows:
  - 1. Mount fixtures rigidly in place. Use expansion anchors and machine screws for concrete surfaces and toggle bolts for hollow concrete-masonry surfaces. Use appropriate fasteners for attachment to other surfaces. Support lighting fixtures independent of suspended acoustical-panel ceiling systems.
  - 2. Where aluminum contacts concrete or dissimilar metal, separate contact surfaces with gasket, nonabsorptive tape or bituminous coating to prevent corrosion. Use stainless-steel fasteners.
  - 3. Mount fixtures plumb, level and in straight lines. Install stems of suspended fixtures plumb. Group-mounted fluorescent fixtures to appear as one unit.
  - 4. Install 12-inch minimum length of liquid-tight flexible conduit for connection between fixture and outlet box unless otherwise shown in accordance with Section 16130. Use fixture wire from outlet box in branch circuit to lighting fixture in accordance with Section 16120, and connect fixtures to branch circuit in accordance with Section 16125
  - 5. Install chase nipple where fluorescent fixtures are installed in continuous groups. Clean lamps, diffusers, globes, reflectors and exposed-to-view surfaces of fixtures after aiming and adjusting has been approved.
  
- B. Installation of Pole-Mounted Fixtures:
  - 1. Prepare and compact that earth foundation for mounting in accordance with Section 02320. Form and reinforce concrete base as shown and in accordance with Sections 03100 and 03200. Mix and place concrete in accordance with Section 03300. Use finish Number 2 for exposed surfaces. Use templates for setting anchor bolts.
  - 2. Install mounting pole of type shown at location shown. Use double nuts to erect poles plumb. Pack void between concrete base and pole with grout in accordance with Section 03300.
  - 3. Install conductors in accordance with Section 16120, leaving three-foot minimum lengths of conductors for fixture connections; tape or otherwise secure in place pending final connection.
  - 4. Install lighting fixtures in accordance with approved shop drawings.
  - 5. Connect wiring using connectors in accordance with Section 16125. Tape connections.
  - 6. Install photoelectric controls as shown or in accordance with fixture manufacturer's instructions and in accordance with Section 16145.
  - 7. Ground lighting fixtures and mounting poles in accordance with NEC and Section 16060.
  - 8. Apply touch-up paint where necessary in accordance with Section 09920.

### **3.02 FIELD QUALITY CONTROL:**

- A. Ensure that earth foundation for mounting poles is prepared and compacted in accordance with Section 02320.
  
- B. Testing:
  - 1. Furnish necessary personnel and equipment and perform tests and adjustments in the presence of the Engineer. Schedule adjustment of exterior installations to occur during hours of darkness.
  - 2. Test lighting circuits for continuity and operation.
  - 3. Test fixtures and mounting poles for continuity of grounding system.

4. Aim and adjust fixtures to provide distribution pattern approximately as shown and as approved.

**SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY DESIGNER.**

**ENDNOTES:**

- \*1. Use first version of 2.1 A.22.a. modification for all contracts requiring lighting fixture mounting poles for S&I yards.
- \*2. Use second version of 2.1 A.22.a. modification for all contracts requiring lighting fixture mounting poles at locations other than S&I yards.

**END OF SECTION**

## SECTION 16565

### FLASHER AND DIMMER CONTROL SYSTEM

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing flasher and dimmer control system for platform-edge lights.
- B. Related Work Specified Elsewhere:
  - 1. Grounding and bonding: Section 16060.
  - 2. Wire, cable and busways: Section 16120.
  - 3. Wire connection accessories: Section 16125.
  - 4. Raceways, boxes and cabinets: Section 16130.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of jurisdictional authorities.
  - 2. NEC.
  - 3. NEMA: ICS2, AB1, 250.
  - 4. ANSI: Z55.1.
  - 5. UL: 50, Electrical Construction Materials Directory.
  - 6. ITS: Directory of ITS Listed Products.
- B. Source Quality Control:
  - 1. Each item listed per referenced UL or ITS directory.

##### 1.01 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Drawing showing outline dimensions, cross section showing internal construction and weights.
    - b. Internal wiring diagram.
    - c. Characteristic data of 24-volt dc coil in flasher and dimmer control system.
  - 2. Certification.
  - 3. Operation and Maintenance Manuals.

##### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage.
- B. Store products in secure and dry storage facility.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. General Requirements:

1. Components of the same type, size, rating, and functional characteristics to be interchangeable.
  2. Furnish similar items such as flasher and dimmer control unit, time switch and selector switch and associated components as products of single manufacturer.
- B. Flasher and Dimmer Control System: Rated to operate on 120/208-volt three-phase four-wire supply with continuous output of six kilowatts, guaranteed life of 10,000,000 flash cycles, all the lamps flashing simultaneously; having suitable protection device, with the following additional requirements:
1. Flasher:
    - a. Solid-state design.
    - b. Flash rate: 60 flashes per minute, plus-or-minus five percent.
    - c. Flash-mode intensity: Adjustable from 50 to 100 percent of lamp brightness.
    - d. Control relay coil:
      - 1) Nominal coil voltage: 24 volts dc.
      - 2) Coil pick-up voltage: 85 percent of nominal voltage, minimum.
      - 3) Coil resistance: 150 ohms, minimum.
      - 4) Suppression network adequate to limit inductive voltage to 250 volts and load to 15 volt-amperes maximum.
    - e. No interaction between intensity control and rate of flashing.
  2. Dimmer:
    - a. Solid-state design.
    - b. Continuous output: Six kilowatts.
    - c. Capable of operating within ambient temperature range of zero degree C to 40C and relative humidity of 20 percent to 90 percent.
    - d. Capable of varying lamp intensity from 50 to 100 percent.
    - e. Capable of withstanding current inrush to incandescent lamps when switched from zero-volt condition to 120-volt supply.
    - f. Designed to prevent false triggering of silicon-controlled rectifiers, interaction with other dimmer system and objectionable radio-frequency interference with communication and signal equipment.
    - g. Maximum voltage drop at full load: Three volts.
    - h. Output-voltage variation with input-voltage variation between 95 and 135 volts: One-volt maximum.
    - i. Equipped with filter choke to eliminate spurious harmonics and lamp-filament singing.
  3. Time switch:
    - a. Seven-day and 24-hour calibration for each day time switch, UL-listed, heavy-duty, suitable for controlling incandescent lighting fixtures when fed via flasher and dimmer control system.
    - b. Three-pole single-throw switch capable of switching a continuous load of 20 amperes at 208Y/120-volt system.
    - c. Seven-day and 24-hour dial dial with day and night zones and 24-hour calibration for each day clearly marked.
    - d. Providing up to four automatic ON/OFF operations each day.
    - e. Adjustable ON/OFF actuators designed for minimum ON period of one hour and minimum two-hour period between one OFF operation and next ON operation.
    - f. Provision for manual ON/OVERRIDE/OFF operation of switch without disturbing weekly preset schedule.
    - g. Provision for omitting operation of switch on selected days.
    - h. Spring-driven reserve power suitable for operation of switch for minimum of 16 hours after failure of power. On restoration of power, switch transfers to synchronous motor drive and automatically rewinds spring.
    - i. Terminals designed to accommodate up to 8AWG conductor cable.

- j. Operation at 208Y/120 volts, 60 Hertz and within temperature range of zero degree F to plus 140F.
4. Enclosure:
    - a. NEMA 250, Type 1, galvanized steel, surface-mounted.
    - b. Hinged, flush front door with latch and handle in accordance with UL 50; screw fastenings will not be accepted in lieu of latch.
    - c. Finish: Metallic surfaces cleaned, degreased, primed with zinc primer and finished with light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.
  5. Selector switch:
    - a. NEMA ICS2-216, UL-listed, heavy-duty rotary switch suitable for controlling incandescent lighting fixtures.
    - b. One three-pole switch or three single-pole switches capable of switching continuous load of 20 amperes at 208 volts.
    - c. Knob for manual operation of the switch to three positions labeled AUTO/OFF/ON. AUTO position provides for controlling the light by time switch through flasher and dimmer control unit, OFF position disconnects the power; ON position bypasses the time switch and turns lights on through flasher and dimmer control unit.
    - d. Selector switch furnished as an integral part of the time switch.
  6. Controls: Following controls provided on door:
    - a. Dimmer control: To vary lamp intensity from 50 to 100 percent, with scale marking.
    - b. Flash-mode intensity control: To vary flash-mode intensity from 50 to 100 percent, with scale marking.
    - c. Two-position selector switch marked MANUAL for manual operation of flasher for testing and AUTO for automatic operation of flasher by dc signal.
    - d. Flasher and dimmer control unit ON/OFF switch.
  7. Indicator lights: Following lights provided and identified on door:
    - a. Red light to indicate unit is ENERGIZED.
    - b. Green light to indicate dimmer is ON.
    - c. Amber light to indicate flasher is ON.
  8. Circuit Breaker: Three-pole, 20-ampere, molded-case, having interrupting capacity of 10,000 amperes conforming to NEMA AB1 provided on outgoing feeder.
  9. Nameplate:
    - a. Three-ply, laminated phenolic plate, engraved through black face to white core and attached by means of stainless-steel rivets or screws on each flasher and dimmer control system and its components. Lettering to be vertical gothic using round or square cutter. V-shaped groove not acceptable.
      - 1) Each flasher and dimmer control system labeled with nameplate 1-1/2 inches high inscribed in letters one-inch high: FLASHER AND DIMMER CONTROL SYSTEM.
      - 2) Each major component of flasher and dimmer control system labeled with nameplate one-inch high inscribed in letters 1/2-inch high: FLASHER AND DIMMER CONTROL SYSTEM or TIME SWITCH, as appropriate.
      - 3) In addition to other information normally displayed on equipment, provide one-inch nameplate showing in letters 1/2-inch high switch positions, meaning of indicator lamp and other pertinent information.
    - b. On each flasher and dimmer control unit and on each time switch, provide nameplate with manufacturer's name, brand designation, reference standard, type, class and rating as applicable.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION:**

- A. Install flasher and dimmer control system at locations shown and in accordance with the NEC.
- B. Install conduit, as shown and as necessary, in accordance with Section 16130.
- C. Install and connect wire and cable as shown and as necessary, in accordance with Sections 16120 and 16125.
- D. Connect and adjust time switch so that it turns on flasher and dimmer control unit for seven-day time schedule as directed.
- E. Connect dc control coil in flasher and dimmer control unit to DTS-cabinet terminals for outbound-train signal or inbound-train signal as directed.
- F. Ground enclosure of flasher and dimmer control system in accordance with Section 16060.
- G. Set dimmer control at 50-percent and flasher-mode intensity control at 100-percent intensity of platform-edge lights.
- H. Apply touch-up paint where necessary.

### **3.02 DIRECTORY OF CIRCUITS:**

- A. Furnish each selector and time switch, flasher and dimmer control unit with legible circuit directory located on an accessible spot inside enclosure.

### **3.03 FIELD QUALITY CONTROL:**

- A. Furnish necessary equipment and perform the following tests:
  - 1. Test circuits for connections in accordance with the wiring diagram.
  - 2. Test cable in accordance with the requirements of Section 16120.
  - 3. Test flasher and dimmer control-system enclosure for continuity of the grounding system.
  - 4. Test operation of time switch for Automatic and OFF of ac power to flasher and dimmer control unit, and ON for manual bypass of time switch.
  - 5. Test operation of flasher and dimmer control unit in conjunction with the time switch with flasher controlled by 24-volt dc signal.
- B. Submit certified test reports.

**END OF SECTION**

## SECTION 16601

### AUTOMATED ENERGY MANAGEMENT SYSTEM (RTU & Interfaces)

#### PART 1 - GENERAL

##### 1.01 SUMMARY

- A. This section specifies a complete and operational automated energy management system. AEMS Remote Terminal Units are required at each Chiller plant, Traction Power Substation and passenger station AC switchgear room.
1. RTU's (Type 3) at Chiller Plants monitor the performance, temperatures and pressures and power usage of the chiller system and allows remote control of selected functions.
  2. RTU's (Type 2) at Traction Power Substations monitor the power usage and provide remote reporting and control of electronic relays.
  3. RTU's (Type 1) at Passenger Stations monitor and control selected lighting, fans, air conditioners, emergency generator unit and other HVAC equipment and electronic relays. The RTU also monitors power usage and the performance of escalators and elevators.
- B. Related Sections:
1. Section 16051- Scope of Work For Traction Power
  2. Section 16052- Basic Materials and Methods For Traction Power
  3. Section 16053- Operation and Maintenance Training
  4. Section 16128- Wire and Cable For Traction Power
  5. Section 16321- High Voltage AC Switchgear (13.8kV) For Traction Power.
  6. Section 16322- High Voltage AC Switchgear (34.5kV) For Traction Power.
  7. Section 16341- Metal-Enclosed DC Switchgear For Traction Power
  8. Section 16721 - Communications Telephone System
  9. Section 15900 - Control Equipment
  10. Section 16425 - Motor Starters and Control Centers
  11. Section 14300 - Heavy Duty Escalator
  12. Section 16145 - Wiring and Control Devices
  13. Section 16130 - Raceways, Boxes and Cabinets
  14. Section 16435 -Low Voltage Switchgear and Switchboard
  15. Section 13905 - Fire Protection, Suppression and Alarm
  16. Section 16220 - Emergency Standby Generator System
- C. Operating Requirements
1. Designed for continuous, unattended operation to perform:
    - a. Analog, digital and pulse data acquisition.
    - b. Digital control.
- D. Power Requirements
1. 120 Volts AC from Emergency Panel.

##### 1.02 REFERENCES

- A. Code, Regulations, Reference Standards and Specifications
1. Code and Regulation of jurisdictional authorities
  2. NEC
  3. NEMA 250, ICS-6, WC8, 12
  4. ANSI C37.90, Z55.1, C12

5. EIA: RS 232.C
6. ASTM: B138
7. ASHRAE/ANSI : 135P
8. ICEA: S-68-516

#### **1.04 QUALITY ASSURANCE**

- A. Qualifications:
  1. AEMS equipment manufacturer: Select manufacturer who maintains a full-time organization for installation and service in the Washington DC metropolitan area.
  2. AEMS installer: Have instruments, piping and wiring installed by a qualified installer approved by the AEMS equipment manufacturer.
- B. Coordination:
  1. The Contractor is responsible for the compatibility of the sensor and transmitters with the Authority's Energy Management System Remote Terminal Units (RTU). The RTUs are manufactured by QEI, Inc., model 4151.
  2. Have the AEMS installer and the AEMS equipment manufacturer review and modify existing mechanical and electric equipment designs to provide analog telemetering, operational status, and equipment control for items identified in the Interface Points List Requirements in PART 3 of this section.
  3. Have AEMS installer coordinate with electrical installers and other contractors as to the exact locations and sizes of new AEMS conduits to be buried in concrete in order to be used by Metro's RTU and AEMS wiring systems.
  4. Have AEMS installer coordinate with Related Work listed above.
- C. For Code, Regulations, Reference Standards and Specifications, refer to Article 1.02 above.
- D. The Contractor shall develop test procedures and obtain Engineer approval prior to testing
- E. Contractor shall perform progressive tests in accordance with an approved test procedure to verify compliance with specified system performance requirements, including as a minimum, proper component operation, module input and output signal operation and telemetry between equipment sensors and each RTU.
  1. Contractor's Quality Assurance Engineer shall witness all progressive testing.
  2. All test discrepancies shall be corrected and test reports submitted to the Engineer prior to scheduling end-to-end testing.
  3. Contractor shall notify the Engineer prior to commencing progressive testing and shall offer the Engineer the opportunity to witness the testing. Witnessing of any portion of the progressive testing by the Engineer shall not relieve the contractor from responsibility for any portion of follow-on testing.
- F. End-to-End Test:
  1. The Contractor shall demonstrate the proper functioning of the completed AEMS system including all components and telemetry between each piece of equipment monitored or controlled by the RTU by using a portable computer terminal connected to the RTU in the presence of the Engineer.
  2. The AEMS RTU must communicate with the existing Master Terminal at the Maintenance Operation Center.
  3. Each device monitored by a remote sensor shall be monitored from the RTU and operation of the device observed in the field.
  4. Each device controlled by the AEMS system shall be operated with the control command initiated at the RTU.
  5. Simulation of sensors by shorting contacts is to be avoided unless other activation is not possible.

- G. Submit certified test report within ten days after completion of field tests.

#### **1.04 SUBMITTALS:**

- A. Submit the following for approval in accordance with the General Requirements in accordance with Division 1 and with the additional requirements as specified for each:
  - 1. Shop Drawings: Show the following as a minimum:
    - a. Proposed changes and revised equipment layouts
    - b. Electrical wiring diagrams and detail control schematics.
    - c. Electrical and mechanical details
    - d. Wire and cable schedules, interconnection diagrams, point assignment charts, and connection diagrams
    - e. RTU point count for various facilities in accordance with Table-1.
    - f. RTU data point assignments are listed in Table-2
    - g. Composite control/status and telemetering sensing equipment schedule.
  - 2. Product Data: Submit annotated product data for each item of equipment and resubmittal for mechanical or electrical equipment which changes as a result of required modification.
  - 3. As-Built Documents: Prior Substantial Completion develop an as-built documents as follows:
    - a. As-built drawings of the installation: 11-inch by 17-inch composite interconnection wiring diagram showing the entire energy management interface system. Provide sufficient copies to be stored in each AEMS interface cabinet door pocket.
    - b. Approved copies of each submittal.
  - 4. Operation and maintenance (O & M) manuals:
    - a. Complete printed operating instructions in manual or handbook form, completely and clearly indexed for ready reference during actual operation and for use as text during instruction of personnel.
    - b. Include descriptions of systems, background information and complete procedures for adjustment, calibration, replacement and repair of components in system.
    - c. Make data contained specific for and exclusive to the systems and equipment for the work of this Contract.
    - d. Field test data and reports.
  - 5. Certification:
    - a. Certified test results for the specified tests on the Remote Terminal Unit or provide certified test reports on identical unit.
    - b. Certificates from manufacturers verifying that equipment conforms to the specified requirements

#### **1.05 OPERATION AND MAINTENANCE TRAINING:**

- A. Operation and Maintenance Training is required only if an alternate vender for the RTU is selected. Operation and Maintenance will not be required if the contractor selects the QUICS 4150 RTU by QEI INC.
- B. Instructional Period: Three consecutive man-days minimum.
- C. Instruction:
  - 1. Train personnel in preventative maintenance on systems and to recognize malfunctions.
  - 2. A minimum of one day devoted to hands-on demonstration of the equipment operation, trouble analysis, repair, adjustment and maintenance.

3. Provide copies of the O & M manuals as specified above for each person being trained. Use these manuals in organizing the instruction.

## **PART 2 - PRODUCTS**

### **2.01 GENERAL:**

- A. Provide equipment identified for AEMS with stand-alone controls by the equipment manufacturer.
- B. Auxiliary contacts, modules and data interfaces added to equipment specified in other sections are to be provided by the particular equipment manufacturer or coordinated with the particular equipment manufacturer so as not to void any warranties.

### **2.01 REMOTE TERMINAL UNIT**

- A. Remote Terminal Units (RTU) for Energy Management, QEI INC. Model No. QUICS 4150 or equal.
  1. RTU to be compatible with existing master station manufactured by QEI.
  2. The contractor shall be responsible for all RTU to master station communication protocols.
  3. The RTU manufacturer shall provide a minimum of 1 week of on-site technical support for each RTU supplied.
  4. The contractor shall provide all software and hardware required for testing and configuration of the RTU's
- B. Remote Terminal Unit Controller
  1. Based on a microprocessor system, executing programs stored in non-volatile semiconductor memory.
  2. Incorporate a unique digital address or identifier. The addressing scheme shall allow operation of several RTUs on a common communications line as well as random access to individual RTU.
  3. The message exchange between the Master Station computer and the RTU shall be controlled and supervised by the master station computer. Commands to which the RTU shall respond may include, but not necessarily be limited to, the following:
    - a. Full scan request - Initiates transmission of all measurement and status.
    - b. Selective scan request - Initiates transmission of selected measurement and/or status points.
    - c. Report by exception - Initiates transmission of only those points which have changed since the last transmission. A range of values or deadband, which may be set by the operator, shall determine whether an analog variable shall be transmitted. If the variable has changed by less than the specified deadband since the last reported value, the value shall not be transmitted. If the variable has changed more than the specified amount since the last reported value, the value shall be retransmitted
    - d. Control point select and verify - Command to select a digital control point select.
  4. Transmit information only after receiving the proper address from the master station. Design RTU so that it will not respond to the reply messages of other RTUs. Replies of the RTU shall include, but not necessarily limited to, the following:
    - a. Analog and pulse data value message.
    - b. Digital data value message.
    - c. Check back response - Acknowledgment of control point select.
    - d. End message - End of block of data.

5. Provide watchdog timer capable of detecting malfunction of the microprocessor, power source, and communications with the master station. The watchdog timer shall operate independently of the microprocessor logic and clock. When a failure has been detected, the watchdog timer shall inhibit further output of all control signals by the microprocessor and force all output relays to the de-energized state.
  6. Provide an internal real-time clock to generate an interrupt to the microprocessor at regular intervals. The internal real-time clock shall be periodically synchronized by the master clock at the master station.
- C. Communication Interfaces
1. Provide a serial EIA RS-232C data communication port and a four-wire RJ11 telephone jack for connection to T1 telephone network.
  2. Generate required modem control signals and perform level translation of these and data lines to EIA RS-232C standard signal levels.
  3. Provide suitable protection equipment to protect the RTU from surges induced on the communications, power or instrumentation lines.
  4. Provide a serial communication port for a test/configuration via a portable computer.
- D. Instrumentation and Control Interfaces Input/Output Modules:
1. Include installed input/output modules to accommodate the specified point and spares. Provide signal conditioning and filtering for each point and include in the modules protection sufficient to meet the surge test requirements specified in ANSI C37.90. "Guide for Surge Withstand Capability (SWC) Tests".
  2. Analog Input Modules shall selectively connect analog data points to one or more analog-to-digital (A/D) converters under control of the common logic. The A/D converter shall have sufficient accuracy and conversion rate to satisfy the performance requirements specified previously. Design the analog input modules such that channel crosstalk is eliminated and a common mode rejection ratio of at least 80 dB and a normal mode noise rejection of at least 30 dB at 60 Hz can be achieved.
    - a. Data multiplexing and transducer termination techniques utilized shall not effectively degrade these noise immunity characteristics. Analog input modules shall be capable of accepting the analog output of transducer with a signal output level of 0-1 mA dc.
  3. Digital Input Modules:
    - a. Monitor status and alarm points via digital input modules. Provide each input point with an optical isolator to provide electrical isolation between the input and the RTU logic and with filtering to suppress relay contact bounce noise and electromagnetic interference impulses. Digital input modules shall accept dry contact inputs.
  4. Digital Control Output Modules:
    - a. Provide separate control relays for each digital output point to operate in a select-check-operate mode as specified by ANSI/IEEE C37.1. Outputs shall be latching continuous output contact closure. Receipt of a point selection address shall cause the RTU to return a verification message to the master station. Execute commands only after the dispatcher has verified that the selected point is the desired point and has issued an execute command for the function to be performed. Control relays shall be installed between the output modules and terminal strips. Contacts shall be rated for 10 Amperes at 120 Volts ac resistive load. Relays shall be factory-mounted and wired.
  5. Analog Control Output Modules:
    - a. Provide separate D/A converter for each analog output point to operate in a select-check-operate mode as specified by ANSI/IEEE C37.1. Receipt of a point selection address shall cause the RTU to return a verification message to the master station. Execute commands only after the dispatcher has issued an execute command for the function to be

performed. The analog output signal level shall be 4-20ma DC. The power source providing the output current shall be supplied internally by the RTU.

6. Pulse Input Modules:
    - a. Pulse input modules shall receive pulses in the form of contact open/closure from 3-wire (Form C) pulse initiators. The accumulated count shall not be altered, nor shall counting be interrupted when a count is transferred to the master station. Each counter shall have enough capacity to accumulate the number of pulses expected at the metering point in a 4-hour period without overflow, assuming an average pulse rate of 1 pulse per second. Pulse counter inputs shall be capable of accepting pulse inputs at a rate of 5 pulses per second. The pulse forming voltage, if required, shall be furnished from the RTU circuit.
    - b. The pulse count registers shall not be reset at the end of the interval and shall continue to accumulate and automatically roll over only when they reach maximum count.
  7. Communications Modules:
    - a. Communications modules shall be provided using an industry standard RS-485 (or RS-232) serial bus to remotely read real-time and min/max measured values, interrogate the event log, reset min/max and kW/kVAR hours and program configuration and any relay set points.
    - b. Isolated Multidrop RS-485/232 Converters shall be provided where daisy chained device communication ports are required.
  8. Terminal Strips:
    - a. Provide barrier-type terminal strips within the RTU cabinet for all external connections for instrumentation and control signal. Direct connections to relay terminals will not be allowed.
- E. Escalator LAN Adapter Panel
1. Provide PLC LAN Adapter panel for communication with escalator PLC's
  2. The panel network shall be equipped with RS232, RS485 or other industry standard network ports as required.
  3. Firmware licenses shall be supplied for the RTU to communicate over these ports to the escalator PLC's
  4. The contractor shall be responsible for all communication interfaces and protocols between the escalator PLC's and the AEMS RTU.

## 2.02 SENSORS AND TRANSMITTERS:

- A. General:
1. Power the transmitters by a 24 dc loop power supply located in the AEMS interface cabinet.
    - a. All transmitters shall be powered by 120-volt AC input, 24-volt DC output power supplies located in the AEMS interface cabinets.
    - b. DC power rating shall be capable of supplying the connected load plus 20-percent spare capacity.
- B. Sensors and Transmitters:
1. Room air temperature transmitters shall be an element contained within a cover, suitable for mounting on a wall
    - a. Insulated base temperature range: Minus 20F to plus 120F
    - b. Accuracy of calibrated points: Plus or Minus 0.5F.
    - c. Sensing elements: Platinum wire resistance type.
    - d. Transmitter output signal: 4 to 20 milliamperes DC.
  2. Single point duct temperature sensor transmitter:
    - a. Minus 20F to Plus 120F.

- b. Accuracy of calibrated points: Plus or Minus 1.2F.
  - c. Transmitter output signal: 4 to 20 milliamperes DC.
  - d. Junction box for wiring connections and gasket to prevent air leakage or vibration noise.
3. Pressure transmitters
- a. Range: Minus 15 to 30 psig
  - b. Accuracy at calibrated span: Plus or Minus 0.20 percent
  - c. Transmitter output signal shall be 4 to 20 milliamperes DC.
  - d. Source: Foxboro model IGP20 or equal.
4. Liquid Immersion Temperature Sensor Transmitter:
- a. Stainless steel thermal, sensor and connection head for wiring connections.
  - b. Temperature range: 30F to 70F.
  - c. Accuracy at calibrated span: Plus or minus 0.15 percent.
  - d. Transmitter output signal: Four to 20 milliamperes dc.
  - e. Sensing element: Platinum 100Ω RTD type.
  - f. Source: Foxboro model 893 or equal.
5. Outside air temperature sensors:
- a. sensor element shall have a tamper-proof protective cover
  - b. Range: Minus 20F to Plus 120F
  - c. Accuracy: Plus or Minus 1.3F.
  - d. Transmitter output: 4 to 20 milliamperes DC.
6. Outdoor humidity sensor transmitters:
- a. Sensor element shall have a tamper-proof shielded cover
  - b. Transmitter output signal: 4 to 20 milliamperes DC output.
  - c. Range: 0 to 100% relative humidity (RH)
  - d. Accuracy: Plus or Minus 5 percent
  - e. Junction box for wiring connections and gasket: NEMA 3R rating.
7. Flow Rate Sensors and Transmitter:
- a. Provide with appropriate orifices and venturis to accommodate flow sensors, pressure differentials, transducers, etc.
  - b. Calibrated in gallons per minute (GPM).
  - c. Transmitter output signal: Four to 20 milliamperes dc.

## 2.03 Cabinets

- A. RTU Cabinet:
- 1. Construction: NEMA 12.
  - 2. Accessories: 120 Volt AC GFI type receptacle and 120 Volt AC strip heater.
  - 3. Apply two finish coats, ANSI No. 61, Light Gray, to exterior surface.
  - 4. Paint interior per manufacturer's standard.
  - 5. Fabrication
    - a. Cabinet with fixed side, rear and roof panels, front swing, full hinged door with flush latch operable by screw driver, key, hasp and staple for padlock.
    - b. Provide protective pocket inside front cover with schematic diagram, connection diagram, operating instructions, and layout drawing of control wiring and components within enclosure.
  - 6. Terminal Blocks:
    - a. Power Terminals: Rated 30 Amp, 600 Volt with insulating barriers between poles and washer-head binding screws on each pole to accommodate up to 10 AWG wire.
    - b. Signal and Control Terminals: Rated 10 Amps, 300 volts, modular construction type, screws to accommodate up to 14 AWG wire.
  - 7. Field Wiring Terminals:
    - a. Provide terminal blocks in the RTU to accommodate all field wires including spares.

- b. The terminal blocks shall not be part of any RTU signal or control components.
    - c. The terminal blocks shall be rated 30 AMPS, 600 volts with insulating barriers between poles and washer-head binding screws on each pole to accommodate up to 10 AWG wire.
  - 8. Nameplate:
    - a. Black laminated plastic composition with permanent white engraved lettering, and beveled edges.
    - b. Fastened to panel using small round-head screws.
    - c. Installed inside cubicle and cabinets with cement.
    - d. Submitted for approval.
- B. AEMS Interface Cabinet
  - 1. NEMA 12 stainless steel Hoffman Engineering or equal in accordance with Section 16130 Data Transmission System (DTS) cabinet.
    - a. Terminal Blocks:
    - b. Assembly rail and modular terminals, Weidmuller Terminations Incorporated or equal in accordance with Section 16130 Data Transmission System (DTS) cabinet.
  - 2. Nameplate:
    - a. Black laminated plastic composition with permanent white engraved lettering, and beveled edges.
    - b. Fastened to panel using small round-head screws.
    - c. Installed inside cubicle and cabinets with cement.
    - d. Submitted for approval.

#### **2.04 Marking Tags:**

- A. Dekafix 6.5-FS or equal, consecutive vertical, No. 4682.2 or No. 5766.6 as approved.
- B. Group marking carrier with paper marking strip and transparent cover.
  - 1. Type SCHAT5, Catalog No. 2924.6.
  - 2. Type ES05, Catalog No. 2937.0.
  - 3. SST5, Catalog No. 2940.0.

#### **2.05 Raceways, Boxes and Conduit**

- A. Provide conduit, raceways, boxes and fittings in accordance with Section 16130

#### **2.06 Control Switch:**

- A. For control of chillers, condenser water pumps, chilled water pumps and cooling tower fans:
  - 1. Heavy duty three-position, selector switch with position labeled HAND/OFF/AUTO (HOA).
  - 2. Provide auxiliary contacts on Hand Operated Switches to indicate "HOA Local/Remote" position on Hand Operated Switches provided in accordance with the provisions of other sections.
- B. For control of station ACU fans, AC units, exterior lighting and unit heaters (over 10 KW):
  - 1. Heavy duty three-position selector switch with position labeled HAND/OFF/AUTO (HOA).
  - 2. Provide auxiliary contacts to indicate HOA position.

NOTE: In addition to AEMS interface connections there may also be DTS connection requirements for the same equipment.

## **2.07 Motor Starters and Contactors:**

- A. Provide auxiliary contacts at motor starters and equipment contactors to indicate equipment ON/OFF status. Equipment included are chillers, condenser water pumps, chilled water pumps, cooling tower fans, ACU fans, AC units, exterior lighting and unit heaters.
- B. Provide wiring and interconnection with motor starters and equipment contactors to AEMS interface cabinet.

## **2.08 WIRING:**

- A. Status, Control and Analog:
  - 1. Multicolor cable, No. 14 AWG, UL-listed conductors of 98-percent copper with type XHHW insulation rated 600 volts. Nonmetallic jacket material complying with ICEA S-68-516, NEMA WC8, free of PVC or PVC-based compounds.
  - 2. Jacket: Chlorosulfanated polyethylene, cross-linked polyolefin, or heavy duty neoprene.
  - 3. Use shielded twisted pair cable for analog inputs and outputs.
  - 4. Wiring to escalator PLC's shall conform with PLC manufacturer's requirements with plenum rated jacket free of PVC or PVC based components.

## **2.09 Electronic Power Meter**

- A. ANSI C37.90.1 and ANSI C12.

## **2.10 Spare Parts:**

- A. In accordance with special conditions and the following:
  - 1. Provide 2 spare of each type of circuit card, 2 power supplies, and 2 modems for each type used. Provide touch up paint in 1-quart container.

## **PART 3 - EXECUTION**

### **3.01 SOURCE QUALITY CONTROL**

- A. Design and Production Tests: Perform and submit in accordance with the General Provisions, certified test results for the tests on each unit of Remote Terminal Unit supplied under this contract.

### **3.02 INSTALLATION**

- A. RTUs shall be delivered and installed as shown in accordance with approved shop drawings at the following facilities:
  - 1. Traction Power Substations
  - 2. Passenger Stations
  - 3. Chiller Plants
- B. The Contractor shall terminate all wiring on terminal strips in accordance with approved shop drawings and interconnection diagrams.
- C. Perform work in accordance with the NEC.
- D. Terminate interface points in the AEMS interface cabinet. Wall-mount each AEMS interface cabinet in the room associated with the equipment.

- E. Raceways Boxes and Cabinets:
1. Install conduit, raceways, boxes, fittings in accordance with Section 16130 as necessary to facilitate connections in accordance with Table 2
  2. Install wall mounted AEMS interface cabinets as necessary in the vicinity of equipment other than AC switchgear, chillers or Traction Power equipment located in the same room where the RTU is installed.
    - a. Label the interface cabinet as the AEMS INTERFACE CABINET.
    - b. Install AEMS interface cabinets at locations in accordance with approved shop drawings.
  3. Install raceways, wiring and terminations between the interface boxes and the RTU unit in the AC switchgear room.
  4. Arrange terminations in AEMS interface cabinets in a sequence to facilitate maintenance. Terminations shall comply with the following requirements:
    - a. Terminal strips shall be identified with markings tags as TB-1, TB-2, TB-3, ext. as required from left to right.
    - b. Terminals shall be identified consecutively on the various terminal strips from top to bottom and from left to right.
    - c. Terminations for equipment shall be grouped by equipment identification with control functions located on top and indication functions located on the bottom within the grouping.
    - d. Terminations for various equipment of the same type/classification such as EF-1 and EF-2 shall be terminated on consecutive terminals from top to bottom in ascending equipment number sequence.
    - e. Spare terminals shall be concentrated in one area of the terminal strip to the extent possible.
- F. Wiring:
1. Use shielded twisted pair cable for analog input and control output signals and multi-conductor cable for all other functions.
  2. Install wiring for AEMS interface circuits for all points identified for branch circuits to power supplies located in selected AEMS interface cabinets and for circuits from power supplies to sensors and transmitters in accordance with the following requirements:
    - a. Terminate shield drain wire of two-conductor, shielded twisted-pair instrumentation cable on a terminal strip in the AEMS interface cabinet located directly below the associated two conductors for the cable. Drain wire shall not be grounded at the AEMS interface cabinet. (Drain will be grounded at the RTU)
    - b. Terminate twisted pair instrumentation cables for analog circuits on terminal strips that are separate from terminal strips used to terminate non-analog circuits.
    - c. Install twisted pair instrumentation cables for analog circuits in conduits that are separate from conduits used for non-analog circuits.
- G. Ground RTU, AEMS interface cabinets and power supplies in accordance with Section 16060
- H. Install auxiliary contacts as required for implementation of AEMS interface connections in contactors and starters specified in Section 16145 and Section 16425
- I. Install thermostats and sensors at locations indicated on drawings with top of thermostat 5'-0" above finished floor.
- J. Connections to escalators shall be via a single daisy-chained digital communications link between each escalator's PLC and the AEMS RTU

- K. Wiring terminations between the chiller and the AEMS located in the chiller plant may be made directly to the AEMS without the requirement for an interface cabinet.
- L. Wiring between the RTU in the traction power substation and traction power equipment may be made directly to the RTU without the requirement for an interface cabinet.
- M. Wiring in the AC switchgear room between the switchgear and the RTU may be made directly to the RTU without the requirement for an interface cabinet. Connections to mechanical equipment in the AC switchgear room shall require an interface cabinet.
- N. At locations where there is a combined AC switchgear room / traction power substation in the same room, the requirement for separate RTU's for each shall not be waived.

**3.03 FIELD TESTING:**

- A. The Contractor shall perform polarity and continuity test on all interconnection wiring.
- B. The Contractor shall perform system start-up for each RTU in the presence of the manufacturing representatives. The manufacturing representative shall verify correct operation of each input/output data card using a simulated master control interface test unit. Additional checkout shall be made to verify wiring terminations, modem operation, power supply operation and CPU operation.
- C. The Contractor shall label all wiring terminations to reflect the connection points.
- D. The Contractor is responsible for testing all RTU input signals to verify correct status and telemetry signal levels. A test data sheet shall be developed for each RTU/AEMS Interface Cabinet which list all I/O signal points. The data sheet shall be submitted as part of the Contractors test plan. The Contractor shall submit a list of discrepant I/O signal points to the Engineer. I/O equipment supplied under this contract that is not reporting properly shall be corrected and retested. The Contractor shall submit a discrepancy report for all I/O points indicating problems found and required action.

Table 1

RTU POINT COUNT

RTU Point	<u>RTU Type 1</u>	<u>RTU Type 2</u>	<u>RTU Type 3</u>
Analog input:			
1. 0-1 mA:	16	16	16
2. 4-20 mA:	16	16	32
Status input:	40	24	24
Control input:			
1. Latching:	16	4	8
2. Momentary	16	4	8
Analog output, 4-20 mA:	0	0	8

Pulse accumulator:

8

8

8

**TABLE 2**

--- CHILLER PLANT DATA POINTS ---		
ANALOG POINTS (4 - 20 mA)		
DATA POINT	FUNCTION	TYPE
1	CH-1 Chilled Water Enter Temperature	deg F
2	CH-1 Chilled Water Return	deg F
3	CH-1 Condenser Water Enter Temperature	deg F
4	CH-1 Condenser Water Return Temperature	deg F
5	CH-1 Chilled Water Flow	GPM
6	CH-1 Condenser Refrigerant Pressure	PSI
7	CH-1 Evaporator Refrigerant Pressure	PSI
8	CH-1 Chiller Oil Pressure	PSI
9	Outdoor Temperature	deg F
10	Outdoor Humidity	0-100%
11	CH-1 Chiller KW Demand	KW
12	CH-1 Chiller Voltage	V
13	CH-1 Chiller Oil Temperature	deg F
14	Chiller Plant Space Temp	deg F
15	Condenser Water Flow Diff. Pressure	PSI
STATUS POINTS (Contact Closure)		
1	CH-1 Chiller Motor	on/off
2	P-1 Condenser Water Pump	on/off
3	P-2 Chilled Water Pump	on/off
4	CT-1 Cooling Tower Fan	on/off
5	Refrigerant Purge Air Pump	on/off
6	Refrigerant Purge Air Pressure	Normal/Abnormal
7	CH-1 Condenser Water Flow	Normal/Abnormal
8	CH-1 Chiller Oil Temperature	Normal/Abnormal

9	CH-1 Chiller Lockout	Normal/Abnormal
10	Control Air Pressure	Normal/Abnormal
11	Chiller Space Temperature	Normal/Abnormal
12	Chiller Control Select Switch	Auto/Hand
13	Condenser Water Pump Control Select Switch	Auto/Hand
14	Chilled Water Pump Control Select Switch	Auto/Hand
15	Cooling Tower Fan Control Select Switch	Auto/Hand
CONTROL POINTS (Contact Closure)		
1	CH-1 Chiller Motor	on/off
2	P-1 Condenser Pump	on/off
3	P-2 Chilled Water Pump	on/off
4	CT-1 Cooling Tower Fan	on/off
ANALOG CONTROL POINTS (4 - 20 mA)		
1	Chilled Demand Limiting	0 - 100%
2	CH-1 Chilled Water Temperature	deg F
PULSE ACCUMULATOR POINTS (Contact Closure)		
1	Utility Meter or Power Meter	KWH
--- PASSENGER STATION DATA POINTS ---		
ANALOG DATA POINTS (4 - 20 mA)		
1	ACU-1,2,3 Chilled Water Supply Temperature	deg F
2	ACU-1,2,3 Chilled Water Return Temperature	deg F
3	ACU-1,2,3 Chilled Water Flow	GPM
4	ACU-1,2,3 Supply Air Temperature	deg F
5	ACU-1,2,3 Return Air Temperature	deg F
6	Station Ambient Temperature	deg F

7	ACU-1,2,3 Return Air Humidity	percent
EQUIPMENT STATUS POINTS (Contact Closure)		
1	ACU-1,2,3 Fan	on/off
2	S/FA-1,2 Under Platform Exhaust Fan	on/off
3	DV-1,2 Dome Exhaust Fan	on/off
4	E/FA-2,3,4,5,6,7,8 Tunnel Ventilation Fan	on/off
5	Exterior Lighting	on/off
6	AC Unit (not including ATC or Comm rooms)	on/off
7	UH-1,6,7,8,9,10 Unit Heater (larger than 10KW)	on/off
HOA SWITCH STATUS POINTS (Contact Closure)		
1	ACU-1,2,3 Fan	Auto/Hand
2	Exterior Lighting	Auto/Hand
3	AC Unit (not including ATC or Comm rooms)	Auto/Hand
4	UH-1,6,7,8,9,10 Unit Heater (larger than 10KW)	Auto/Hand
CONTROL POINTS (Contact Closure)		
1	ACU-1,2,3 Fan	on/off
2	Exterior Lighting	on/off
3	AC Unit (not including ATC or Comm rooms)	on/off
4	UH-1,6,7,8,9,10 Unit Heater (larger than 10KW)	on/off
PULSE ACCUMULATOR (Contact Closure)		
1	Utility Meter or Switchgear Power Meter	KWH
ESCALATOR ANALOG POINTS *		
1	Handrail 1 Speed	FPM

2	Handrail 2 Speed	FPM
3	Drive Motor Current	AMPS
4	Brake Stopping Distance	inches
ESCALATOR STATUS POINTS *		
1	AC Overload	Normal/Fault
2	Brake Wear Limit	Normal/Fault
3	Brake Picked	Normal/Fault
4	Broken Step	Normal/Fault
5	Broken Handrail	Normal/Fault
6	Broken Step Chain	Normal/Fault
7	Comb-plate Impact	Normal/Fault
8	Handrail Entry Guard	Normal/Fault
9	Handrail Over/Under Speed	Normal/Fault
10	Main Drive Chain	Normal/Fault
11	Non-Reversal	Normal/Fault
12	Skirt Impact	Normal/Fault
13	Step Level	Normal/Fault
14	Step Upthrust	Normal/Fault
15	Gate Switch	Normal/Fault
16	Missing Step	Normal/Fault
17	Motor Over-Temperature	Normal/Fault
18	24 VDC Power	Normal/Fault
19	Balustrade Stop Switch	Normal/Fault
20	80% Break Wear	Normal/Fault
21	Latched Fault	Normal/Fault
22	Non-Latch Fault	Normal/Fault
23	Fire & Smoke Alarm	Normal/Fault
24	Inspection Mode	Normal/Inspection
25	Pit Stop Switch	Normal/Fault
26	Running Up	Running/Off

27	Running Down	Running/Off
28	PLC Low Battery	Normal/Fault
29	PLC Comm. Active	Normal/Fault
GENERATOR STATUS POINTS		
1	Run Status	On/Off
2	Transfer Switch Status	Normal/Emergency/ Transition
3	Battery Charger	Normal/Abnormal
4	Low Fuel Level	Normal/Abnormal
5	Low Coolant Level	Normal/Abnormal
6	Generator in Auto	Normal/Abnormal
7	Low Engine Temp	Normal/Abnormal
8	Pre-High Coolant Temp	Normal/Abnormal
9	Pre-Low Oil Pressure	Normal/Abnormal
10	Battery Voltage	Normal/Abnormal
11	Leaking Tank	Normal/Abnormal
12	Utility Power	Normal/Abnormal
13	Shutdown Fault	Normal/Abnormal
GENERATOR CONTROL POINTS		
1	Generator Run Test	On/Off
--- TRACTION POWER SUBSTATIONS ---		
STATUS POINTS		
1	Unit Heater	On/Off
2	Unit Heater HOA	Auto/Hand
CONTROL POINTS		
1	Unit Heater	On/Off

ANALOG DATA POINTS		
1	Rectifier 1,2,3,4 Current	AMP
2	Rectifier 1,2 3,4 Wattage	KW
3	DC Bus Voltage	volt
4	Incoming AC Voltage	volt
5	Auxiliary Transformer AC Voltage	volt
PULSE ACCUMULATOR POINTS (Contact Closure)		
1	Utility Meter or Power Meter	KWH

\* RS485 Digital output from Escalator PLC

**END OF SECTION**

## SECTION 16701

### DEFINITIONS OF COMMUNICATION SYSTEM TERMS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. Standard Definitions
  - 1. Definitions pertaining to the communication design and equipment description shall conform to the standard definitions promulgated by the following organizations unless otherwise specified in this Section (16701)
    - a. Current versions of the Association of American Railroads (AAR)
    - b. Electronic Industries Alliance (EIA)
    - c. The Institute of Electrical and Electronics Engineers, Inc. (IEEE)
    - d. The National Fire Prevention Association (NFPA)
    - e. Local and state building and fire procedure codes not superseded by provision of the "Fire Protection Equipment and Life Safety Agreements" executed between WMATA and local jurisdictions.
- B. Order of Priority
  - 1. Where definitions conflict, the order of priority shall be:
    - a. Definitions of Communications Systems Terms (Section 16701)
    - b. Current versions of the Association of American Railroads (AAR);
    - c. EIA;
    - d. IEEE.
    - e. NFPA
- C. Glossary of Communication Terms Used in These Communication Specifications

##### 1.02 RELATED SECTIONS

- 1. All Sections in the 16700 and 16800 Series.

##### 1.03 REFERENCES

- A. Current versions of the Association of American Railroads (AAR)
- B. Electronic Industries Alliance (EIA)
- C. The Institute of Electrical and Electronics Engineers, Inc. (IEEE)
- A. "Fire Protection Equipment and Life Safety Agreements" executed between WMATA and local jurisdictions

##### 1.04 GLOSSARY OF COMMUNICATION TERMS

- A. Words, terms, and phrases used in these Communication System Specifications are defined as follows:
  - 1. AAR:
    - a. Association of American Railroads  
50 F Street, N.W.  
Washington, D.C. 20001-1564
  - 2. Absorption Losses:

- a. (Fiber Optics) Reduction in light amplitude or strength caused by impurities in the optical fiber and by the scattering of light from the optical fiber.
- 3. AC Service Room:
  - a. Room housing equipment and facilities for the distribution of ac power throughout an installation such as a passenger station or shop building.
- 4. Alarm
  - a. An alerting signal indicating an abnormal condition.
- 5. Alphanumeric:
  - a. Alphabetic and numeric representation, letters, numbers, and symbols.
- 6. Amplitude Modulation (AM):
  - a. The process of varying the amplitude of a carrier wave in accordance with the instantaneous value of a modulating signal.
- 7. Ambient:
  - a. Typical of the environment. Specifically used to designate properties of the surroundings which are measurable and distinguishable from absolute zero energy levels.
- 8. Angstrom:
  - a. (Fiber Optics) A unit of optical wavelength historically used in the field of optics, but not an International System unit.
- 9. 1 Angstrom = 0.1 nanometer
- 10. American Standard Code for Information Interchange (ASCII):
  - a. Consists of 10 or 11 bits per character - one start bit, seven information bits, one parity bit, one or two stop bits.
- 11. Ancillary Building:
  - a. A room, area or structure which is not considered typical to all Metrorail passenger stations.
- 12. Annunciator:
  - a. An audible signaling device which usually includes signal lights, each one indicating the conditions that exist or have existed in an associated circuit.
- 13. ANSI:  
1819 L Street, NW  
Suite 600  
Washington, DC 20036
- 14. Armored Cable:
  - a. A cable provided with a wrapping of metal primarily for the purpose of mechanical protection. The armor is sometimes used as an electrical shield.
- 15. ASTM:
  - a. American Society for Testing and Materials  
100 Barr Harbor Drive  
West Conshohocken, Pennsylvania 19428-2959
- 16. At-Grade:
  - a. That portion of the system which is constructed at the approximate elevation of the adjacent ground surface.
- 17. Attenuation:
  - a. A decrease in the amplitude of a signal as it travels along or through a transmission medium, usually expressed as a ratio or in dB.
  - b. (Fiber Optics) A measure of the decrease in energy transmission (loss of light) expressed in dB/km. In optical waveguides it is primarily due to absorption losses and scattering losses.
- 18. Attenuation Distortion:
  - a. Distortion caused by the non-uniform attenuation or gain of a system, with respect to frequency, under specified terminal conditions.
- 19. Audio Frequency:

- a. Frequency range approximately equal to 15 Hz to 20,000 Hz (i.e. frequencies typically audible by human ears).
20. Authority, The:
- a. Washington Metropolitan Area Transit Authority (WMATA).
21. Auto Scan:
- a. The automatic scan of the TV cameras in the horizontal (pan) plane.
22. Automatic Fare Collection (AFC):
- a. Computer controlled system for the collection of fares, control of access, and associated functions.
23. Automatic Frequency Control (AFC):
- a. Means whereby the frequency of a circuit is automatically maintained, within specified limits, with respect to a reference frequency.
24. Avalanche Photodiode (APD):
- a. (Fiber Optics) One type of receiver or detector used in the receiving portion of Fiber-Optics terminals or repeaters. It is called a detector or receiver, since it detects and converts the light signal to a copy of the original electrical signal.
25. Bandwidth:
- a. Limiting frequencies between which the performance of a device or system falls within specified limits.
  - b. (Fiber Optics) The capacity of an optical fiber to transmit information, expressed in bits of information transmitted per specific time period for a specific length of optical waveguide. Bandwidth is limited by pulse spreading or broadening due to dispersion, so that adjacent pulses overlap and cannot be distinguished.
26. Ballast:
- a. Crushed rock or stones placed between, under, and at the ends of railroad ties.
  - b. (Electronics) A device utilized to limit current flow.
27. Battery:
- a. An assembly of cells electrically connected for producing electric energy. In telephone systems, it usually refers to centralized dc source, located in the central office, nominally -48 volts.
28. Baud:
- a. Unit of signaling speed equal to the number of discrete signal events per second.
  - b. Binary Coded Decimal (BCD)
  - c. A notation in which each individual decimal digit is represented by a pattern of "ones" and "zeros."
29. Bit:
- a. A binary digit, 0 or 1 in number representation, with the radix 2.
30. Bus:
- a. A conductor, or group of conductors, that serve as a common connection for two or more circuits.
31. Cable Binder:
- a. A wrapping of tapes or cords around several conductors of a multiconductor cable used to hold them together which may be color coded to designate the group of conductors enclosed.
32. Cable Tray:
- a. A tray or rack used for the installation and support of cable.
  - b. Cable Trough
  - c. A trough used for the installation, support, and protection of cable.
33. Call:

- a. The act of establishing and completing a telephone connection from one telephone instrument to another.
- 34. Called Party
  - a. The telephone instrument at the "distant end" being called.
- 35. Calling Party:
  - a. The telephone instrument that originates the call.
- 36. Cardioid (Pattern):
  - a. A heart-shaped pattern obtained as a response or radiation characteristic of certain directional antennas, or as the response characteristic of certain types of microphones.
- 37. Cassette:
  - a. A small reel-to-reel tape magazine on which is recorded analog or digital information.
- 38. Cassette Recorder:
  - a. A tape recorder used to record or playback cassettes.
- 39. CCS:
  - a. Hundred-Call-Seconds - A measure of communications traffic equal to one hundred seconds of communicating. In practice, "CCS" is used for hundred call seconds per hour.
- 40. Central Office:
  - a. Equipment in a telephone system that provides centralized switching, battery, and supervision for a group of subscribers or terminals (i.e. a Main PABX or Satellite PABX Equipment Room).
- 41. Channel:
  - a. A path for transmitting electrical signals.
- 42. Character:
  - a. A combination of bits denoting a specific alphanumeric symbol.
- 43. Chromatic or Material Dispersion:
  - a. (Fiber Optics) This refers to "colors" or wavelengths in a lightwave source. Light rays with different wavelengths travel along a fiber at different speeds. The broader the range of wavelengths emitted, the more light pulse will spread as it traverses the length of the fiber.
- 44. Circuit:
  - a. A conductor or system of conductors through which an electric current is intended to flow. A network providing one or more closed paths.
- 45. Cladding:
  - a. (Fiber Optics) The low refractive index material which surrounds the core of the fiber and protects against surface contaminant scattering. The cladding may be glass or clear plastic. In interoffice telecommunication systems, glass cladding is used.
- 46. C-Message Weighting:
  - a. Noise weighting used in a noise measuring set to simulate use of the Type 500 telephone (which has characteristics that are typical of most modern telephone instruments in commercial use in this Metropolitan area).
- 47. Combined Distribution Frame (CDF):
  - a. A distribution frame which, in addition to the functions of an MDF, provides for the cross-connection of the PABX subscriber line multiple and the subscriber line circuits.
- 48. Command Message:
  - a. Digital message transmitted from the Mobile Radio System control console to base stations to query status or to direct action.
- 49. Command Message Enable:
  - a. Message used to cause selected base station(s) to be ready for two-way voice operation.
- 50. Command Message Station Connect:

- a. Message used to restore a base station(s) to service in the system in a quiescent mode with its receiver in a monitoring condition with squelch operating.
- 51. Command Message Station Disconnect:
  - a. Message used to intentionally remove a base station(s) from service in the system.
- 52. Commercial Telephone Network:
  - a. The public telephone system. In the WMATA area, usually Bell Atlantic for local public network and special services cable connections.
- 53. Communications Equipment Room:
  - a. Room housing centralized communications equipment for an installation such as a Metrorail passenger station or yard.
- 54. Communications Ground:
- 55. Compandor:
  - a. An earth ground connection of 5 ohms or less resistance that is provided in the Communications Equipment Room in each passenger station and yard for the sole purpose of grounding communications equipment. The Communications Ground in the Communications Equipment Room at Jackson Graham Building has a resistance of 1 ohm or less to earth.
  - b. A combination of a compressor at one point in a communications path for reducing the amplitude range of signals followed by an expander at another point for a complementary increase in the amplitude range. The purpose is to improve the ratio of the signal to the interference entering the path between the compressor and the expander.
- 56. Compartmental Cable:
  - a. A multiconductor cable with its core divided into two compartments, a transmit section and a receive section, which are separated by an insulated metallic divider.
- 57. Conduit:
  - a. A tube-like structure for electrical wires or cables. Conduit may be either rigid or flexible, metallic or non-metallic, as specified.
- 58. Conduit Stub Out:
  - a. A short length of conduit that is joined as a branch to a conduit run and, as used in these Specifications, is the termination of a conduit run.
- 59. Console:
  - a. A panel or cabinet on which are mounted switches or lamps for use by a human operator in monitoring and controlling equipment and functions.
- 60. Contact Rail:
  - a. A bus bar alongside a track that carries electric energy for the propulsion of trains.
- 61. (The) Contractor:
  - a. The person, partnership, corporation, or joint venture that is awarded the prime contract to provide the facilities, equipment, and installations described in these Specifications. The usage of this term in these Specifications also includes subcontractors, suppliers, vendors, and employees thereof, except as otherwise stated (subject at all times to the Contractor's responsibility therefore).
  - b. The person or company who is awarded a contract to provide all the facilities, equipment, and installations described in these Specifications.
- 62. Core:
  - a. (Fiber Optics) The light conducting portion of the optical fiber, defined by the high refractive index region. The core is normally in the center of the optical fiber, bounded by the cladding material.
- 63. Coverage:

- a. Inclusion within the range of a communications device, equipment unit, system or medium.
- 64. Crosstalk:
  - a. Undesired signal coupling between two different communications channels or signal components.
- 65. Data Acquisition and Display System (DADS):
  - a. A system for the collection, recording, consolidation, and display of fare collection data at the passenger stations.
- 66. Enhanced Data Acquisition and Display System (EDADS):
  - a. An upgraded version of the DADS System.
- 67. Data Transmission System (DTS):
  - a. The bi-directional, non-vital digital communications system between Central Control and the Train Control Room. The DTS utilizes a channel of the CTS as a transmission medium.
- 68. Decibel (dB):
  - a. Unit used to express the ratio between two amounts of electrical power, P1 and P2, defined as:

$$\text{dB} = 10 \log_{10} \frac{P_1}{P_2}$$

- b. Also used to express voltage and current ratios, defined as:(Voltages and currents must be measured with identical impedances.)

$$\text{dB} = 20 \text{Log}_{10} \frac{V_1}{V_2} = 20 \text{Log}_{10} \frac{I_1}{I_2}$$

- c. Also used to express intensity of sound; defined as equal to 20 times the common logarithm of the ratio of the sound pressure of a wave to a reference pressure of 0.0002 dyne per square centimeter.
- 69. dBm:
  - a. Measure of absolute electrical power in decibels referred to one milliwatt.
- 70. dBm0:
  - a. A measure of power, with reference to zero dBm, at the reference transmission level point (RTLTP).
- 71. dBmnc0:
  - a. A measure of noise power in dB above one picowatt measured with a C-message weighting network referred to or measured at an RTLTP.
- 72. Delay Distortion:
  - a. Distortion caused by differences in transit time for different frequencies within a specified system bandwidth.
- 73. Desk Telephone:
  - a. A telephone instrument designed for desk top use.
- 74. Detector:
  - a. A device used to sense a particular condition - smoke, temperature, open circuit, received signal, etc.
- 75. Dial:
  - a. Normally, a face plate which has been graduated into arbitrary units. As a special case, in telephony, the hand operated device used to generate pulses or tones for establishing connections over a telephone switching system.

76. Dialing:  
a. The act of operating a dial - specifically, a telephone dial. As used in this document, includes the act of operating a telephone instrument "touchtone" pad.
77. Diode Auctioneering:  
a. A method of obtaining redundancy in use of power supplies by utilizing diode coupling from each power supply to a common load.
78. Direct Burial:  
a. A method of installing cable underground, not in conduit or duct, in such a manner that it cannot be removed without disturbing the soil.
79. Dry Contact:  
a. An electrical contact through which no direct current flows.
80. Duct Bank:  
a. An arrangement of conduit providing more than one duct to accommodate and protect cables between two points.
81. DTMF:  
a. Dual Tone Multifrequency audio signaling scheme utilized as the standard subscriber line tone signaling method in the USA. Also known as Touch-tone dialing, which is a copyrighted Bell Telephone Company term for such signaling. (Utilized for some other remote control devices also.)
82. Duplex:  
a. Type of operation that permits simultaneous communications in both directions.
83. EIA:  
a. Electronic Industries Alliance  
2500 Wilson Boulevard  
Arlington, Virginia 22201
84. E&M Signaling:  
a. A signaling system characterized by the use of separate paths for the signaling and voice signals. The M lead transmits battery or ground to the distant end of the circuit while incoming signals are received as ground or open on the E lead.
85. E&M Trunk:  
a. An audio trunk circuit utilizing E&M signaling.
86. Electro-Mechanical:  
a. An electrical device with moving parts.
87. Elevated:  
a. That portion of the Metrorail System which is constructed above the adjacent ground surface.
88. Emergency Power:  
a. Electrical power provided to operate essential equipment during periods of failure of primary power source.
89. Emergency Trip Station: (ETS):  
a. An enclosure containing an emergency telephone and an electric switch to de-energize a section of the contact rail.
90. ETS Telephone:  
a. An emergency telephone generally located along Metrorail R.O.W. and collocated with or enclosed in Emergency Trip Station boxes in most instances.
91. Engineer (The):  
a. Wherever, on the Contract Drawings or in the Specifications, the term "Engineer" is used, it shall mean the Resident Engineer or other duly authorized representative of the Contracting Officer.
92. Engineering Services:

- a. Engineering Service to be provided, as detailed in Article 3.1, Article 3.20, and as required elsewhere in these Specifications and Contract Drawings.
- 93. Entrance Escalator:
  - a. Escalator from street level to a passenger station.
- 94. Environment:
  - a. The universe within which the system must operate, the elements over which the designer has no control.
- 95. Error Rate:
  - a. The ratio of the number of characters of a message(s) received incorrectly to the total number of characters of the message(s) received.
- 96. Factory Test:
  - a. Test of equipment at the manufacturer's plant.
- 97. Failure:
  - a. An inability to perform an intended function.
- 98. Fare Gates:
  - a. Gate in stations through which passengers pass separating FREE (UNPAID) and PAID areas.
- 99. FCC:
  - a. Federal Communications Commission  
445 12<sup>th</sup> Street, SW  
Washington, D.C. 20554
- 100. Fiber Buffer:
  - a. (Fiber Optics) A material that may be used to protect an optical fiber from physical damage, thus providing mechanical isolation and/or protection.
- 101. Fiber Bundle:
  - a. (Fiber Optics) In a fiber optics cable, a group of parallel optical fibers over which a loose-fitting jacket (fiber buffer) has been extruded. (As used in "loose tube" type fiber optic cables, for example).
- 102. Fiber Optics:
  - a. (Fiber Optics) The branch of optical technology concerned with the transmission of radiant power through fibers made of transparent materials such as glass, fused silica, or plastic.
- 103. Fiber Optics Cable:
  - a. A cable made up of several optical fibers incorporated into an assembly of organic materials arranged for providing the necessary tensile strength, external protection, and handling properties. (Communications cables usually utilize "loose tube" or "open channel" type internal construction.)
- 104. Fire Zone:
  - a. A portion of a building, installation or area designated for fire detection by a specific circuit.
- 105. Flutter:
  - a. Cyclic deviation of signaling power (with a period in the neighborhood of 10 Hz for audio, for example).
- 106. Foot Lambert (fl):
  - a. The amount of light energy reflected from an object or scene equal to the product of illumination in footcandles and the luminous reflectance of the object or scene.
- 107. 4-Wire Terminating Set:
  - a. A hybrid set for interconnecting a four-wire and a two-wire circuit (usually refers to audio frequency devices).
- 108. Free (Unpaid) Area:
  - a. Area of passenger station to which public has access prior to passing through fare gates.
- 109. Frequency Modulation (FM):

- a. The process of varying the instantaneous frequency of a sine wave carrier by an amount proportional to the instantaneous value of a modulating signal.
- 110. Frequency Response:
  - a. The measure of effectiveness with which a circuit or device receives or transmits a range of frequencies.
- 111. Frequency Shift Keying (FSK):
  - a. The form of frequency modulation in which the modulating wave shifts the output frequency between predetermined values, and the output wave has no phase discontinuity (usually accomplished at audio frequencies).
- 112. Fuse:
  - a. An overcurrent protective device with a circuit-opening part that is heated and severed by the passage of overcurrent through it.
- 113. Fuse Alarm:
  - a. A circuit which produces a visual or audible signal to indicate a blown fuse.
- 114. Fusion Splice:
  - a. (Fiber Optics) A splice accomplished by the application of localized heat sufficient to fuse or melt the ends of two lengths of optical fiber, forming a continuous, single fiber.
- 115. Gallery Place:
  - a. A Metrorail passenger station located at the junction of Routes B, E, and F, which is a secondary hub of the WMATA Rail Rapid Transit System.
- 116. Gatehouse:
  - a. A building at the entrance to a Metrorail train yard, from which control of pedestrian and vehicular (other than trains) access to the yard is exercised.
- 117. Graded-Index:
  - a. (Fiber Optics) An optical fiber type wherein the core refractive index decreases almost parabolically radially outward toward the cladding. This type of fiber combines high-bandwidth capacity with moderately high coupling efficiency.
- 118. Ground:
  - a. A conducting connection, whether intentional or accidental, by which an electric circuit or equipment is connected to the earth, or to some conducting body of relatively large extent that serves in place of the earth. A common return to a point of zero potential. (Intentional grounding for WMATA projects providing low resistance current return paths to the earth.)
- 119. Half Duplex:
  - a. A method of operation in which two-way communication is possible, but only one way at a time.
- 120. Handset/Speaker Station:
  - a. A self-contained terminal station of the paging-intercom subsystem of the Yard Public Address System.
- 121. Hardware:
  - a. Physical entities such as computers, equipment, and instruments. Also parts made of metal such as fasteners, straps, clamps, and anchors.
- 122. Harmonic Distortion:
  - a. Non-linear distortion of a system or transducer characterized by the appearance in the output of harmonics, other than the fundamental component, when the input wave is sinusoidal.
- 123. Hertz (Hz):
  - a. Unit of frequency equal to one cycle per second.
- 124. ICEA:

- a. Insulated Cable Engineers Association  
PO Box 440  
South Yarmouth, Massachusetts 02664
- 125. Identifying Digits:
  - a. Alphanumeric digits that identify each passenger station and yard.
- 126. Idle:
  - a. In communications systems, indicates a circuit, device or system is not in active use (i.e. in the quiescent state).
- 127. Idle Noise:
  - a. That noise which is inherent in a circuit or device and is not contingent upon modulation.
- 128. IEEE:
  - a. Institute of Electrical and Electronics Engineers, Inc.  
345 East 74th Street  
New York, N.Y. 10017
- 129. Impedance:
  - a. The opposition in an electrical circuit to the flow of alternating current.
- 130. Impulse Noise:
  - a. Noise characterized by transient disturbances separated in time by quiescent intervals.
- 131. Inbound Track:
  - a. Track that is normally used by trains traveling toward Metro Center passenger station in the A, B, C, D, G, and K routes; and towards the Gallery Place passenger station in the E, F, and L routes.
- 132. Incident Scene Illumination:
  - a. The amount of light expressed in foot-candles which is actually falling on an object.
- 133. Index of Refraction:
  - a. (Fiber Optics) The relative index of refraction is a fraction or ratio of the velocity of light in one medium, compared to the velocity of light in another medium.
- 134. Infrared:
  - a. (Fiber Optics) The region of the electromagnetic spectrum between the long-wavelength of the visible spectrum (about 750nm) and the shortest microwaves (about 1300nm). Infrared is used extensively in the transmission of light through optical waveguides.
- 135. Injection Laser Diode:
  - a. (Fiber Optics) A laser employing a forward-biased semiconductor junction as the active medium. Light is emitted from the diode edge.
- 136. Insertion Loss:
  - a. The loss resulting from the insertion of a transducer or other device in a transmission system.
- 137. Install:
  - a. When used in these Specifications, the verb install shall signify that the Contractor shall furnish, install, and test the equipment and materials specified, unless specifically indicated differently in the text.
- 138. Interface:
  - a. A shared boundary. The interconnection between two pieces of equipment or systems/facilities.
- 139. Interlocking:
  - a. An arrangement of signals and signal appliances interconnected so that their operations must succeed each other in proper sequence, thereby permitting train movements over controlled routes, only if safe conditions exist.
- 140. Intermodulation Noise:

- a. That noise which is contingent upon modulation and results from any non-linear characteristic in the path or device.
141. Interphone:
- a. Equipment used to provide telephone communications between personnel at various locations within a defined space. As used in these Specifications, provides communications between the Station Manager in the Kiosk and the public.
142. Intrusion Zone:
- a. A portion of a building, installation or an area designated for detection of intrusion by a specific circuit.
143. Jacket:
- a. A thermoplastic or thermosetting covering, sometimes fabric reinforced, applied over the insulation, core, metallic sheath or armor of a cable.
144. Jackfield:
- a. An arrangement of telephone jacks, usually grouped on a mounting strip, to provide convenient access to lines and equipment for testing.
145. Joint Electron Device Engineering Council (JEDEC):
- a. Cooperative effort of Electronic Industries Alliance (EIA) and National Electrical Manufacturers Association (NEMA).
146. Key Telephone System (KTS):
- a. Assemblage of telephone relay or electronic equipment which provides switching and control of telephone service within a localized area. KTS equipment is differentiated from PABX equipment primarily by more limited switching functions. Insofar as external telephone trunks are concerned, KTS equipment is generally limited to applications requiring less than 100 subscriber lines and the provision of service that is generally limited to a single building or area of a building.
147. Kiosk:
- a. A booth-like structure within Metrorail passenger stations which contains station monitoring and control facilities and from which an attendant may provide information and assistance to passengers.
148. Laser:
- a. (Fiber Optics) A device that produces optical radiation using population inversion to provide Light Amplification by Stimulated Emission of Radiation and (generally) an optical resonant cavity to provide positive feedback.
149. Light Emitting Diode (LED):
- a. A pn junction semiconductor device that emits incoherent optical radiation when biased in the forward direction.
150. Main Distribution Frame (MDF):
- a. Provides for the termination and cross connection of outside lines entering a building, including electrical protection devices, internal subscriber lines, and terminal equipment.
151. Manhole:
- a. A subsurface chamber or opening in the route of a conduit or duct run that provides facilities for splicing, testing, and maintaining cables and conductors.
152. Manual Pull Box:
- a. Specifically refers to FIRE alarm switch which, when operated manually, initiates a FIRE alarm.
153. MDF/Protector Cabinet:
- a. Specifically refers to a cabinet located in passenger stations and yard buildings containing MDF and cable protection facilities.
154. Major Items:

- a. Major Items are defined as items listed in Estimated Quantities Tables 3.1-X.X.
- 155. Mechanical Splice:
  - a. (Fiber Optics) An optical fiber splice accomplished by fixtures or materials, rather than by thermal fusion. Index matching material may be applied between the two fiber ends.
- 156. Metro Center:
  - a. A Metrorail passenger station located at the junction of routes A, B, C, and D which is the major hub of the WMATA Rail Rapid Transit System.
- 157. Microbar:
  - a. Unit of pressure equal to one dyne per square centimeter.
- 158. Millisecond (ms):
  - a. A unit of time equal to one one-thousandth of a second.
- 159. Mobile Radio Unit:
  - a. A radio transmitter/receiver designed for installation in a vehicle or train.
- 160. Modal Dispersion:
  - a. (Fiber Optics) The component of pulse spreading caused by differential optical path lengths in a multimode fiber.
- 161. Modem:
  - a. A modulator and demodulator housed in a common assembly.
- 162. Multi-Mode Fiber:
  - a. (Fiber Optics) An optical fiber that will allow more than one mode to propagate. May be either a graded index or step index configuration.
- 163. Multiline Telephone:
  - a. A telephone instrument with the capability of being connected to more than one line.
- 164. Multiplexer (MUX):
  - a. A device which combines several inputs into a single output.
- 165. Muting:
  - a. The action of reducing a sound level.
- 166. NEMA:
  - a. National Electrical Manufacturers Association  
1300 North 17<sup>th</sup> Street  
Suite 1847  
Rosslyn, Virginia 22209
- 167. Noise:
  - a. Any undesired, interfering signal contained in a communications channel or circuit.
- 168. Noise Weighting:
  - a. An amplitude-frequency characteristic of a noise measuring set. C-Message weighting is so designed as to give numerical readings which approximate the amount of transmission impairment, due to noise, that an average listener experiences using a specific commonly utilized modern class of telephone subset. "Flat" weighting and other wideband weighting may be utilized to measure noise on data channels. Meters designed to measure ambient noise (environmental) utilize other weighting networks (to obtain readings in dBa, for example).
- 169. Numerical Aperture:
  - a. (Fiber Optics) Measure of light acceptance of an optical fiber.
- 170. OCC:
  - a. Operations Control Center (now in the Jackson Graham Building which was previously designated as the OCC Building - OCCB on some WMATA documentation). The operational center for the WMATA Metrorail and Metrobus systems (includes centralized operations and communications functions). Also known as Central Control and Command Center.

171. OCCS:  
a. Operations Control Center - Security. Usually refers to the consoles in the Security Center for the WMATA system.
172. Off-Hook:  
a. A telephone line condition or the signal indicating that the circuit is in use (i.e., the handset is off its switch-hook).
173. Omni-Directional:  
a. (Antenna) An antenna having essentially non-directional pattern in azimuth but that may have a directional pattern in elevation in many instances.  
b. (Microphone) A microphone, the response of which is essentially independent of the direction of sound input.
174. On-Hook:  
a. A telephone line condition or the signal indicating that the circuit is idle - not in use.
175. On-Site Test:  
a. Test of equipment or system after installation in its operational location.
176. Open:  
a. A break or discontinuity in a circuit which normally passes a current.
177. Optical Fiber:  
a. (Fiber Optics) Any filament or fiber, made of dielectric material, that guides light.
178. Outbound Track:  
a. Track normally used by trains traveling away from Metro Center passenger station in the A, B, C, D, G, and K routes, and away from Gallery Place passenger station in the E, F, and L routes.
179. Override:  
a. A communications trunk feature whereby one call has a greater priority of using a common facility over another call.
180. PABX:  
a. A designation used in the national telephone system to denote a privately owned telephone switching center which operates by the use of dialing (i.e. Private Automatic Branch Exchange). PABXs can be differentiated from KTS systems by their generally more extensive trunk and remote line switching capability, and by the fact that they generally handle 60 or more subscriber lines.
181. PABX Extension:  
a. A telephone instrument connected to a PABX.
182. PAID Area:  
a. Area of passenger station to which the passengers have access after passing through fare gates.
183. Paging-Intercom:  
a. A system which provides for public address type paging and telephone type intercom service.
184. Parity:  
a. Used in digital code formats for self-checking in which the total number of 1s or 0s in an acceptable code is always odd or always even, depending on whether an odd or even parity check is used.
185. Passenger Station:  
a. A location which provides the public access to the WMATA Rail Rapid Transit System (Metrorail System). Provides facilities for payment of fares, train information, entrance and exit of passengers.
186. Phase Modulation (PM):  
a. The process of varying the angle of a carrier from its reference value by an amount proportional to the instantaneous value of a modulating signal.
187. Pin Photodiode:

- a. (Fiber Optics) A diode with a large intrinsic region sandwiched between p-doped and n-doped semiconducting regions. A commonly used detector or receiver in fiber systems.
188. Plug-In Unit:
- a. A communications device so designed that connections to the device may be completed through pins, plugs, jacks, sockets, receptacles or other forms of ready connectors.
189. Portable Radio:
- a. A radio transmitter/receiver designed to be carried by or on a person.
190. Power Distribution Panel:
- a. A facility which provides for the distribution of power circuits and overload protection for those circuits.
191. Power Supply:
- a. A unit for converting power from an ac or dc source into ac or dc power at voltages suitable for supplying power to equipment.
192. Pre-empt:
- a. A communications trunk feature whereby one call takes a common trunk facility away from another call.
193. Primary Cable:
- a. Specifically refers to the normally on-line cable of the dual redundant communications cable facility of the Fiber Optics/Carrier Transmission Systems.
194. Protection Tube:
- a. An expulsion arrestor or glow-discharge cold cathode tube that employs a low-voltage breakdown between two or more electrodes to protect circuits against over-voltage.
195. Pulse Dispersion:
- a. (Fiber Optics) The separation or spreading of the input characteristics of the optical signal that appears along the length of the optical fiber and limits the useful transmission bandwidth of the fiber. Expressed in time and distance as nanoseconds per kilometer. Three basic mechanisms for dispersion are the material effect, the waveguide effect, and the multimode effect.
196. PT&Z Camera(Pan, Tilt, Zoom):
- a. A television camera with facility for remote control of azimuth, elevation, and zoom.
197. Public Address System:
- a. A system which provides transmission, amplification, and reproduction of speech with high communications band fidelity and sufficient power to make sound simultaneously available, and fully intelligible, to large numbers of people.
198. Pulse Code Modulation (PCM):
- a. A modulation process involving the conversion of a wave form from analog to digital by means of coding. Usually a form of pulse modulation in which a code is used to represent quantized values of instantaneous samples of the signal waves.
199. Push-To-Talk (Operation):
- a. Voice communications on a circuit in one direction at a time requiring activation of a switch prior to and during transmission.
200. Quench:
- a. An action whereby an active circuit is stifled or inhibited.
201. Radio Base Station:
- a. A complete assemblage of equipment for radio transmission and reception including antenna(s) and control devices or interfacing equipment accommodating remote control devices.

202. Rail Rapid Transit System:  
a. The portion of the WMATA transportation system that is a third rail electrified system as distinguished from the motor bus operations.
203. Rapid Battery Charger:  
a. Electrical device used for rapidly charging storage batteries.
204. Redundancy :  
a. The existence in a system of more than one means of accomplishing a given function, for the purpose of increasing security or reliability.
205. Reliability :  
a. The probability of performing a specified function, without failure and within design parameters, for the period of time intended under actual operating conditions.
206. Redundant Cable:  
a. Specifically refers to the secondary cable of the dual cable facility of the Fiber Optic/Carrier Transmission Systems.
207. Reference Transmission Level Point (RTLTP):  
a. In a communications system it is an arbitrarily chosen point to which the levels at all other points in the system are referenced. It is frequently the input to the 2-wire side of the 2-wire/4-wire terminating set at the transmitting end of a telephone channel.
208. Remote Building:  
a. An area or structure (frequently containing support equipment, such as: Fan shafts, chiller plants, substations, and tie breaker stations) generally within or along the WMATA right-of-way, but not part of a passenger station or yard. Remote buildings may also include MRS Two-Way Line Drivers, Fire and/or Intrusions alarm detectors, wayside telephones, etc.
209. Relay Contact Types:  
a. FORM-A: SPNO (Single-Pole, Normally Open) Contact  
b. FORM-B: SPNC (Single-Pole, Normally Closed) Contact  
c. FORM-C: SPDT (Single-Pole, Double-Throw) Contact
210. Remote Terminal Unit (RTU):  
a. A modem installed at each ATC field control location (usually at passenger station TCRs) to act as the interface unit between the Data Transmission System (DTS) and the local ATC and support system functions.
211. Response Message:  
a. Digital message transmitted from base station(s) of the Mobile Radio System to the control console with information in reply to a command message initiated at the control console.
212. Revenue Service:  
a. The transportation of passengers who have paid a fare.
213. Revenue System:  
a. The portion of the METRO System on which revenue service is conducted.
214. Right-of-Way (R.O.W.):  
a. The land or structure surface occupied by the Metrorail Transit System, especially for its mainline. Also, the land or structure surface used by another transportation facility such as a railroad or highway.  
b. The right of traffic on a given route to take precedence.
215. Ringdown:  
a. A method of signaling in which ringing current is transmitted over a circuit to operate a device or circuit to produce a steady signal.
216. Ringing:  
a. The audible or visual signal produced by an alternating or pulsating current to signal a telephone station, central office or other terminating equipment.
217. Root Mean Square (rms):

- a. The square root of the mean of the squares of the sum of instantaneous voltages or currents during a complete cycle.
- 218. Rotary Hunting Group (RHG):
  - a. A group of telephone lines which are accessible under a common calling number and are used sequentially as calls are received.
- 219. Scene Highlight Brightness:
  - a. The amount of illumination which is reflected off an object of interest expressed in foot lamberts.
- 220. Seize:
  - a. In communications signaling terminology, to take control of a connecting circuit.
- 221. Sensitivity:
  - a. The degree to which a component, circuit or system is affected by some condition.
- 222. Sensor:
  - a. A device for detection of a condition or change in condition - such as smoke, temperature, humidity, light level, open circuit, closed circuit.
- 223. Service and Inspection (S&I) Yard:
  - a. Yard which provides for the make-up, cleaning, maintenance, inspection, and repair of trains.
- 224. Shield:
  - a. A housing, screen or other object, usually conductive, that substantially reduces the effect of electric or magnetic fields on one side and upon devices or circuits on the other side.
- 225. Shop Building:
  - a. Building within a Metrorail yard or elsewhere which houses repair facilities.
- 226. Short Circuit:
  - a. An abnormal connection of relatively low resistance between two points of different potential in a circuit.
- 227. Simplex:
  - a. A method of operation in which communications takes place in one direction only.
- 228. Singing Point:
  - a. The point at which the gain is just sufficient to make the circuit break into oscillation.
- 229. Single Mode Fiber:
  - a. (Fiber Optics) An optical fiber in which only the lowest order mode can propagate at the wavelength of interest.
- 230. Slotted Coaxial Cable:
  - a. A coaxial cable with slots cut into the outer conductor, thereby permitting radio frequency radiation into and from the cable.
- 231. Software:
  - a. Computer programs and routines; a collection of related utility, assembly, and other programs that are desirable for proper utilization of a device or equipment; detailed procedures, documents, manuals, drawings, and diagrams relating to a device, equipment or system.
- 232. Solid State:
  - a. A device or system whose operation is dependent upon a combination of optical, electrical or magnetic phenomena occurring within a solid. Functions are performed by semiconductors and wholly static components, i.e., resistors, capacitors, etc.
- 233. Span Section:
  - a. A span section is defined in these Specifications as a transmission segment of the Fiber Optic System or Carrier Transmission System that

- extends from the Control Center to and including the passenger station, yard or other intermediate repeater or terminal of the span.
234. Spare:  
a. Equipment, assemblies or components, complete or in parts, on hand for repair or replacement.
235. Speech-Plus:  
a. Method of operation that permits the simultaneous transmission of speech and telegraph signals over a single voice channel.
236. Sound Pressure Level (SPL):  
a. A measure, in dB, of acoustic loudness, usually designated to be the effective rms sound pressure referenced to 0.0002 dyne per square centimeter.
237. Squelch:  
a. An action whereby a signal is completely cut off, unless a predetermined threshold level is attained.
238. Stationing:  
a. A system for establishing reference points along the Rail System. Civil stationing is used in initial design and development of the Rail Right-Of-Way. Train Control Stationing is later established as a permanent reference for operation of the Rail System.
239. Storage and Inspection Yard:  
a. A Metrorail yard which provides for the make up of trains and for the cleaning and minor maintenance of cars. No major repair facilities are provided.
240. Sub-Ballast:  
a. Crushed rock or stone that is placed between the ballast and the sub-grade.
241. Subscriber Loop:  
a. A circuit that is formed by the subscriber's telephone, the cable pairs and other conductors, and the telephone central office, PABX or other terminating equipment.
242. Substation, Traction Power:  
a. Building housing equipment and facilities for providing electrical energy to the trains via the contact rail.
243. Subway:  
a. That portion of the system which is constructed beneath the ground surface (i.e. underground Metrorail facilities).
244. Supervision:  
a. The process of monitoring the condition of a circuit to determine its status.
245. Supervisory Alarm Subsystem (SAS):  
a. A subsystem of the Technical Control Facility which provides for the transmission of alarm information from a remote terminal in passenger stations and yards to the Control Center.
246. Talkback System:  
a. A system of the yard which provides two-way voice communications between the Yard Communications Console and the track areas.
247. Talk Path:  
a. In a telephone or radio system, the circuit or channel which provides for the transmission of voice signals.
248. Terminal Strip (Board):  
a. An insulating base equipped with terminals for connecting wires.
249. Third Rail:  
a. See contact rail.
250. Tie Breaker Station:

- a. Building housing power switching equipment for the purpose of sectionalizing contact rail power.
- 251. Tone Call:
  - a. A system of exchanging calling or alerting signals and acknowledgment signals between mobile radio units and base stations that utilize modulated tones in the voice band.
- 252. Tone Dialing:
  - a. The transfer of digital information from a telephone instrument to a central office or other terminal device utilizing multi-frequency tones. (Typically by standard DTMF tone signaling)
- 253. Tone Generator:
  - a. A device for providing audio frequency currents suitable for signaling purposes.
- 254. Total Harmonic Distortion (THD):
  - a. A measure of the total effect of the various higher order harmonics of a sinusoidal signal.
- 255. Trackbed:
  - a. The area and material directly under the track which provides support to the track. It includes ties, ballast or other supporting material.
- 256. Train Control Contractor:
  - a. The contractor who has been awarded a contract to provide Automatic Train Control System.
- 257. Train Control Room:
  - a. A room located in a passenger station or at some other strategic point to house wayside ATC equipment including a Remote Terminal Unit. A major wayside control point for the ATC system.
- 258. Trunk:
  - a. A one or two-way channel connecting two telephone central offices, or a central office and an individual terminal.
- 259. Vehicular Radio:
  - a. Radio transmitter/receiver and associated equipment designed to be installed in and operated from vehicles.
- 260. Voltage Standing Wave Ratio (VSWR):
  - a. The ratio of the highest to the lowest voltage of a standing wave at a feed through point.
- 261. Wayside Telephone System:
  - a. A subsystem of the WMATA Telephone System.
- 262. Wet Contact:
  - a. An electrical contact through which direct current flows.
- 263. WMATA:
  - a. Washington Metropolitan Area Transit Authority
- 264. Headquarters Building:
  - a. Jackson Graham Building  
600 Fifth Street, N.W.  
Washington, D.C. 20001
- 265. WMATA Configuration:
  - a. The arrangement of hardware or software, wiring, etc. within the equipment, equipment racks, rooms, or systems utilized by WMATA.
- 266. WOW:
  - a. The slow cyclic deviation of audio signaling power with an approximate period of 0.5 Hz.
- 267. Yard:

- a. A system of Metrorail tracks and buildings within defined limits provided for the make-up of trains, storage of cars, and for cleaning, maintenance, inspection, and repair of trains.
268. Yard Control Room:
- a. The room in the yard which contains the yard train control console.

**PART 2 - PRODUCTS**

**NOT USED**

**PART 3 - EXECUTION**

**NOT USED**

**END OF SECTION**

## SECTION 16702

### COMMUNICATIONS ABBREVIATIONS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION

- A. Article 1.03 COMMUNICATION ABBREVIATION LIST, of this Section lists various abbreviations for terms and organizations and prescribes the meanings for the abbreviations as used in the Communication Specifications. For further definition of the terms abbreviated, see Section 16701, Definition of Communication Terms.

##### 1.02 SECTION INCLUDES

- A. Communication Abbreviation List

##### 1.03 RELATED SECTIONS

- A. All Sections in the 16700 and 16800 series.

##### 1.04 COMMUNICATION ABBREVIATION LIST

<u>Abbreviation</u>	<u>Meaning</u>
AAR	Association of American Railroads 50 F St., N.W. Washington D.C. 20001-1564
AASHTO	American Association of State Highway and Transportation Officials
ACD	Automatic Call Distributor
ac	Alternating Current
AFC	Automatic Fare Collection Automatic Frequency Control
AG	Above Ground
AGC	Automatic Gain Control
AHA	American Hardboard Association
AM	Amplitude Modulation
ANSI	American National Standards Institute, Inc. 1819 L Street, NW Suite 600 Washington, DC 20036

amp	Ampere
APAAS	Automatic Public Address Announcement System
APA	American Plywood Association
APL	Average Peak Level
APD	Avalanche Photodiode
AR	As Required
ASCII	American Standard Code for Information Interchange
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASTM	American Society for Testing and Materials 100 Barr Harbor Drive West Conshohocken, Pennsylvania 19428-2959
ATC	Automatic Train Control
AWG	American Wire Gauge
<b><u>B</u></b>	
BCD	Binary Coded Decimal
BER	Bit Error Rate
BG	Below Ground
bps	Bits Per Second
BUS OCC	Metrobus Operation Control Center
BW	Bandwidth
<b><u>C</u></b>	
C	Celsius (Centigrade)
CCITT	International Telegraph and Telephone Consultative Committee
CCS	Hundred Call - Seconds
CTV	Closed Circuit Television (System)
CDF	Combined Distribution Frame
CHP	Chilled Water Plant
cm	Centimeter

CMF	Central Maintenance Facility (building) now FMC
COMM	Communications
CPU	Central Processing Unit
CRT	Cathode Ray Tube
CTS	Carrier Transmission System

### D

DADS	Data Acquisition and Display System
dB	Decibel
dc	Direct Current
DCDPW	District of Columbia, Department of Public Works
DPS	Drainage Pumping Station
DS	Digital Signal
DTMF	Dual Tone Multiple Frequency
DTS	Data Transmission System

### E

ECS	Emergency Communications System
EDADS	Enhanced Data Acquisition and Display System
EE	Emergency Exit
EIA	Electronics Industries Alliance 2500 Wilson Boulevard Arlington, VA 2201
EMS	Emergency Medical Service
EMT	Electrical Metallic Tubing
EPR	Ethylene-Propylene-Rubber
ETS	Emergency Trip Station

### F

F	Fahrenheit
FCC	Federal Communications Commission

FD	Fire Department
FDM	Frequency Division Multiplex
FEP	Fluorinated Ethylene Propylene
FIA	Fire and Intrusion Alarm (System)
Fig	Figure
FM	Frequency Modulation
FMC	Facility Maintenance Center
FMFB	Facilities Maintenance Field Base
FMNT	Facilities Maintenance
FOS	Fiber-Optics System
FRE	Fiberglass Reinforced Epoxy
FREC	Fiberglass Reinforced Epoxy Conduit
FRTS	Fire and Rescue Telephone System
FS	Fan Shaft Federal Specification
FSK	Frequency Shift Keying
ft	Foot, Feet
FVD	Flammable Vapor Detection (System)

### G

GAC	General Architectural Consultant
GCC	General Construction Consultant
GEC	General Engineering Consultant
GMFB	General Maintenance Field Base (building) now FMFB

### H

H	Horizontal
HIB	Halon Interface Box
HVAC	Heating, Ventilation, and Air Conditioning
Hz	Hertz

**I**

IC	Integrated Circuit
ICEA	Insulated Cable Engineers Association PO Box 440 South Yarmouth, Massachusetts 02664
ID	Identification or Identifier
IDF	Intermediate Distribution Frame
IDW	Intrusion Detection and Warning (System)
IEEE	Institute of Electrical and Electronics Engineers, Inc.
ILD	Injection Laser Diode
IMC	Intermediate Metal Conduit
ips	Inches Per Second
IR	Infrared

**J**

JEDEC	Joint Electronic Device Engineering Council
JGB	Jackson Graham Building 600 5th St., N.W. Washington, D.C. 20001

**K**

K	Kelvin
kHz	Kilohertz
km	Kilometer
KTS	Key Telephone System

**L**

LA	Line Applique
LED	Light Emitting Diode
LF	Linear Feet
LOI	Low Oxygen Index

**M**

M&TE	Measuring and Test Equipment
mA	Milliampere
Main PABX	Main PABX (at the JGB)
max	Maximum
MDF	Main Distribution Frame
mF	Microfarad
mFd	Microfarad
MHz	Megahertz
min	Minimum or Minute
mm	Millimeter
MPH	Miles Per Hour
MRS	Mobile Radio System
ms	Millisecond
MTBF	Mean Time Between Failures
MTPD	METRO Transit Police Department
MTTR	Mean Time to Repair
MUX	Multiplexer
mV	Millivolt
mW	Milliwatt
μm	Micrometer
<b><u>N</u></b>	
N	Newton, North
NA	Numerical Aperture
N/A	Not Applicable
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association 1300 North 17 <sup>th</sup> Street Suite 1847 Rosslyn, Virginia 22209

NFPA	National Fire Prevention Association
NIC	Not Included in (this) Contract
NIST	National Institute of Standards and Technology
nm	Nanometer
NRZ	None Return to Zero
NTSC	National Television System Committee

**O**

O&M	Operations and Maintenance
OCC	Operations Control Center
OCCB	Operations Control Center Bus
OCCB	Jackson Graham Building (formerly the Operations Control Center Building or Operations Command Center Building)
OCCS	Operations Control Center Security (Console)
OD	Outside Diameter
OEM	Original Equipment Manufacturer
OTDR	Optical Time Domain Reflectometer

**P**

PA	Public Address (System)
PABX	Private Automatic Branch Exchange
PAM	Pulse Amplitude Modulation
PAS	Public Address System
PC	Printed Circuit
PCM	Pulse Code Modulation
PD	Police Department
PEP	Peak Envelop Power
PERS	Passenger Emergency Reporting System
PERT	Program Evaluation and Review Technique
PIN	Positive-Intrinsic-Negative (refers to solid state structure of device)

PLJ	Primary Local Jurisdiction (Radio System)
PM	Phase Modulation
P/O	Part of
Pr	Pair
psi	Pounds Per Square Inch
p to p	Peak to Peak
PT&Z	Pan, Tilt, and Zoom
PVC	Polyvinylchloride

**Q**

QC	Quality Control
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**R**

RCA	Radio Corporation of America
RCF	Revenue Collection Facility (building)
RCV	Receive
RCVR	Receiver
REA	Rural Electrification Administration
RF	Radio Frequency
RHG	Rotary Hunt Group
RMFB	RAIL Maintenance Field Base
rms	Root Mean Square
ROW	Right-of-Way
RPTR, RPT	Repeater
RTCR	Remote Train Control Room
RTLTP	Reference Transmission Level Point
RTRC	Reinforced Thermosetting Resin Conduit
RTU	Remote Terminal Unit
RZ	Return to Zero

S

S&I	Service and Inspection (Yard)
SAS	Supervisory Alarm Subsystem
SCI	Substantial Completion Inspection
SPABX	Satellite PABX
SEJ	Sewage Ejector
SMADS	Station Monitor and Display System
SP	Sump Pump
SPDT	Single-Pole, Double-Throw Contact
SPL	Sound Pressure Level
SPNO	Single-Pole, Normally Open Contact
SPNC	Single-Pole, Normally Closed Contact
SSHB	Standard Specifications for Highway Bridges

T

TBS	Tie Breaker Station
TC	Train Control
TC/COMM	Train Control/Communications
TCR	Train Control Room
TDM	Time Division Multiplex
TDR	Time Domain Reflectometry
THD	Total Harmonic Distortion
TPSS	Traction Power Substation
TS,TEL	Telephone System
TV	Television
TX	Transmit

U

UHF	Ultra High Frequency
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UL Underwriters Laboratories  
UPS Uninterruptible Power Supply

**V**

V Vertical  
Vac Volts, Alternating Current  
Vdc Volts, Direct Current  
Vpp Volts, Peak to Peak  
VS Vent Shaft  
VSWR Voltage Standing Wave Ratio

**W**

WDM Wavelength Division Multiplex  
WMATA Washington Metropolitan Area Transit Authority (METRO).  
Also referred to as: "the Authority"  
600 Fifth St., N.W.  
Washington, D.C. 20001

**X**

X Transmit  
XLPE Cross-Linked Polyethylene  
XMT Transmit  
XMIT Transmit  
XMTR Transmitter

**PART 2 PRODUCTS  
NOT USED**

**PART 3 EXECUTION  
NOT USED**

**END OF SECTION**

## SECTION 16703

### COMMUNICATIONS STANDARD SPECIFICATIONS - ENGINEERING SERVICES

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION OF ENGINEERING SERVICES

- A. The Contractor is required, under WMATA Communications Systems Specifications, to design, furnish, install, test, and document communications systems that conform to WMATA operational, performance and other requirements outlined therein. Standard Specifications apply where more specific requirements are not included in other (specific systems) specifications.

##### 1.02 SECTION INCLUDES

- A. Standard Specifications for Contractor-furnished engineering services. These Specifications apply to all engineering services and to all equipment furnished unless otherwise specified elsewhere in this Contract (i.e. conflicting Specification requirements found in other Specification sections or on Contract Drawings take precedence over Standard Specifications in this section).

##### 1.03 UNIT PRICES

- A. Unit Prices include all Required Contractor furnished engineering services for the communications systems and facilities and incidental items, not specifically mentioned, but required for complete and proper system operation.

##### 1.04 RELATED SECTIONS

- A. Section 16706 - Communications System Submittals & Services
- B. Section 16710 - Communications Grounding.
- C. Section 16721 - Communications Telephone System.
- D. Section 16723 - Communications Garage Emergency Telephone System.
- E. Section 16727 - Communications Passenger Emergency Reporting System.
- F. Section 16731 - Communications Fire and Intrusion Alarm System.
- G. Section 16733 - Communications Kiosk System.
- H. Section 16771 - Communications Carrier Transmission System.
- I. Section 16776 - Communications Fiber Optics System.
- J. Section 16791 - Communications Mobile Radio System.
- K. Section 16820 - Communications Public Address System.
- L. Section 16821 - Communications Automatic Public Address Announcement System.

- M. Section 16851 - Communications Passenger Station Closed Circuit Television System.
- N. Section 16852 -Communications Parking Garage Closed Circuit Television System

#### **1.05 REFERENCES**

- A. Federal Communications Commission (FCC) (Specifically Parts 15, 90 and other applicable regulations).
- B. National Electrical Code. (NEC).
- C. Underwriters Laboratories.(UL).
- D. American National Standards Institute.(ANSI).
- E. Rural Electrification Administration.(REA).
- F. Insulated Cable Engineers Association.(ICEA)
- G. Electronic Industries Alliance (EIA).
- H. National Electrical Manufacturers Association.(NEMA).
- I. Institute of Electrical and Electronic Engineers , Inc. (IEEE).
- J. Association of American Railroads.(AAR).
- K. WMATA General Provisions and Standards Specifications for Construction Projects.

#### **1.06 SUBMITTALS**

- A. Submit under provisions of Section 16706.

#### **1.07 ENVIRONMENTAL**

- A. The communications system/facility shall be such that, when operating within the specified environmental limits, the maximum temperature attained by any component shall be lower than that which will adversely affect the life or performance of equipment.
- B. Unless otherwise specified, equipment shall be fully operable without damage or functional degradation under any combination of the following:
  - 1. Ambient Temperature -18EC to 55EC.
  - 2. Relative Humidity 0 percent to 95 percent.(This requirement does not apply to equipment installed at the Jackson Graham Building).
- C. Permanently mounted equipment, exclusive of the equipment installed and operated in the Jackson Graham Building, shall be so constructed or installed that it will remain fully operative while being vibrated with simple harmonic motion having an amplitude of 0.005 inch (total excursion of 0.01 inch), with the frequency varied uniformly from 10 cycles to 55 cycles per second for a period of 30 minutes in each of three mutually perpendicular planes.
- D. All moving contacts (including relay contacts, jack contacts, switch contacts) shall be protected from dust.

- E. Equipment panels shall be furnished with dust covers. Proper internal air flow shall be provided when dust covers are in position during operation of the equipment.
- F. Unused mounting spaces in equipment racks, equipment cabinets, Kiosk cabinetry and consoles shall be provided with blank panels which are consistent with the arrangement of the assembly.
- G. The circuitry of Kiosk equipment panels, yard console equipment panels, and other custom-developed equipment shall be completely enclosed to protect against moisture and dust.
- H. Each system, facility, and subsystem element will generally be operated in the unfavorable electrical environment of a Rail Rapid Transit System characterized by heavy direct-current and chopper-controlled pulsating direct-current propulsion equipment, which will cause electrostatic, electromagnetic, and radiated interference. Suitable effective engineering techniques and installation practices shall be incorporated to eliminate the effects of such interference on the performance of the systems, equipment, and devices furnished or installed by the Contractor, and those provided by others for use within or outside of the Metrorail System.
- A. Some sources of interference are: 60 Hz ac system, dc traction power system, propulsion power contact shoe and third rail arcing, rotating machinery, lightning discharges and high energy level, chopper-controlled propulsion systems. The arcing between the transit car contact shoe and the third rail which is supplying up to 780 volts dc is a major source of electrical noise. The noise spectrum includes harmonics which vary in amplitude with the change in loading of the section. Relatively high amplitude noise impulses occur throughout the spectrum.

#### **1.08 INTERCHANGEABILITY**

- A. Standard commercial products shall be furnished whenever such equipment and materials will satisfy the stated Specifications. Suitable modified standard commercial devices shall be furnished when required to satisfy Specification requirements. Custom developed and fabricated equipment units and devices shall be confined to those items for which suitable off-the-shelf commercial products are not available to guarantee compliance with the Specifications. When custom design, fabrication, or assembly is required, every effort shall be made to minimize the number of different modules, solid-state devices, etc. used.
- B. With each system, subsystem and facility, two or more like functions shall be performed by identical units. In no case shall the equipment or hardware used in one portion of a system, subsystem or facility be different from that used in another portion to perform the same function under similar operating and environmental conditions.
- C. Insofar as possible equipment shall be physically and plug compatible with recent versions of existing Authority equipment performing similar functions and used for comparable applications elsewhere in similar WMATA facilities. The use of adapter plugs, interface boxes, and replacement mounting brackets or enclosures that fit available space and mounting holes may be allowed by the Engineer to maintain interchangeability, when competitive products that do not require such devices are determined to be unavailable (applicable to off-the-shelf major equipment items only). Custom designed and custom fabricated equipment must be fully interchangeable without requiring the use of such devices. If a determination is made to allow use of such devices, the Contractor shall provide all necessary adapters and interface devices with each item of equipment furnished, at no additional cost to the Authority.

- D. Major items of equipment furnished by the Contractor shall be within the physical size and configuration limitations specified in provisions of this Contract. If such specifications are not included in the provisions of this Contract, major items of equipment shall be of a physical size and configuration closely comparable to equipment currently in use for comparable applications elsewhere in similar WMATA facilities.
- E. Exception: Lighter weight and smaller sized, more modern versions of equipment are sought by the Authority where their use presents significant advantages. The use of new generations of equipment that differ in size and are not fully interchangeable will be considered for approval by the Engineer, in order to take advantage of significant technological improvements developed by industry.

#### **1.09 MAINTAINABILITY AND RELIABILITY**

- A. The physical and mechanical configurations of equipment and rack assemblies shall give a high priority to the ease with which units may be inspected and removed.
- B. Except as otherwise specified, rack mounted equipment shall be mounted on standard equipment racks or in standard equipment cabinets. Each rack and cabinet configuration shall present a neat and orderly appearance and shall be uniform for like systems/facilities at all Communications Equipment Rooms.
- C. Equipment units or subassemblies shall be easily removable from rack, cabinet, or equipment cases without the need to disturb unit rack/cabinet/case wiring.
- D. Equipment units shall utilize plug-in printed circuit cards or plug-in assemblies whenever the quantity, equipment, size and weight of the components lend themselves to this technique
- E. Printed circuit cards in rack mounting equipment units shall plug into either card files or card drawers, whenever feasible and practical.
- F. Printed circuit cards shall be keyed to prevent incorrect interchange of cards. However, cards performing a given function in a subsystem or subsystem element shall be interchangeable with cards of another subsystem element performing the same function whenever practical.
- G. The replacement of a printed circuit card plug-in subassembly, or component by a new unit shall not require compensating adjustments of devices other than the circuit card or component replaced.
- H. Equipment and installation engineering services and designs shall incorporate accepted industry standards and good engineering practices selected to enhance maintainability and reliability.
- I. Test points shall be provided for printed circuit cards to permit detection of a failure without removal of wiring. Go/No-Go techniques shall be used to localize failures where possible. Card extenders may be used for this purpose.
- J. Test points shall be readily accessible and clearly designated, and shall be capable of accepting probes and connectors furnished with standard test equipment. All testing shall be performed at the front of racks whenever practical.
- K. Appropriate equipment, electrical test points, fuses, and adjustment controls shall be available at the front panel.

- L. Equipment units shall be of ample capacity and of proper arrangement to perform the functions specified, under the conditions specified, and shall operate in accordance with the specified reliability criteria.

**1.10 CUSTOM DEVELOPED AND CONTRACTOR MODIFIED OFF-THE-SHELF EQUIPMENT**

- A. The construction, panel and chassis layouts, circuit arrangements, components, graphics, and component layouts of custom-developed equipment shall be approved by the Engineer. Drawings detailing all aspects of the developed equipment shall be submitted for preliminary review and comment. The submitted drawings shall include details of the required external connections. After incorporating the comments and obtaining acceptance by the Engineer, the Contractor shall fabricate prototypes of the custom-developed equipment (one for each custom-developed item) in accordance with the approved configurations. The prototypes shall be submitted for evaluation, inspection, testing, and acceptance or rejection by the Authority. Production models shall not be manufactured until the acceptance of the corresponding prototype by the Engineer (including incorporating any additional comments). Only production models shall be furnished to fulfill the requirements of these Specifications.
- B. Contractor modified "off-the-shelf" commercial product major items shall be subject to the same review, and all prototype requirements specified above for custom developed equipment, except as otherwise directed by the Engineer. Relief from these requirements will be considered in instances where only minor modifications are proposed.
- C. At the discretion of the Engineer, equipment developed and manufactured specifically to fulfill a WMATA requirement, although considered by the manufacturer as "off-the-shelf," shall be considered as developed equipment and shall comply with the requirements specified herein.

**PART 2 - PRODUCTS**

**NOT USED**

**PART 3 - EXECUTION**

**NOT USED**

**END OF SECTION**

## SECTION 16704

### COMMUNICATIONS STANDARD SPECIFICATIONS - INSTALLATION

#### PART 1 -GENERAL

##### 1.01 SECTION INCLUDES

- A. Standard Specifications for Contractor-furnished installation services. These Specifications apply to all Contractor installation services, unless otherwise specified elsewhere in this Contract (i.e. conflicting Specification requirements found in other Specification sections, or on Contract Drawings take precedence over Standard Specifications in this section). Unless otherwise specified, communications, electronics and electrical installations shall be governed by the provisions of the "National Electrical Code, Standard of the National Board of Fire Underwriters for Electrical Wiring and Apparatus." All provisions of this code must be considered applicable, whether specifically mentioned in the body of these Specifications or not. In no case shall the installation in one portion of the system be different from the installation in other portions for similar configurations under similar operating and environmental conditions, unless specified.

##### 1.02 UNIT PRICES

- A. Unit Prices include all Required Contractor furnished installation services for the communications systems and facilities and incidental items, not specifically mentioned, but required for complete and proper system operation.

##### 1.03 RELATED SECTIONS

- A. Section 16706 - Communications System Submittals & Services
- B. Section 16710 -Communications Grounding.
- C. Section 16721 -Communications Telephone System.
- D. Section 16723 -Communications Garage Emergency Telephone System.
- E. Section 16727 -Communications Passenger Emergency Reporting System.
- F. Section 16731 -Communications Fire and Intrusion Alarm System.
- G. Section 16733 -Communications Kiosk System.
- H. Section 16771 -Communications Carrier Transmission System.
- I. Section 16776 -Communications Fiber Optics System.
- J. Section 16791 -Communications Mobile Radio System.
- K. Section 16820 -Communications Public Address System.
- L. Section 16821 -Communications Automatic Public Address Announcement System.
- M. Section 16851 -Communications Passenger Station Closed Circuit Television System.

- N. Section 16852 -Communications Parking Garage Closed Circuit Television System

#### **1.04 REFERENCES**

- A. Federal Communications Commission (FCC) (Specifically Parts 15, 90 and other applicable regulations).
- B. National Electrical Code. (NEC).
- C. Underwriters Laboratories.(UL).
- D. American National Standards Institute. (ANSI).
- E. Rural Electrification Administration. (REA).
- F. Insulated Cable Engineers Association. (ICEA).
- G. Electronic Industries Alliance (EIA).
- H. National Electrical Manufacturers Association (NEMA)..
- I. Institute of Electrical and Electronic Engineers Association, Inc. (IEEE)..
- J. Association of American Railroads (AAR)..
- K. WMATA General Provisions and Standards Specifications for Construction Projects.

#### **1.05 SUBMITTALS**

- A. Submit under provisions of Section 16706.

#### **1.06 CONDUIT PLANT**

- A. Unless otherwise specified, all wiring in structures and tunnels that is external to equipment enclosures and racks, shall be installed in suitable Intermediate Metal Conduit (IMC), or shall be installed in existing cable tray, underfloor duct, or racked to existing channel inserts on tunnel walls, if space is available and assigned by the Engineer. All conduit and cable installations shall be subject to the approval of the Engineer.
- B. Available embedded conduit will be assigned for use by the Contractor when not reserved for other requirements. Conduit cleaning, the construction of conduit extensions or rearrangements, cable rerouting, and the construction of conduit plant to enclose all remaining wiring shall be furnished by the Contractor. Surface conduit construction shall not be permitted in most public areas of stations or in a few other places. Core boring of structures may be required to obtain means of passage during conduit plant construction.
- C. Inside diameters of conduit shall be determined by the Contractor, based on the NEC, using the appropriate fill factors for the class of service and number and size of conductors. The proposed conduit sizes shall be submitted to the Engineer for approval. Conduits smaller than 0.75 inch shall not be used.
- D. All exposed conduit runs shall be installed parallel to walls, floors and ceilings, whenever possible, except where pitch is required for proper drainage. Conduits shall be rigidly

supported at intervals not to exceed eight feet. Standard one-hole, malleable iron galvanized pipe straps of the proper size shall be used for single conduit runs on concrete surfaces. Where conduits are supported on concrete surfaces, machine-bolt type expansion shields and bolts of the proper size shall be used. All screws, bolts and fittings for conduit supports shall be galvanized or cadmium plated. Stainless steel 304 conduit spacers shall be used for conduits running on flat surfaces. Standard conduit elbows or field bends are permitted; they shall not be less than the minimum radius, as required by the NEC, .

- E. Conduits shall be connected to equipment metal enclosures using two locknuts and a bushing, except where conduit hubs are provided. Where enclosures, fittings with openings, or boxes of any type are installed in locations determined by the Authority to be subject to moisture, watertight conduit fittings shall be used. Watertight covers with seals shall be provided, and approved sealant applied to openings to effectively prevent the entry of moisture.
- F. All conduit entering Communications Equipment Rooms of passenger stations and yards shall be covered and sealed. Watertight conduit and cable seals shall be used where the building or structure penetration is at a lower elevation than the manhole or below the water table. Details are furnished in the Information Drawings.
- G. All terminal ends of conduits shall be provided with insulated metallic bushings.
- H. Whenever a conduit or exposed cable enters or leaves a box, it shall be permanently tagged, external to the box, with a plastic tag approved by the Engineer. The tags shall be permanently stenciled with a number which shall identify the conduit or cable with an assigned circuit.
- I. All conduits installed shall be free of burrs and other sharp edges throughout the entire length. Conduit fittings or boxes shall be installed in conduit runs, where required, to limit the number of bends to a maximum of three 90-degree bends or equal. All conduits used shall be thoroughly cleared by pulling through a mandrel tool, and shall be blown clean by forcing compressed air through the run before wires or cables are pulled.

#### **1.07 CUTTING AND PATCHING**

- A. All necessary cutting and patching of existing construction shall be provided by the Contractor for the installation of the equipment and cables.
- B. All cuttings shall be of the appropriate required sizes and shapes for the materials, cables and equipment to be installed. All cuttings shall be performed using the appropriate type of tools and equipment for the corresponding surfaces and material. The locations, sizes, shapes, and methods of performance for all cuttings shall be subject to approval by the Authority.
- C. All patching shall match existing adjacent construction to the satisfaction of the Authority, using the best possible workmanship of the various trades involved. All required material, compounds, sealants and hardware for all patching shall be provided. Fire wall integrity shall be maintained in appropriate construction.
- D. Services shall be provided by the Contractor for the removal and reinstallation of all necessary existing items (i.e., platform tiles, manhole covers) to accomplish the installations. Replacement shall be provided for any removed items that are damaged or missing during the performance of work, at no additional cost to the Authority. Replacements shall be identical in manufacture and type to the damaged or missing items.

- E. All existing items and construction (i.e., platform tiles, plenums, ceilings, floors, lighting fixtures, junction boxes, structures, and finishes) that are damaged, changed, or modified in the performance of work shall be restored to their original condition and/or surfaces. Appropriate required material, hardware, paints, finishes, and compounds shall be provided. Any items that are damaged, which are determined to be unrepairable, are to be replaced at no additional cost to the Authority. Replacements shall be identical in manufacture and type to the damaged items.

#### **1.08 JUNCTION BOXES**

- A. Junction boxes shall be furnished and installed for terminating cable runs and for pulling of cables. Boxes provided in conduit runs, to minimize the number of 90-degree bends in a run, shall be considered junction boxes, although used only for the pulling of cable.
- B. All boxes shall be mounted plumb and level and shall be rigidly anchored to the supporting surface. Machine bolt type expansion anchors shall be used to fasten boxes to concrete surfaces where inserts are not otherwise provided. In no case shall bolts of less than 0.25-inch diameter be used. Stainless steel spacers shall be used on bolts to provide a 0.25-inch air space between boxes and mounting surfaces.
- C. All boxes shall have a number stenciled on the cover. Numbers shall identify the service of the circuits in the box, as approved by the Engineer.

#### **1.09 CABLE TRAYS**

- A. Unless otherwise specified, cable tray construction shall be allowed only in Communications Equipment Rooms and other equipment rooms assigned for the installation of significant quantities of communications-related equipment. Tray supports shall be located on eight-foot centers, maximum, and shall be subject to the approval of the Engineer. Sufficient supports shall be provided to keep the loaded cable tray deflection to 0.25 inch maximum at mid-span. Tray supports and trays shall be mounted plumb and level.
- B. Tray supports, angle iron, or prefabricated channels shall be anchored to ceilings or walls by machine-bolt type expansion anchors and 0.5-inch minimum diameter bolts. Where cable tray fittings occur in a run, trays shall be supported immediately adjacent to, and on both sides of, the fittings.
- C. Trays shall be bolted to support members. Precautions shall be taken to prevent anchoring bolts from damaging cables placed in the trays.
- D. Cable tray fill shall not exceed 75 percent of the cross-sectional area of the tray, assuming an area of each cable to be equal to the square of the cable diameter.

#### **1.10 EQUIPMENT MOUNTING**

- A. Unless otherwise specified, equipment shall be anchored to the concrete walls, floors, or ceilings by machine-bolt type expansion shields and 0.5-inch minimum diameter bolts. The number of bolts shall be adequate to provide a rigid and safe support. Where required, concrete bases or pedestals shall be provided by the Contractor with anchor bolts cast in place for the mounting of equipment. All equipment shall be mounted plumb and level.

#### **1.11 PAINTING**

- A. All painted areas damaged in route to, or at the installation site, shall be repainted with matching colors by the Contractor. The surfaces of equipment and material not accessible after mounting shall be painted prior to installation.

#### **1.12 WIRE AND CABLE**

- A. Powdered soapstone or other suitable lubricating medium non-injurious to insulation shall be used, if required, when pulling wires or cables in conduits or ducts.
- B. Each conduit, duct and pipe shall be cleaned before installing cables therein. The conduits, ducts and pipes shall be maintained in a clean and dry condition during the installation process up to and including the time which each conduit, duct, and pipe is sealed
- C. Wires shall not cross one another when they are pulled into a conduit nor shall the conductors be pulled tight or kinked in conduit fittings or boxes.
- D. Cables shall be laid, not pulled, into trays or in troughs provided by others. Cables shall be installed with a minimum amount of crossover in the trays and troughs and shall not be placed tightly around bends. Where cables enter or leave trays via conduits, such conduits shall be rigidly affixed and supported at their ends by suitable brackets and conduit straps from the sides of the trays.
- E. Wires and cables shall be permanently tagged with plastic tags at each entry to and exit from all equipment terminal blocks. Tags shall be permanently marked to identify the system in which the wire or cable is used. Tags and markings shall be subject to the approval of the Engineer.
- F. All cable pairs, including spares, shall be terminated on connectors, protectors, or line terminating blocks on the MDF.
- G. Solder with a minimum of 60 percent tin and 40 percent lead with non-corrosive flux shall be used in soldering wires and cables.
- H. The Contractor shall seal all openings through which cable, conduit and cable trays pass. The material used to seal the openings shall be furnished and installed by the Contractor. It shall be a fire retardant, non-toxic material and shall comply with the local fire prevention code.
- I. All exposed wires and cables entering or leaving equipment housing or junction boxes shall be protected from abrasion by sharp metallic edges. Chase nipples shall be provided in openings having conduit hubs. Chase nipples and locknuts shall be provided in drilled or punched openings.
- J. The Contractor shall seal all openings in equipment enclosures and junction boxes where exposed cables enter the enclosure or box. A pliable sealing compound made expressly for the purpose shall be furnished and installed after the cables are in place.
- K. Nylon straps shall be furnished and installed for bundling and cabling of conductors where two or more single conductors of the same circuit are run exposed in cable trays or in cable troughs. Straps shall be installed approximately every five (5) feet along the cable run. Wires of multi-conductor cables exposed by the stripping of the cable jacket for termination shall be trimmed in a neat, workmanlike manner and tied approximately every three inches with nylon straps. Care shall be taken in terminating or splicing cable. Removal of insulation shall be done in a manner which does not nick the conductor material. In no case shall the conductor be kinked or bent at sharp angles. Smooth bends shall be utilized.

- L. Appropriate exposed cables entering or leaving equipment enclosures and junction boxes shall be protected from abrasion by sharp metallic edges. Chase nipples shall be provided in openings having conduit hubs. Chase nipples and locknuts shall be provided in drilled or punched openings.
- M. All cables and wires installed in environmental air plenums, cable vaults, and under passenger station platforms shall be placed in appropriately sized electrical metallic tubing (EMT) unless otherwise specified.
- N. Appropriate channel inserts, arms and insulators shall be provided to support cables in the manholes of the duct bank.
- O. Dewatering and removal of all dirt and trash from trenches, manholes, pull chambers, cable troughs, surface trenches, conduit and duct banks shall be provided prior to, and maintained during, the installation of cables.
- P. Cables shall be permanently tagged with plastic tags at each entry to and exit from all junction boxes, cable trays, cable ladders, equipment enclosures, conduits, ducts and pipe. Appropriate identification shall be permanently marked on each tag. These plastic tags shall be provided in two forms: Sleeve and flat. The sleeve form shall be of the heat shrinkable type and shall be properly sized to fit the cable for which it is intended. The sleeve form type may be used on cables with an outer diameter of 1/2 inch or less. The flat form type shall be made of flat sheet stock with slots for installation with nylon tie-wrap fasteners. The markings on the tags shall be provided in a color that will contrast sharply with the color of the associated tags. The plastic tags shall be properly installed.
- Q. Low-smoke, low-toxicity (not PVC) plenum rated wire and cable shall be utilized throughout installations of equipment in the Jackson Graham Building Communications Equipment Room (i.e., for cables extending outside of equipment enclosures, for inside plant cables extending to other rooms and floors, but not for outside plant cables extending to areas outside of the building), unless otherwise specified. Exceptions may be allowed by the Engineer when such plenum rated cable is not commercially obtainable only from equipment manufacturers, and when appropriate to avoid potential electrical signal mismatching, or to otherwise improve system performance or reliability.

### **1.13 DIRECT FIXATION IN TUNNEL AREAS**

- A. Unless otherwise directed, cables shall be installed along the tunnel walls in an organized fashion within the area allotted for communications cables. Cable crosses shall be kept to a minimum.
- B. Channel inserts have been provided by others, mounted on approximately four-foot centers, in the tunnel walls. Stainless steel type fasteners or mounting devices shall be provided to secure the cables to the channel inserts. Cables shall be individually mounted to the channel inserts. Cable shall be secured to each channel insert. The fasteners or mounting devices shall be properly sized to the cable, or shall be adjustable to the proper size to support the cable without undue compression. Prior to cable installation, the channel inserts shall be cleaned and foreign material shall be removed, where necessary.
- C. Unless otherwise specified, cables shall be installed on the channel inserts in the space allocated for communications cables.
- D. In those areas where the specified locations for cables within the tunnels do not coincide with the channel inserts provided by others, or when channel inserts are not available for communications cables, and as necessary to secure MRS antennas, and other cables,

appropriate type cable ladder with hardware, cement anchors, fasteners, and mounting devices, shall be provided to secure cables to the tunnel structure. Appropriate type cement anchors, fasteners, and mounting devices, shall also be provided to secure cables to the tunnel structure when routed to equipment, equipment housings, junction boxes, terminals, and conduits.

- E. Sufficient slack shall be provided in the cables between fasteners and mounting devices to allow for expansion and contraction of the cables without damage to the cables or the fasteners and mounting devices.
- F. The Authority is installing Tunnel Ventilation Barriers in the tunnels between passenger stations in the vicinity of some fan shafts. The Contractor shall install communications cables running along the tunnel walls through the cable openings that are provided in the Tunnel Ventilation Barrier structures. Openings are either provided on the side near the cable runs or at the top near the ceiling area of the tunnel.

#### **1.14 CABLE TROUGHS ALONG THE TRACK RIGHTS-OF-WAY**

- A. Cable troughs along the track rights-of-way are utilized for the installation of Communications cables, Automatic Train Control cables and Traction Power Substation (TPSS) control cables.
- B. A vertical metal divider has been installed throughout most of the length of the track right-of-way cable troughs to separate the TPSS control cables from the Automatic Train Control and Communications cables. In some locations, the metal divider has been omitted in favor of a small TPSS-control-cable trough mounted within the regular cable troughs.
- C. The following conditions and potential problems with the track rights-of-way cable troughs are noted:
  - 1. The covers for the cable troughs may not be of uniform length of drilling, i.e., each cover section should be regarded as unique to that particular section of trough.
  - 2. The pressure of ballast on the outside of all metallic constructed cable troughs may cause the outer side to deflect somewhat when the top covers are removed, a condition which may interfere with reinstallation of the trough covers.
  - 3. The covers are not watertight.
- D. The following required installation services shall be provided by the Contractor when installing cables in the track rights-of-way cable troughs:
  - 1. Removal of snow, ice, dirt and debris from the metal trough covers to obtain access.
  - 2. Removal of all the metal trough covers.
  - 3. Removal of fluids, snow, ice, dirt and debris from the troughs.
  - 4. Protection of all cables already installed in the cable troughs.
  - 5. Provision for access to conduits entering the cable troughs (possibility of shifting already installed cables).
  - 6. Proper reinstallation of the trough covers when cable installation is completed.

#### **1.15 FIBER-OPTIC COMMUNICATION CABLE**

- A. Splicing of single mode fiber-optic communications cable is authorized only at designated cable terminal locations and in Communications Equipment Rooms (splicing trays or enclosures) at passenger stations and transit yards, and in other approved locations, only when essential to join the ends of one or more standard or larger sized full reels of cable together with one partial reel of cable. Only low loss (0.20 dB or less) fusion type splicing and splicing to factory installed pigtailed connectors will be authorized. Approval of the

exact location and methods utilized to make and protect each splice shall be obtained from the Engineer prior to commencing field work.

#### **1.16 COPPER INSIDE PLANT CABLE**

- A. Splicing is not authorized in cables within the passenger station limits, or within ancillary structures, garages, parking lots, and transit yard S&I Shop and Operations Buildings.

#### **1.17 COAXIAL, TRIAXIAL AND SPECIAL PURPOSE CABLE**

- A. Splicing is not authorized in coaxial and triaxial cables, or in cable or cable harnesses designated by equipment manufacturers or the Engineer as "special purpose cable." Properly installed and protected connectors shall be used in lieu of splicing.

#### **1.18 COPPER OUTSIDE PLANT CABLE**

- A. Outside plant cables extending beyond passenger station limits shall be free of splices, unless approval for splicing is obtained from the Engineer. Approval may be granted for splice(s) in cable runs or CTS cable spans, only if the following conditions exist:
- B. No more than one splice in each individual cable run (or individual CTS cable span) shall be authorized except where deemed necessary to join two or more standard sized full reels plus one partial reel of cable together to make up the required length for an individual cable run (or individual CTS cable span) which extends between two cable end terminations.
- C. Exception:
  - 1. Splicing of multi-pair copper CTS cables shall not be allowed within 400 feet of either end of the span.

#### **1.19 SPLICE CASE TYPES**

- A. Highly durable, watertight splice cases shall be furnished and installed in accordance with the manufacturer's instructions, when splicing is authorized. Filled splice cases shall be utilized when splicing filled cable (REA PE-39 telephone and CTS cable, for example).

#### **1.20 SPLICE CASE (AND FIBER-OPTIC CONNECTOR) TECHNICAL SPECIFICATIONS**

- A. Splice case (and fiber-optic connector) technical specifications and samples must be submitted to the Engineer for review and approval prior to installation.

#### **1.21 SPLICE CASE PHYSICAL PROTECTION**

- A. Splice cases must be protected from physical damage and must be accessible (i.e. in manholes, hand-holes, cable troughs, terminal or junction boxes, or other protected locations readily accessible for maintenance purposes.) Splices shall not be placed in conduit.

#### **1.22 MAINTENANCE OF FIBER-OPTIC AND COPPER CONDUCTOR IDENTIFICATION**

- A. When multi-conductor copper or fiber-optic cables are spliced, the same color code, number and group identification shall be maintained throughout the entire cable run. Conductors and individual fibers shall be clearly identified at both end terminals (or cable ends - if not terminated).

### **1.23 SIGNAL ATTENUATION, CONTINUITY, CROSSTALK AND GROUNDING**

- A. Splicing shall be accomplished in such a manner that optical or electrical signal attenuation, discontinuities, or cross-talk, do not appreciably increase as a result of such splicing. Cable shields, armor, and all other metallic elements shall be bonded across splices with copper straps and clamps or other approved hardware, to maintain electrical continuity with less than 0.2 ohm increase in resistance. Grounding for electrical protection shall be accomplished as specified or as approved by the Engineer (or, if not specified or detailed in the Engineer's approval, in accordance with applicable NEC provisions).

### **1.24 AS-BUILT RECORD DRAWING REQUIREMENTS**

- A. The Contractor shall clearly indicate the location, size, and type of all splices and terminals on As-Built Record Drawings.

### **1.25 EQUIPMENT ENCLOSURES AND JUNCTION BOXES**

- A. All equipment enclosures and junction boxes shall be mounted plumb and level, and shall be rigidly anchored to the supporting surface. Appropriate type expansion anchors and bolts shall be used to fasten the enclosures and boxes to support surfaces. An adequate number of bolts of the proper diameter with lock washers shall be used, but in no case shall bolts of less than 0.25 inch diameter be used. Stainless steel 304 spacers shall be used on bolts to provide a 0.25-inch air space between all enclosures/boxes and mounting surfaces.
- B. Where equipment enclosures and junction boxes are to be mounted on walls of material other than concrete, the method of mounting and the hardware to be used shall be approved by the Authority.
- C. All junction boxes and equipment enclosures shall have a unique identification stenciled on one exposed accessible surface and on the exterior of the cover. The painted stencil markings shall be applied with a procedure that produces clear, legible letters/numbers without voids and without paint running between the stencil and the surface being marked. The marking paint shall provide a definite contrast with the surface on which it is applied.

### **1.26 BURIED CABLES**

- A. When direct burial of cable is specified, the following shall apply:
  - 1. Only cable and wire specified by the manufacturer to be for direct burial shall be buried.
  - 2. Cable shall be buried not less than 42 inches below grade and shall be below the frost line. The cable trench shall have a minimum width of 12 inches or three times the cable diameter, whichever is greater. The trench floor shall be free of rock, roots and debris, and shall provide a smooth bed for the cable. A minimum of four inches of sand shall be placed on the trench floor. The cable shall be placed in the trench, on the top of the sand, with slack and without kinks or bends. The cable shall be covered with four inches of sand before backfilling. If the trench spoil is used for backfill, it shall be free of rock, stone and debris. The backfill shall be compacted and leveled at specified grade. At no time shall a communications cable or wire be buried within 12 inches of a power conductor.
  - 3. The Contractor shall provide all shoring required. The Contractor shall mark the cable trench for future location and identification.

4. No digging below the ties within the trackbed shall be permitted. The trackbed is defined as the area along the track extending one foot beyond the end of each track tie.
5. When it is necessary to drive conduit under the trackbed, Authority approval shall be obtained for each case prior to commencement of work. The request for approval shall include details on the type of conduit, depth below surface and method.
6. All wires and cables shall be tested after installation as detailed in Table 3.22-1 and other applicable specification provisions. Installation Completion Tests shall verify that cable shields and armor are bonded across each splice or junction box authorized (if any), and that twisted pairs maintain their identity and continuity end-to-end without crosses, shorts, opens, transpositions or splits. Insulation resistance tests shall be made either with an insulation resistance test set or a dc megohm meter utilizing a test voltage of 250 Vdc or greater, and shall be made in the presence of the Engineer's representative.

#### **1.27 SPECIAL REQUIREMENTS FOR STAINLESS STEEL CORROSION RESISTANT HARDWARE**

- A. Except as otherwise specified, equipment enclosures, cabinets, boxes and hardware of all types in tunnels, tunnel crossovers, along the surface rights-of-way, and in all ancillary structures that are open to tunnels (vent shafts, fan shafts, pumping stations, etc. - excluding rooms within these areas that are heated/air conditioned) shall consist of stainless steel 304 material. Also, except as otherwise specified, equipment enclosures, cabinets, boxes and hardware of all types; in platform plenums (and including track side walls and under-platform slab and extensions into service rooms); along station train room safety walks, in stairways, corridors, and plenums that are not heated/air conditioned; and in all shafts to the surface and dome reliefs, escalator well ways, elevator pits and surface elevator shafts, shall consist of stainless steel 304 material.
- B. Exception: Galvanized conduit may be used with stainless steel 304 mounting hardware. Electronic equipment connectors, and other relatively small sized specialty items that are not available in Stainless Steel 304 material may be allowed by the Engineer as exceptions (Ref. Article 3.1 Request for Approval Of Minor Technical Specification Deviation).
- C. Unless otherwise specified, stainless steel equipment enclosures, cabinets, and boxes with dull gray colored epoxy paint applied shall be utilized in areas where surface glare may be visible to rail car operators, to avoid glare.
- D. Definitions: "Hardware" includes bolts, screws, clamping devices, anchoring devices, threaded rods, nuts, washers, hangers, covers/wall plates etc. "Boxes" includes junction boxes, outlet boxes, disconnect switch boxes, circuit breaker boxes, and terminal boxes, etc. "Cabinets" includes terminal cabinets, equipment cabinets, MDF cabinets, and power distribution panelboards. (Note: Definitions include, but are not limited to, the items listed herein.)

TABLE 3.22-1

INSTALLED CABLE AND WIRE CONTINUITY  
INSTALLATION RESISTANCE AND MISCELLANEOUS TEST REQUIREMENTS

<u>Application</u>	<u>Type(s)/ Characteristics</u>	<u>Continuity</u> Conductor loop resistance, each pair: Shield resistance, each: Armor resistance, each: <u>Insulation Resistance</u> Conductor to Conductor (all): Conductor (all) to core separator and shield: Shield to armor: Armor to ground:	<u>Required Minimum Reading</u> <u>Calculated Value</u> <u>+7%</u> <u>+15%</u> <u>+20%</u> <u>Megohms</u> 500 500 500 50 100 <u>Calculated Value</u> <u>+10%</u> <u>+20%</u> <u>Calculated Value</u> <u>+10%</u> <u>+20%</u> <u>Megohms</u> 100 30 <u>Calculated Value</u> <u>+10%</u> <u>Megohms</u> 10 10
(Tunnel, wall shaft, duct bank and direct burial outside plant applications - terminal-to-terminal, including extensions through en-trance conduits and to inside terminal(s)).	With Compartmentalized Core	Shield resistance, each: Armor to ground: <u>Continuity</u>	<u>Calculated Value</u> <u>+10%</u> <u>+20%</u> <u>Megohms</u> 100
	Without Compartmentalized Core	Conductor loop resistance, each pair: Shield resistance, each: <u>Continuity</u> Conductor resistance, each: Shield resistance, each: <u>Insulation Resistance</u> Conductor to shield: Shield to shield(s) - if applicable: Outer shield to ground:	<u>Calculated Value</u> <u>+10%</u> <u>+20%</u> <u>Megohms</u> 100 30 <u>Calculated Value</u> <u>+10%</u> <u>Megohms</u> 10 10
	Jacketed, shielded, filled or nonfilled, twisted multipair cable	Conductor resistance, each: Shield resistance, each: <u>Insulation Resistance</u> Conductor to shield: Shield to shield(s) - if applicable: Outer shield to ground:	<u>Calculated Value</u> <u>+10%</u> <u>+20%</u> <u>Megohms</u> 100 30 <u>Calculated Value</u> <u>+10%</u> <u>Megohms</u> 10 10
	Jacketed coaxial cable, single center conductor plus shield(s)	Conductor resistance, each: Shield resistance, each: <u>Insulation Resistance</u> Conductor to shield: Shield to shield(s) - if applicable: Outer shield to ground:	<u>Calculated Value</u> <u>+10%</u> <u>+20%</u> <u>Megohms</u> 100 30 <u>Calculated Value</u> <u>+10%</u> <u>Megohms</u> 10 10
	Insulated wire, 600 volt or less rating	<u>Continuity</u> Conductor resistance: <u>Insulation Resistance</u> Conductor to Conductors (all) - if applicable: Conductor (each) to ground:	<u>Calculated Value</u> <u>+10%</u> <u>Megohms</u> 10 10

Measurement Description

NOTES:

1. Additional tests may be required in accordance with other applicable Specification provisions.
2. The Authority may require the testing, or may elect to re-test, the insulation resistance of tunnel wall, duct bank, or direct burial outside plant cable during periods of high dampness or high ground water. Any single failure to obtain the minimum required readings shall be considered conclusive in determining that defects requiring Contractor repair or replacement are present.
3. Disconnect grounded and terminated cable elements as necessary to facilitate testing.
4. Full information concerning the type, application, to/from terminal destinations, junction boxes/splices (if any), size, conductor size, and actual installed length, must be included on test data sheets for each cable tested.
5. Notwithstanding manufacturers specifications or REA standards, cable(s) that does not meet minimum readings specified shall be replaced by the Contractor, at no additional cost to the Authority.

**PART 2 PRODUCTS**

**NOT USED**

**PART 3 EXECUTION**

**NOT USED**

**END OF SECTION**

## **SECTION 16705**

### **COMMUNICATIONS STANDARD SPECIFICATIONS - EQUIPMENT AND MATERIAL**

#### **PART 1 - GENERAL**

##### **1.01 SECTION INCLUDES**

- A. Standard Specifications for Contractor-furnished equipment and materials. These Specifications shall apply to all equipment and materials furnished, unless otherwise specified elsewhere in this Contract (i.e. conflicting Specification requirements found in other Specification sections or on Contract Drawings take precedence over Standard Specifications in this section).

##### **1.02 UNIT PRICES**

- A. Unit Prices include all Required conduits and fittings, wiring, and cabling to provide rack, cabinets and enclosures for the communications systems and facilities and incidental items, not specifically mentioned, but required for complete and proper system operation.

##### **1.03 RELATED SECTIONS**

- A. Section 16706 - Communications System Submittals & Services
- B. Section 16710 - Communications Grounding.
- C. Section 16721 - Communications Telephone System.
- D. Section 16723 - Communications Garage Emergency Telephone System.
- E. Section 16727 - Communications Passenger Emergency Reporting System.
- F. Section 16731 - Communications Fire and Intrusion Alarm System.
- G. Section 16733 - Communications Kiosk System.
- H. Section 16771 - Communications Carrier Transmission System.
- I. Section 16776 - Communications Fiber Optics System.
- J. Section 16791 - Communications Mobile Radio System.
- K. Section 16820 - Communications Public Address System.
- L. Section 16821 - Communications Automatic Public Address Announcement System.
- M. Section 16851 - Communications Passenger Station Closed Circuit Television System.
- N. Section 16852 - Communications Parking Garage Closed Circuit Television System

##### **1.04 REFERENCES**

- A. Federal Communications Commission (FCC) (Specifically Parts 15, 90 and other applicable regulations).
- B. National Electrical Code (NEC).
- C. Underwriters Laboratories (UL).
- D. American National Standards Institute (ANSI).
- E. Rural Electrification Administration (REA).
- F. Insulated Cable Engineers Association (ICEA).
- G. Electronic Industries Alliance (EIA).
- H. National Electrical Manufacturers Association (NEMA).
- I. Institute of Electrical and Electronic Engineers Association, Inc. (IEEE).
- J. Association of American Railroads (AAR).
- K. WMATA General Provisions and Standards Specifications for Construction Projects.

#### **1.05 SUBMITTALS**

- A. Submit under provisions of Section 16706.

### **PART 2 - PRODUCTS**

#### **2.01 EQUIPMENT RACKS**

- A. Construction: Open Frame, Aluminum 3-Inch X 1.410 Channel, 1/4 Inch Thick.
- B. Panel Mounting Size: Standard 19-inch or 23-inch panels.
- C. Finish: Baked Enamel.
- D. Color: ANSI 61 Gray.
- E. Hole Spacing: Standard EIA 1.75-inch vertical rack mounting spaces.
- F. Hole Size: No. 12-24.
- G. Base Width: 20.25 inches for 19-inch panels and 24.25 inches for 23-inch.
- H. Base Depth: 15-inches.
- I. Base Mounting Holes: Front-to-back centers of 12.5-inches and side-to-side centers of 16.0-inches and 20.0-inches.
- J. Rack Height: Maximum 7.5 feet.

- K. Equipment racks shall have a ground bus bar, bolt mounted near the top of the rack, consisting of a 6.0-inch by 0.25-inch by 0.5-inch copper bar drilled and tapped for six connections. The ground bus bar shall be electrically connected to the equipment rack.

## **2.02 EQUIPMENT CABINETS**

- A. Construction: Assembled frame with a flush frame base, suitable side panels and top panel, a front door and a rear door.
- B. Assembled frame: Zinc plated 14-gauge steel and shall have the required front-to-back stiffeners to distribute the equipment load.
- C. Base: Zinc plated 14-gauge steel or greater.
- D. Panel Mounting Rails: Drilled and tapped in accordance with EIA Standard RS-310-C.
- E. Front Door and Rear Door: 16-gauge steel with a lockable handle.
- F. Ventilation: Louvers front door and/or the rear.
- G. Finish: Baked enamel/acrylic, gray color.
- H. Cabinet Height: Maximum 7.5 feet.
- I. Equipment cabinets shall have a ground bus bar, bolt mounted near the top of the rack, consisting of a 6.0-inch by 0.25-inch by 0.5-inch copper bar drilled and tapped for six connections. The ground bus bar shall be electrically connected to the equipment cabinet.

## **2.03 DISTRIBUTION FRAMES**

- A. All systems distribution frames, including the Main Distribution Frame (MDF)/Protector Cabinet, shall consist of the required multisection cable terminal housings, top and bottom assemblies for each housing, a hinged end section at both ends of the distribution frame, a lift-out door for each housing, and a fungus resistant solid plywood backboard in each housing. Each housing of the distribution frame shall contain four distribution rings to permit neat installation of wires and cables within the housing.
- B. Finish: Baked enamel gray color.
- C. Multisection cable terminal housings shall have a ground bus bar installed near the bottom on the plywood backboard, consisting of a 6.0-inch by 0.25-inch by 0.5-inch copper bar. The ground bus bar shall be drilled and tapped for the required ground connections within the housing. The ground bus bar shall be electrically isolated from the distribution frame enclosures.

## **2.04 JUNCTION BOXES**

- A. Junction boxes shall be constructed of 12-gauge sheet steel, except for sizes 24-inch x 36-inch and smaller, which shall be constructed of 14-gauge sheet steel. Boxes shall have all seams welded. The boxes shall be finished to be a NEMA Type 4 rating with the door/cover gasket with an oil resistant gasket material and adhesive. Boxes shall be either galvanized, and painted with ANSI 61 gray paint after priming or shall be a phosphatized surface with ANSI 61 gray polyester powder coating applied. Associated hardware shall be constructed of stainless steel. Junction boxes shall be sized to provide ample space for terminating the

wires and cables installed at each location, including terminal blocks and considering the minimum bending radii of cables. Junction boxes exposed to the weather shall have all wire entrances protected from weather and dust with a pliable sealing compound, and shall be equipped with a drain plug.

- B. Junction boxes shall be furnished and installed complete with terminals, fittings, mounting brackets, cable supports and all other necessary hardware. All conductors within a junction box (including spares) shall be terminated on terminal blocks. Junction boxes to be used only for the pulling of cable do not require terminals.
- C. Where the Contractor furnishes and installs junction boxes as means of terminating cables, cable supports shall be provided in the boxes.
- D. The Contractor may request a waiver to use outlet boxes in lieu of junction boxes for specific application(s) in specific locations. The request must be approved by the Authority prior to the purchase of material or the beginning of installation.

## **2.05 CONDUIT PLANT**

- A. All conduit, except as noted, shall be intermediate metal conduit (IMC). The rigid metal conduit shall conform to UL Standard Number 6, Rigid Metal Conduit and National Electric Code Article 345 Intermediate Metal Conduit. The exterior surface shall be thoroughly and evenly coated with metallic zinc applied directly to the surface of the steel (electroplated zinc coating). The conduit furnished shall be supplied in nominal 10-foot lengths, threaded on each end with one coupling attached. The intermediate metal conduit, elbows, coupling, and fittings shall be protected by corrosion protection when subject to severe corrosive influences. Conduit fittings selected for removable covers shall be complete with gaskets and blank covers.
- B. Flexible conduit shall be provided only where specifically required by these Specifications or where, at the request of the Contractor, its use has been approved by the Engineer and allowed by the National Electrical Code. The flexible conduit shall be constructed of interlocking spiral strip steel of the best quality. The flexible conduit shall be thoroughly annealed and fully coated with metallic zinc. The flexible conduit shall conform to Underwriters Laboratories standards and Federal Specification WW-C-5568. The flexible conduit shall have an extruded liquid-tight neoprene jacket in those locations where the conduit will be exposed to a wet environment, or required by the Engineer for an approved installation. Appropriate type and sized connectors, couplings and fittings supplied or recommended by the manufacturer for the specific flexible conduits shall be provided.
- C. Rigid non-metallic conduit shall be provided only where specifically required by these Specifications or where, at the request of the Contractor, its use has been approved by the Engineer and allowed by the National Electrical Code. Unless otherwise specified, the rigid non-metallic conduit shall be classified as heavy wall type construction. Appropriate type and sized connectors, couplings and fittings supplied or recommended by the manufacturer for the rigid non-metallic conduit shall be provided.
- D. The Contractor shall furnish systems and facilities and select equipment with features that will allow for the utilization of cables sized to fit existing conduit (if any), or the Contractor shall be required to furnish and install suitable conduit to Authority standards to accommodate the communications cables required.

## **2.06 CABLE TRAYS**

- A. Cable trays shall be prefabricated aluminum, open ladder type, approximately 3 inches in depth and shall conform to NEMA Standard VE-1. The width of cable trays shall be determined by the Contractor, but shall be a minimum of 6 inches. Cable tray bottoms shall have rungs on 4-inch centers. Where applicable, a cantilevered single "wall support" type of tray shall be used.
- B. The cable trays shall support a 100 pound per linear-foot load, with a maximum mid-span deflection of 0.25 inch when considered as a simple beam with supports on eight-foot centers.
- C. Appropriate type and size curved sections, cross sections, tee sections, fittings, accessories and supports shall be furnished in accordance with the manufacturer's recommendations.

## **2.07 CABLE LADDERS**

- A. Cable ladders shall be prefabricated aluminum, open ladder type, approximately three (3) inches in depth and shall conform to NEMA Standard VE-1. The width of cable ladders shall be determined by the Contractor to support cables in cable vault or mounted on wall when conduit is not available or conduit is not suitable for installation.

## **2.08 HARDWARE**

- A. Unless otherwise specified, all mounting hardware shall be galvanized. Appropriate type mounting hardware shall be provided for the corresponding supporting surfaces.
- B. Unless otherwise specified, brackets for the mounting and supporting of equipment and material in passenger station areas, yard buildings and other facility buildings shall be painted. Unless otherwise specified, brackets installed in tunnel or outdoor areas shall be galvanized after fabrication in accordance with ASTM A386.
- C. All bolts, nuts and washers for mounting and supporting of equipment within equipment enclosures shall be cadmium plated.

## **2.09 PAINTING**

- A. Equipment furnished and installed by the Contractor other than galvanized, copper, plastic and electrical contact surfaces shall be factory painted internally and externally, except as otherwise specified.
- B. Paint colors shall be selected to match existing equipment, where applicable, and shall be subject to the approval of the Engineer.

## **2.10 SPECIAL REQUIREMENTS FOR STAINLESS STEEL CORROSION RESISTANT HARDWARE**

- A. Except as otherwise specified, equipment enclosures, cabinets, boxes and hardware of all types in tunnels, tunnel crossovers, along the surface right-of-way, and in all ancillary structures that are open to tunnels (vent shafts, fan shafts, pumping stations, etc. - excluding rooms within these areas that are heated/air conditioned) shall consist of stainless steel 304 material. Also, except as otherwise specified, equipment enclosures, cabinets, boxes and hardware of all types; in platform plenums (and including track side walls and under-platform slab and extensions into service rooms); along station train room safety walks, in stairways, corridors, and plenums that are not heated/air conditioned; and in all shafts to the surface and dome reliefs, escalator well ways, elevator pits and surface elevator shafts, shall consist of stainless steel 304 material.

- B. Exceptions: Galvanized conduit may be used with stainless steel 304 mounting hardware. Gray colored fiberglass boxes may be utilized for Emergency Trip Station(ETS) Telephones (Ref. Article 3.7 for product specifications). Non-metallic mounting hardware may be utilized for tunnel and passenger station Mobile Radio System (MRS) antenna cable mounting (Ref. Article 3.13 for product specifications). Electronic equipment connectors, and other relatively small sized specialty items, that are not available in Stainless Steel 304 material, may be allowed by the Engineer as exceptions (Ref. Article 3.1, Request for Approval Of Minor Technical Specification Deviation).
- C. Unless otherwise specified, dull "powder gray" colored Original Equipment Manufacturer (OEM) factory painted exterior surfaces of stainless steel 304 equipment enclosures, cabinets, and boxes shall be utilized in areas where surface glare may be visible to rail car operators, or the Contractor shall neatly apply dull colored epoxy paint to surfaces to avoid glare. McMaster-Carr Supply Company (New Brunswick, NJ) Catalog No. 7892T78 (from Cat. #98) gray primer (or approved equal) shall be utilized for the Contractor applied paint.
- D. Definition: "Hardware" includes bolts, screws, clamping devices, anchoring devices, threaded rods, nuts, washers, hangers, covers/wall plates etc. "Boxes" includes junction boxes, outlet boxes, disconnect switch boxes, circuit breaker boxes, and terminal boxes, etc. "Cabinets" includes terminal cabinets, equipment cabinets, MDF cabinets, and power distribution panelboards. (Note: definitions include but are not limited to the items listed herein.)

## **2.11 ELECTRICAL**

- A. All electrical and electronic components furnished in accordance with this Contract shall be:
  - 1. New and free of manufacturing defects;
  - 2. Free of storage and handling damages;
  - 3. Clearly and permanently labeled with value or identification type;
  - 4. Rated to operate at power, voltage, and current levels exceeding, by at least 20 percent, those which the components will be subject to in service, unless otherwise noted;
  - 5. Commercially available;
  - 6. Capable of operating in the environment specified in these Specifications;
  - 7. Identical, if performing the same function; and
  - 8. Selected with tolerance limits such that the equipment fabricated from the components shall not malfunction over the specified system/facility or equipment operating range.
- B. The selection of the electrical and electronic components shall be such as to provide maximum convenience and safety to personnel in installing, operating and interchanging a complete assembly or component part. Provisions shall be made to prevent personnel from accidentally coming into contact with hazardous voltages. Components shall be selected to prevent reversed assembly or installation of connectors and cables. Cables shall be suitably identified with their mating connections.
- C. Any deviation from these requirements and the requirements detailed herein, including those inherent in standard production equipment, shall be subject to the approval of the Engineer.

## **2.12 TRANSISTORS AND DIODES**

- A. All transistors and diodes shall carry a Joint Electronic Device Engineering Council (JEDEC) number, shall be available from at least two manufacturers, and shall be silicon. Specially selected transistors and diodes within a type number shall not be permitted.
- B. Resistors shall have a maximum tolerance of plus-or-minus 5 percent and shall be rated to dissipate a minimum of 1.5 times the maximum power they will be required to dissipate in operation.
- C. Zener diodes used for voltage regulation or reference levels shall be of such rating that they will not be damaged if the entire load is removed abruptly, and shall have a Zener voltage tolerance of plus-or-minus 5 percent or better.
- D. Zener diodes used for transient protection shall be of such a rating that they will not be damaged in performing their function within all actual conditions encountered in the operating system/facility.

### **2.13 CAPACITORS**

- A. Wet electrolytic capacitors shall not be used. Only dry electrolytic capacitors shall be provided.
- B. Capacitors shall have a maximum tolerance of plus-or-minus 10 percent and shall be rated for at least 1.5 times the maximum peak voltage they will be subjected to in operation.

### **2.14 OTHER SEMICONDUCTORS**

- A. All other semiconductors shall carry a Joint Electronic Device Engineering Council (JEDEC) number and shall be available from at least two manufacturers. All other semiconductors shall be of the silicon type, unless otherwise approved, in writing, by the Engineer.

### **2.15 INTEGRATED CIRCUITS**

- A. All integrated circuits (ICs) shall be available from at least two manufacturers. The Contractor shall take all necessary precautions to ensure that no system or facility using ICs shall malfunction in any fashion due to internally or externally generated noise or cross-talk.
- B. Integrated circuits shall not be damaged by the failure or partial failure of any one or any combination of the various supply voltages. Integrated circuits shall not be damaged by overvoltage of 1.4 times the normal supply voltage, or by short circuits on their inputs and/or outputs.

### **2.16 TRANSFORMERS**

- A. All transformers provided under this Contract shall be of air-cooled, dry type, unless otherwise approved by the Engineer.
- B. Unless otherwise specified, all transformers shall have minimum interwinding and winding to core breakdown voltage of 600 Vdc. Transformers used in electronic circuitry are an exception.
- C. Unless otherwise specified, all transformers shall conform to the following requirements:

1. Core laminations shall be grain oriented silicon steel. Maximum flux densities shall be substantially below saturation level. The core volume shall allow efficient transformer operation at 10 percent above the highest tap voltage. All laminations must be core plated or annealed, free of burrs and firmly butted. The core laminations shall be tightly clamped and compressed to provide quiet operation. Transformers shall not emit audible noise in excess of 50 dB referenced to .0002 dynes per sq. cm., at a distance of three feet, while operating at rated voltage and load.
  2. Coil conductors shall be continuous with terminations brazed or welded without auxiliary flux material. The entire core and coil assembly shall be pre-dried by heat, impregnated with varnish or other approved compound, and cured at a minimum of 350 degrees F to reduce hotspots and seal out moisture. Coils shall be protected with an outer layer of glass tape or similar quality insulation.
- D. Unless otherwise specified, all transformers provided under this Contract shall be equipped with suitably insulated screw terminals for all primary and secondary lead wires. Transformers used in electronic circuitry and video isolation transformers are an exception. Appropriate type video connectors shall be provided for the input and output leads of video isolation transformers.

## **2.17 POWER SUPPLIES**

- A. Unless otherwise specified, all power supplies shall have the characteristics and meet the requirements listed herein.
- B. Power supplies shall be for continuous duty and shall be rated at a minimum of 120 percent of maximum load at 50 degrees C.
- C. Power supplies shall be selected for mounting in a standard 19-inch equipment rack and shall be housed in a metal panel-chassis combination with no exposed electrical connections or wires. Appropriate type terminals shall be provided on the rear of the chassis for the connections of all external input and output power leads. An appropriate sized power cord (internally connected) may be provided for the input power leads.
- D. Power supplies shall be selected for natural convection cooling. No supplementary fans or other cooling devices will be allowed.
- E. The power supplies shall not be damaged by a sustained input voltage varying from 0 to 150 percent of the rated input voltage. Power supplies shall have current limiting, which shall protect the power supplies from damage due to overload or short circuits. Overvoltage protection shall be contained on those power supplies driving solid-state circuitry.
- F. Each power supply shall have an output voltmeter, an output ammeter, and a normally illuminated power light (lamp or LED) mounted on its front cover. All panel mounted indicating, adjusting, and protective devices, or openings for such devices, shall be legible and permanently labeled.
- G. Each power supply shall be equipped with a failure alarm device, which shall detect any internal failure that will impair the ability of the power supply to deliver its full rated load. This device shall be normally energized by a small percentage of the rated load current of the power supply. Upon detection of a failure, the failure alarm device shall provide an independent contact closure for an external alarm indication circuit. The contacts shall be wired to appropriate type terminals on the rear of the chassis. In addition, the failure alarm

device shall extinguish the normally illuminated power light on the front cover, when a failure is detected.

- H. Unless otherwise specified, all redundant power supplies shall be diode coupled to the loads with the corresponding main power supplies.

## **2.18 CONNECTORS**

- A. Connectors shall be provided on wires, multi-conductor cables, coaxial cables, and triaxial cables, when required to permit the connection to or removal of equipment items for maintenance, as determined by the Engineer. In-line connectors shall be provided only where specifically required by these Specifications or where, at the request of the Contractor, its use has been approved by the Engineer. Appropriate type and size connectors shall be provided for the joining, splicing, and terminating of all coaxial cables and triaxial cables.
- B. Unless otherwise specified, connectors shall not be required for the termination of wires and cables to those equipment items which contain screw type terminals as the interface connection for wires and cables. Connectors shall not be provided in system distribution frames. Appropriate type mating connectors, recommended by the manufacturers, shall be provided for those equipment items requiring connectors for the interfacing of wires and cables. Appropriate type connector assemblies and mating connectors shall be provided to interface wires and cables to all equipment (including system control panels) in the Kiosk and yard consoles.
- C. Appropriate type, size, and rated power connectors (plugs) shall be provided to interface equipment power cords and cables to ac power receptacle strips, ac power outlet assemblies, and ac outlets.
- D. Unless otherwise specified, all multi-conductor cable connectors (including those provided for custom-made equipment and control panels) shall consist of a molded plastic connector block equipped to hold the required number of contacts, a protective shell (plastic or metal), a mechanical keying device, a device to grip the external wiring firmly in order to prevent strain on the contacts, and the required solderless contacts (pins or sockets). The pin and socket contacts shall be fabricated from commercial bronze or brass and have a minimum 0.00003-inch gold plating over nickel underplate. The pins and sockets shall be appropriately sized to interface the corresponding conductor sizes that are to be terminated to the connector. Connectors provided on equipment for the interfacing of wires and cables shall be firmly secured to the chassis.
- E. All connector assemblies shall be easily connected and disconnected by hand. Tools used to apply connector contacts to wires and cable conductors shall be of the size and type recommended by the manufacturer of the connector.
- F. Each connector shall be marked in such a manner that its mating half shall be distinctly identified as being related to each other, but to no other connector within the immediate area. These identification markings shall be applied in such a manner that they will not be obscured or worn off in normal use.
- G. All conductors (including spares) within a cable that interfaces with a connector shall be terminated in the connector.
- H. All in-line connectors installed in wires and cables located inside structures, within tunnel areas, and all connectors installed to equipment which are not located within rooms of passenger stations, ancillary buildings and yards shall be protected by silicon sealer

coating, enclosed by heat shrinkable tubing (sleeves). This requirement shall be excluded for all connections with a weatherproof classification.

- I. All in-line connections installed in manholes, hand-holes, cable troughs or cable trenches (direct burial) shall be enclosed in filler splice cases, utilizing products and methods approved by the Engineer.
- J. In-line connection shall not be allowed in conduits, ducts, pipes and cable trays.
- K. All locations of in-line connections shall be documented on As-Built drawings.

## **2.19 RELAYS, SWITCHES AND PUSHBUTTONS**

- A. All electromagnetic relays shall be plug-in type and secured to their corresponding socket to reduce the effects of shock and extreme vibration. Where applicable, retaining wire springs shall be provided with the relays. The contacts of the electromagnetic relays shall be palladium, silver, or gold plated, or shall be mercury-wetted. All contacts shall be bifurcated and shall have a wiping action. The coil and contacts of each electromagnetic relay shall be enclosed in a protective dust cover. Unless otherwise specified or required for a specific function within the associated circuitry, all double throw contacts shall be break-make type (Form "C").
- B. All solid-state relays shall be completely encapsulated in a rugged epoxy case. A minimum of 2500-Vrms isolation shall be provided between the input and the output of all solid-state relays.
- C. All relays shall be of the appropriate type (Vac or Vdc operation) and be of the required input control rating for their intended use. The contacts of the electromagnetic relays and the isolated outputs of the solid state relays shall have ratings that equal or exceed the corresponding connected load requirements (voltage and current).
- D. Arc suppression circuits shall be provided for all relays used in electronic circuitry. Arc suppression may be built into the relays or provided on the printed circuit cards on which the relays are mounted. All time delay relays shall have solid-state timing circuits.
- E. All switch and pushbutton contacts shall be palladium, silver or gold-plated. The contacts shall have a wiping action and shall be rated for their intended use. All switches and pushbuttons shall have a long life expectancy of more than 10,000 operations.
- F. Unless otherwise specified, the types of switches (rocker, toggle, etc.), the operation of the pushbuttons and switches (momentary action, maintained action, etc.), and the configuration of the pushbuttons and switches on developed equipment shall be determined by the Contractor and approved by the Engineer. Unless otherwise specified, all pushbuttons and switches on developed equipment shall contain LEDs, if indicators are required. Mechanical interlocking shall be provided when required. Full guard bezel which surrounds the button to help prevent accidental operation and barriers between pushbuttons and switches shall be provided, upon request by the Authority.
- G. All switches and pushbuttons on equipment shall be permanently labeled. Labeling of the switches and pushbuttons shall either be provided on the surface of the equipment to which they are mounted or provided on the switches and pushbuttons themselves. All graphics on pushbuttons and switches shall be hot stamped in a color that will contrast with the color of the buttons (lenses).

## **2.20 TEST POINTS**

- A. Test points shall be provided for each major function. Labeled test points on printed circuit boards and other plug-in modules shall be accessible while the device is in operation.

## **2.21 PRINTED CIRCUIT BOARDS**

- A. All printed circuit boards (cards) shall be constructed of fire-resistant glass epoxy material of NEMA quality FR4 or better. Cards shall have sufficient thickness to permit easy insertion and removal without buckling or breaking and shall be keyed to prevent incorrect interchange. All circuits on the printed circuit boards shall be formed by etching. Conductor material shall be copper and shall be protected from exposure to air.
- B. Boards shall be produced with plated through holes, for component mounting and connecting, and for interfacial connections. If all interconnecting circuitry is confined to one side of the board, the board may be produced with unsupported holes for mounting the components which will be soldered to the pattern side of the board.
- C. Printed circuit boards shall be coated with an approved moisture-proofing compound after assembly, except when this requirement is waived by the Engineer, due to non-availability from manufacturers of approved off-the-shelf dust protected equipment units.
- D. Each printed circuit board shall be permanently and legibly marked with a unique number identifying that type of circuit board (i.e., model number). In addition, each printed circuit board shall be permanently and legibly marked with a unique serial number.

## **2.22 LED AND INDICATING LAMPS**

- A. All indicating lights (LEDs and lamps) shall have a life expectancy of 25,000 hours minimum. All indicating lights shall be operated between 85 percent and 95 percent of their rated voltage.
- B. All indicating lights on equipment shall be permanently labeled. Labeling of the indicating lights shall either be provided on the surface of the equipment to which they are mounted or provided on their associated lenses. All graphics on the lenses shall be hot stamped in a color that will contrast with the color of the lenses.
- C. Unless otherwise specified, all indicating lights (LEDs and lamps) shall be replaceable from the front of the light assemblies.
- D. Unless otherwise specified, all numeric and alphanumeric displays shall be solid state LED display or liquid crystal display. Numeric characters shall be 7-segment type display and alphanumeric characters shall be 14-segment type display. However, a dot matrix display will be considered upon request by the Contractor. Unless otherwise specified, all character displays shall be a minimum of 1/2-inch. Appropriate filters and windows shall be provided.

## **2.23 METERS**

- A. Unless otherwise specified, traditional meter movements shall have a full scale accuracy of  $\pm 2$  percent.
- B. All meters shall be of the appropriate type for their intended use; i.e., a meter with an ampere scale shall not be acceptable for the measurement of milli-amperes. All meters shall be legible and permanently labeled.

## **2.24 TERMINAL BLOCKS**

- A. All terminal blocks and terminal strips shall be rated for service at 300 volts minimum. All terminal blocks and terminal strips shall be of the appropriate current rating for corresponding terminated circuits. All terminals of the terminal blocks and terminal strips shall be sized to accept corresponding terminated wire and cable conductor sizes (gauges). Resistance of the terminals shall not exceed 0.0002 ohms.
- B. Unless otherwise specified, terminal blocks and terminal strips provided in junction boxes, equipment enclosures, system distribution frames, equipment cabinets, and termination facilities shall be of the modular, feed-thru type mounted to a metal channel or be of the single molded construction barrier type.
- C. Unless otherwise specified, the modular, feed-thru type terminal blocks and terminal strips shall have pressure clamp contact terminals suitable for solid and stranded wire. Appropriate sized (length) continuous mounting channel shall be provided for each terminal block and terminal strip. Appropriate accessories (end sections, channel clamps, partitions, mounting hardware, etc.) shall be provided for each terminal block and terminal strip. Disconnect apparatus (without removing wires) shall be provided in the terminal assemblies of those terminal blocks and terminal strips, which are utilized in conjunction with protector block assemblies, or otherwise specified within these Specifications.
- D. The barrier type terminal blocks and terminal strips shall be constructed of molded fire-retardant thermoplastic with double row terminals. The terminals shall consist of binding head screws, with the two screws associated with each terminal electrically connected with a brass strip. Appropriate mounting hardware shall be provided for each terminal block and terminal strip.

## **2.25 PROTECTOR BLOCKS**

- A. Unless otherwise specified, each protector block shall be selected for the termination of two pairs (four conductors). The base of each protector block shall be constructed of molded fire-retardant thermoplastic and shall be equipped with four binding posts and four related screw-in arrester units. The four binding posts shall be connected internally to the corresponding arrester units. Each binding post shall be equipped with two nuts and four beveled washers. A ground plate shall be provided on the face of the base of each protector block between the arrester units. The arrester units shall be 2-electrode gas type and provide 400 Vdc fail-short protection.
- B. Multiple protector blocks (two pair type) shall be provided and installed adjacent to each other (vertical rows) for the termination of multi-conductor cables containing more than two pairs.
- C. Appropriate length brass or copper mounting and ground bar assemblies shall be provided for the installation and grounding of the protector blocks. Each mounting and ground bar assembly shall have a minimum of two binding posts with appropriate nuts and washers for the termination of ground wires. Appropriate hardware shall be provided to secure and ground the protector blocks to the mounting and ground bar assemblies. Appropriate mounting hardware shall be provided to install the mounting and ground bar assemblies.
- D. Unless otherwise specified, all wires and cables that enter/exit the Communications Equipment Rooms of passenger stations and yards to/from the WMATA right-of-way shall be terminated on protector blocks in the Communications Equipment Room. All wires and cables that enter/exit equipment within the WMATA right-of-way and enter/exit remote ancillary buildings shall be terminated on protector blocks at the equipment and in the remote ancillary buildings. All wires and cables that enter/exit yard buildings and other

special buildings shall be terminated on protector blocks in the yard buildings and special buildings. All wires and cable conductors (including spares) shall be terminated on protector blocks at each location. Coaxial cables and triaxial cables are exceptions.

## **2.26 FUSES AND CIRCUIT BREAKERS**

- A. All equipment shall be protected by fuses or circuit breakers of the appropriate size. Fuses and circuit breakers shall be readily accessible, surface mounted, on all equipment. Fuse wire within the equipment shall not be acceptable.

## **2.27 WIRES AND CABLES**

- A. Only continuously extruded outer jackets free of polyvinylchloride (PVC) and PVC-based compounds shall be furnished on cables provided in these Specifications. Exceptions may be allowed by the Engineer when such cable is not commercially obtainable only from equipment manufacturers, and when appropriate to avoid potential electrical signal mismatching, or to otherwise improve system performance or reliability.
- B. All single conductor wire and individual conductors of multi-conductor cables shall be copper and shall be insulated.
- C. Multi-conductor cable shall be made by assembling individual or twisted pairs of insulated conductors into a tight cylindrical form. Individual conductors or twisted pairs in a cable having more than two wires shall be assembled helically and with adjacent layers wound in opposite directions. Twisted pairs shall consist of two individually insulated conductor cables with a length of lay as short as good construction will permit, but not longer than ten inches. Where more than one twisted pair is included, length of lay of adjacent pairs shall differ by at least one-half inch.
- D. Unless otherwise specified, all multi-conductor cables installed within the WMATA right-of-way shall contain a metallic shield and a corrugated metallic tape armor. The shield and armor shall be separated by an inner jacket.
- E. Multi-conductor cables containing more than two conductors shall contain 20 percent spare conductors, or two spare conductors (two spare pairs if composed of twisted pairs), whichever is greater.

## **2.28 HOOK-UP-WIRE**

- A. All wiring within electronic equipment selected, or wired by the Contractor shall have passed the Underwriters Laboratories VW-I Vertical Flame Test. The wire size shall be commensurate with the application.
- B. All wires within electronic subassemblies and assemblies shall be identified by adequate color-coding, in accordance with best commercial practices.

## **2.29 GROUNDING**

- A. Communications systems and facilities, equipment and cables shall be grounded using a single-point grounding scheme. Each Communications Equipment Room will have a separate isolated ground bus bar, provided by others, designated as "communications ground."

- B. Unless otherwise specified, the shields of all single shielded communications cables, the shields of multi-conductor cables that have individually shielded pairs, and the inner shield of all double shielded communications cables and communications cables with separate shield and armor, shall be grounded only at a single point and only to the "communications ground." These shields shall be electrically continuous throughout the cable length by bonding across all splices and terminations in equipment enclosures and junction boxes.
- C. The outer shield of all double shielded communications cables and the armor of all communications cables with separate shield and armor shall be grounded only at a single point in each cable section. The single point ground shall be located at the end of the cable section nearest to the associated Communications Equipment Room. Cable sections originating at Communications Equipment Rooms shall have the outer shield or armor grounded to the "communications ground."
- D. The Contract Drawings show details of the cable grounding scheme.
- E. Equipment racks and equipment cabinets shall be electrically isolated from the building structure, adjacent equipment racks and equipment cabinets. Minimum resistance between adjacent equipment racks and equipment cabinets, and between equipment racks and equipment cabinets and the building structure, shall be 10 megohms. Each equipment rack and equipment cabinet shall be individually wired to the communications ground, via the copper ground bus bar on the equipment rack and equipment cabinet, by a No. 6 AWG, stranded, insulated wire, Type XHHW.
- F. Each copper ground bus bar in the multi-section cable terminal housings of the MDF/Protector Cabinet and the systems distribution frames shall be wired to the communications ground by a No. 6 AWG, stranded, insulated wire, Type XHHW.
- G. All power conductors shall be electrically insulated from equipment racks and equipment cabinets, and power ground shall be separate and isolated from communications ground. Conduit containing power conductors running from ac distribution boxes to equipment racks, equipment cabinets, ac receptacle boxes on equipment racks and equipment cabinets shall be insulated from the equipment cabinet or equipment rack by means of short lengths of non-conducting conduit.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. Adjacent equipment racks and equipment cabinets shall have a 0.25-inch separation between upright members. They shall be mechanically secured to each other by 0.25-inch nylon bolts and spacers.
- B. Adjacent equipment racks and equipment cabinets shall use rigid non-metallic conduit for interconnecting wiring.

**END OF SECTION**

## **SECTION 16706**

### **COMMUNICATIONS SYSTEM SUBMITTALS & SERVICES**

#### **PART 1 - GENERAL**

##### **1.01 SECTION INCLUDES**

- A. Submittal procedures.
- B. Construction progress schedules.
- C. Proposed Products list.
- D. Product Data.
- E. Shop Drawings.
- F. Contract Record Drawings
- G. Spare Parts
- H. Equipment Manuals
- I. Training
- J. Samples.
- K. Design data.
- L. Test reports.
- M. Certificates.
- N. Manufacturer's instructions.
- O. Manufacturer's field reports.

##### **1.02 RELATED SECTIONS**

- A. Division 1
- B. Section 16707 - Communications Systems Quality Assurance & Testing.

##### **1.03 REFERENCES**

- A. AGC (Associated General Contractors of America) publication "The Use of CPM in Construction - A Manual for General Contractors and the Construction Industry."

##### **1.04 SUBMITTAL PROCEDURES**

- A. Transmit each submittal with Engineer accepted form.
- B. Sequentially number the transmittal form. Revise submittals with original number and a

sequential alphabetic suffix.

- C. Identify Project, Contractor, Subcontractor or supplier, pertinent drawing and detail number, and specification section number, as appropriate.
- D. Apply Contractor's stamp, signed certifying that review, approval, verification of Products required, field dimensions, adjacent construction Work, and coordination of information is in accordance with the requirements of the Work and Contract Documents.
- E. Schedule submittals to expedite the Project, and deliver to Engineer. Coordinate submission of related items.
- F. For each submittal for review, allow 30 days excluding delivery time to and from the contractor.
- G. Identify variations from Contract Documents and Product or system limitations that may be detrimental to successful performance of the completed Work.
- H. Provide space for Contractor and Engineer review stamps.
- I. When revised for resubmission, identify all changes made since previous submission.
- J. Distribute copies of reviewed submittals as appropriate. Instruct parties to promptly report any inability to comply with requirements.

#### **1.05 CONSTRUCTION PROGRESS SCHEDULES**

- A. Submit initial schedule in duplicate within 20 days after date established in Notice to Proceed.
- B. Revise and resubmit as required.
- C. Submit revised schedules with each Application for Payment, identifying changes since previous version.
- D. Submit a computer generated network analysis diagram using the Program Evaluation and Review Technique (PERT) Technique method, as outlined in AGC - The Use of CPM in Construction.
- E. Show complete sequence of construction by activity, identifying Work of separate stages and other logically grouped activities. Indicate the early and late start, early and late finish, float dates, and duration.
- F. Indicate estimated percentage of completion for each item of Work at each submission.
- G. Indicate submittal dates required for shop drawings, product data, samples, and product delivery dates.

#### **1.06 PROPOSED PRODUCTS LIST**

- A. Within 30 days after date of Notice to Proceed, submit list of major products proposed for use, with name of manufacturer, trade name, and model number of each product.
- B. For products specified only by reference standards, give manufacturer, trade name, model or catalog designation, and reference standards.

- C. The Contractor shall use the major products described in the Communications Sections when practical, to avoid increasing WMATA's maintenance requirements.
- D. If "equal" products are proposed by the Contractor, he shall insure that the proposed products will interface and operate properly with other Contractor-supplied products, subsystems and systems, and with existing communications products, subsystems, and systems.
- E. Whenever the Contractor proposes a new major product (one where salient characteristics have been described in any Communications Section) that has not been previously used on the Transit System, the Contractor shall include that new product in his training program to be conducted for WMATA operations and maintenance personnel.

#### **1.07 PRODUCT DATA**

- A. Product Data For Review:
  - 1. Submitted to Engineer for review for the limited purpose of checking for conformance with information given and the design concept expressed in the contract documents.
  - 2. After review, provide copies and distribute in accordance with SUBMITTAL PROCEDURES article above and for record documents purposes.
- B. Product Data For Information:
  - 1. Submitted for the Engineer's review.
- C. Product Data For Project Close-out:
  - 1. Submitted for the Authority's benefit during and after project completion.
- D. Submit the number of copies that the Contractor requires, plus two copies that will be retained by the Engineer.
- E. Mark each copy to identify applicable products, models, options, and other data. Supplement the manufacturers' standard data to provide information specific to this Project.
- F. Indicate Product utility and electrical characteristics, utility connection requirements, and location of utility outlets for service for functional equipment and appliances.
- G. After review distribute in accordance with the Submittal Procedures article above and provide copies for record documents.

#### **1.08 SHOP DRAWINGS**

The Contractor is not required to prepare new Shop Drawings for the Kiosk Fabrication. The Contract Drawings specify the details for fabrication of the Kiosk. These Kiosk Fabrication Drawings may be submitted by the Contractor as Shop Drawings, with a notation on each drawing stating that the Contractor has elected not to change the drawing, or with the Contractor's changes clearly marked. Alternatively, the Contractor may elect to submit individual sheets of Contractor developed Shop Drawings, which replace specific Kiosk Fabrication Contract Drawing Sheets.

- A. The Contractor shall, unless otherwise directed, submit one reproducible original and four black ink on white paper copies of all communications system shop drawings to the

Engineer for approval using standard transmittal forms in accordance with detailed instructions furnished by the Engineer. Shop drawings shall be 11" x 17" except for drawings designated by the Authority to be full size.

- B. The Contractor shall develop an Engineering Drawing Index which shall be submitted to the Engineer for review and approval. The drawing index shall include descriptive titles, drawing numbers, revision numbers, and the dates of completion of drawings for communications systems and facilities covered in these Specifications and for all Contractor-furnished equipment. The Engineering Drawing Index shall be definitive as to the availability and content of subsequent drawings. It shall be compatible in format and drawing number sequence with Authority Drawing Index for previous Communications Contracts and subject to approval. The Engineer shall assign the drawing number sequence. The drawing number sequence shall be 15XXX. The Contractor shall be responsible for maintaining, revising and updating the Engineering Drawing Index for the duration of the Contract. The Engineering Drawing Index shall be revised and updated quarterly, or as required by the Engineer. A completed Final Drawing Index shall be provided to the Engineer at the conclusion of the Contract.
- C. Shop drawings shall be complete, detailed and dimensioned. All necessary shop drawings shall be provided for use in fabricating, assembling, handling, erecting, installing, connecting, trouble-shooting, testing, and maintaining each complete system/facility, all changes to existing systems, facilities and equipment, and all equipment furnished, as follows:
1. Equipment installation drawings, including sections, elevations, and floor plans showing dimensions necessary for installation, equipment base or mounting details, and location of entrance/exit for cable(s).
  2. Outline drawings indicating overall dimensions, aisle space requirements, locations of all devices mounted on equipment racks/cabinets and panels, locations of all terminal blocks or connectors for connections to external cable, and removable plates for cable entry; sufficient detail shall be provided to show accessibility for maintenance.
  3. Complete detail system/facility block and level diagrams for each system/facility and for all equipment that is provided by the Contractor; each block shall represent one specific function, and each apparatus shall be divided into as many blocks as required. Such system/facility diagrams shall also include existing equipment details.
  4. Complete cable/wire plan and riser diagrams for each system/facility and all equipment that is provided by the Contractor; including designations, destinations, color codes, and termination details for the conductors of each cable and wire.
  5. Separate and complete schematic and logic functional diagrams for circuits of equipment furnished by the Contractor; circuits which are repetitive may be shown as a single schematic and/or logic functional diagram with identical parts indicated. All variations in circuitry must be clearly shown on individual diagrams for each subsystem. Notes which indicate exceptions to typical layout schematics or logics will not be acceptable. Schematic and logic diagrams shall indicate signal flow for all inputs and outputs, bus connections, and all terminal points for external connection. These shall be clearly identified and in agreement with corresponding terminal points on the wiring diagrams. Functional blocks plus their module schematic diagrams on separate drawings will be acceptable for solid-state portions of the logic servicing a specific function. Logic diagrams and schematic diagrams shall conform to the applicable IEEE standards or to alternate approved standards.
  6. Interconnecting wiring drawing(s) for each piece of equipment, indicating all terminal points for external cable connections, including cable designations, wire

- colors or designations; the number of conductors in each cable; and the destination of each cable, by reference to the appropriate unit and Contractor's drawing number or point device and drawing number as provided in the Contract Drawings.
7. Wiring drawings with all terminals, relays, modules, and other devices shown in their relative physical locations shall be provided. Each drawing shall indicate exact point-to-point connections between interconnected devices and between devices and terminals for external connections. Wire lists and cable running lists will be accepted if they include a description and a diagram of the system/facility. The Contractor shall be responsible for the accuracy of the wiring, terminal point identifications, device identifications, and device designations which shall be in exact agreement with schematic functional diagrams accepted by the Engineer.
  8. Schematics and wiring diagrams for all printed circuit boards with all electronic components and test points shown in their relative locations.
  9. Both the schematic functional diagrams and the wiring drawings shall indicate all the points essential for troubleshooting, with their respective operating voltage levels, logic state, current, or other applicable measurable parameters.
  10. Fabrication and assembly drawings for developed equipment, including panel and chassis layouts, circuit designs, components, graphics, component layouts and list of material.
  11. Additional requirements specified in the various Communications Sections.
- D. Groups of associated drawings shall be submitted together, so that Authority reviewers can evaluate the composite design and interface considerations involved for specification compliance. Submissions not in compliance with the foregoing requirement may be returned by the Authority without action.
- E. Separate drawings shall be furnished for each passenger station, building structure, yard, and site along the right-of-way. Notes which indicate exceptions to a typical drawing for a passenger station, building structure, yard, or site along the right-of-way shall not be acceptable.
- F. During construction, (after Shop Drawing approval) the Contractor shall maintain for inspection by the Engineer a record set of Shop Drawings annotated to show all authorized changes incorporated as work progresses. Three set of annotated Shop Drawing shall be submitted not later than three working days after changes are authorized by the Engineer. Information shall include, but not be limited to, the following:
1. Field changes of any type.
  2. Changes accomplished by Change Orders (Change Orders may also specify requirements for the prior submission and approval of Shop Drawings before work commences).
- G. Before Substantial Completion Inspection (SCI), the Contractor shall furnish to the Engineer one set (2 vellum and 1 black on white paper print) of Shop Drawings for the record, all clearly revised and completed and brought up to date, showing the permanent construction as actually accomplished. Not later than 15 calendar days after Substantial Completion, updated shop drawings shall also be submitted on electronic media (optical compact disk or 3.5 inch magnetic disk) using either AutoCad Version 14 (.DWG) or other Authority approved drawing file formats. In addition to these submission requirements for SCI, additional submissions are required subsequently in accordance with the CONTRACT RECORD DRAWINGS article.
- H. Work in the Contract requires modifications, reconfigurations and connections of various existing communications systems and facilities in the passenger stations, transit yards, sites along the rights-of-way and the Jackson Graham Building. Upon request by the Contractor,

and approved by the Engineer, existing Authority Record Drawings may be obtained to incorporate the requirements of this Contract and may be submitted as Contract Shop Drawings. Process for utilizing the Authority Record Drawings shall be in accordance with the requirements of the CONTRACT RECORD DRAWINGS article of this Section.

**1.09 CONTRACT RECORD DRAWINGS**

- A. General:
  - 1. Before the scheduled date of the Final Acceptance of all Contract work, the Contractor shall submit approved as-built mylar original drawings, electronic media, and microfilmed aperture cards for the completed work.
  - 2. As-built drawings shall be on 22 inch by 34 inch Mylar.
  
- B. As-built Drawings:
  - 1. As-built CONTRACT RECORD DRAWINGS shall include Installation Drawings, Shop Drawings, Working Drawings, kiosk data file drawings and revisions to all affected existing Authority Record Drawings.
  - 2. Authority Record Drawings are as-built drawings provided to the Authority in previous communications contracts. The Contractor shall coordinate with the Authority to determine which existing Authority Record Drawings require revisions.
  - 3. The Authority will furnish the original mylars of the Authority Record Drawings which require revisions from which the Contractor shall make reproductions for his use in preparing as-built drawings. Such reproductions shall be on three-mil plastic film for black line Diazo printing, both sides matte, similar to mylar and Estar. Images shall be clear, sharp and readily legible. The original Authority Record Drawings shall be returned to the Authority not later than 10 calendar days after their receipt from the Authority.
  - 4. Revisions to Authority Record Drawings shall match the base drawings in line weights, symbols, and lettering style and size. Drafting shall be performed with AutoCad software, and shall match original Contract Drawings in line weights, symbols, and lettering style and size.
  - 5. The Contractor shall submit three sets of prints of as-built drawings in a timely manner for review and approval.
  - 6. Additions and corrections resulting from Authority review comments shall be incorporated by the Contractor. One mylar original and two copies shall be submitted to the Authority not later than the applicable date specified in the Contract Schedule. Final As-Built Drawings shall also be submitted on electronic media (5 sets of CD-ROM's) using either AutoCAD(.DWG) or other Authority approved drawing file formats.
  - 7. Completed as-built Contract Record Drawings shall bear the signature of an officer of the Contractor's organization, certifying compliance with as-built conditions using a rubber stamp, or electronic facsimile, as follows:

<p>As-Built</p> <p>Date _____</p> <p>I certify that this drawing accurately depicts the work as constructed.</p> <p><u>An Officer of the Company</u></p> <p>Signature _____ Title _____</p> <p>CONTRACTOR'S NAME</p>
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## 1.10 SPARE PARTS

- A. This Contract includes the requirement for Communications spare parts. The Contractor shall assure that all spare parts required by this Contract are provided and delivered in accordance with the requirements of Division 1.

## 1.11 EQUIPMENT MANUALS

- A. The Contractor shall furnish Operations and Maintenance (O&M) Manuals for communications systems, as specified in Division 1. The Contractor shall also furnish complete sets of O&M Manuals for each type and variation of Contractor furnished equipment - including all communications equipment and other electronic equipment and associated peripheral equipment, of the communications systems (Contractor furnished items only - unless otherwise specified). Sets of manuals shall generally describe the operation, specifications and characteristics, theory of operation, maintenance, and troubleshooting procedures for each type of equipment. Complete parts lists and detailed information concerning specific equipment options installed at WMATA shall be included in equipment manuals. The communications manuals shall be divided into three (3) categories and will meet the additional requirements, as follows:
1. Volume A Manuals shall consist of system-related manual(s) with contents as specified herein.
  2. Volume B Manuals shall consist of equipment-related manual(s) with contents as specified herein.
  3. Manufacturers Service Manuals shall consist of the most complete and most extensive manufacturers' service manual sets available for each item of equipment (applicable to test equipment, or as otherwise specified). (No Contractor furnished supplements or oil resistant covers are required for this category of manuals.)
  4. Accurate, technically correct, easily understandable, concise text, charts, tables, illustrations, photographs, and drawings; all of which are directly applicable to the subject matter and are highly appropriate for their intended purpose; shall be provided by the Contractor subject to review and approval by the Engineer.
  5. Page layouts, formats, spelling and grammar utilized, and reproduction quality, shall be of good commercial quality and shall be subject to review and approval by the Engineer.
  6. Dividers with custom printed tab labels shall be provided for each major subsection (1-1, 1-2, 1-3, etc.), and a distinctive type of divider with custom printed labels shall be provided to separate major parts of each multi-part manual.
  7. Secure screw-down, or other equivalent manual bindings shall be furnished by the Contractor, subject to approval by the Engineer. Standard 3-ring binders will not be acceptable for these manuals. Binders shall have front or back (preferably both) pockets for convenient document storage, if this feature is available as an option to the binders otherwise approved by the Engineer.
  8. Revision Log sheet shall be included in the front of each manual.
  9. The Authority will grant access to all available technical documentation pertaining to prior versions of Communication Systems to aid the Contractor in developing Communication System Manuals.
  10. The Authority will provide one copy of manufacturer's specification sheets for existing equipment installed in prior systems at the start of the Contract. Most of these Specifications will not be of reproducible quality and will require retyping before including them in the manuals. Whenever good reproductions of manufacturers' specification sheets can be made, especially those with photos or illustrations, their use in manuals is preferred.

- B. Adequacy and Completeness
  - 1. Each complete manual set shall contain a significant amount of detail and significant degree of depth of technical content, including all available details for subsystems. Completeness and accuracy to best commercial standards shall be required. Printing, reproduction, drafting, photographs, graphics, illustrations, and organization, shall be to best commercial standards. All manuals shall be written in English. Each individual manual furnished shall be subject to examination by the Authority for Specification compliance. The Engineer will exercise wide latitude in determining Specification compliance, and may reject manual(s) for noncompliance in minor degrees thereof.
  
- C. Volume A System Related O&M Manuals
  - 1. The Contractor shall furnish complete sets of Volume A Manuals for each of the individual systems.
  
- D. Volume B Equipment Related O&M Manuals
  - 1. The Volume B Manuals shall be equipment-related manual(s). Complete sets of the most extensive and complete Manufacturers' Manuals available shall be provided, with contractor-developed supplemental parts lists, data covering specific options utilized at WMATA, etc. - when applicable.
  - 2. As an exception to the requirements stated herein, abbreviated requirements shall apply to all "Test Equipment," and "Additional Equipment" (i.e. only standard Manufacturers' Service Manuals shall be required, in the quantity specified for such equipment).
  
- E. Submittals Required for Each Volume A and Volume B Manual
  - 1. Five copies of sample formats and Table of Contents outlines (with or prior to the Engineering Development Review).
  - 2. Three copies of complete manuals in draft form prior to Installation Completion Testing.
  - 3. See Tables for quantities of final manuals.

Table of Contents Outline with Minimum Content Requirements:  
 Carrier Transmission System O&M Manual  
 (Volume A - CTS Systems Manual)

<u>SECTION</u>	<u>TITLE/CONTENTS</u>	<u>QTY</u>	<u>MAKEUP</u>
1-1	<b>INTRODUCTION</b> (scope of manual coverage, i.e. all types of carrier transmission systems installed in WMATA passenger stations)	1	page (text)

1-2	<b>SYSTEM DESCRIPTION</b> (detailed description of the latest system, with brief information about major differences in prior systems installed in WMATA passenger stations)	9+ 2+ 1+	pages (text) photographs illustration (sketch)
1-3	<b>SYSTEM SPECIFICATIONS</b> (complete detailed specifications for the latest system, with major differences for prior versions still in use)	1	table
1-4	<b>SYSTEM THEORY OF OPERATION</b> (system theory of operation in detail, covering the latest version of the WMATA Carrier Transmission System)	5+	pages (text)
1-5	<b>INSTALLED SYSTEM CONFIGURATIONS</b> (include written and photographic details covering all types of carrier transmission systems in use)	3+ 15+	pages (text) photographs
1-6	<b>EQUIPMENT LIST</b> (separate lists for each configuration installed in WMATA passenger stations)	1+	page (text)
1-7	<b>EQUIPMENT CHARACTERISTICS</b> (including all models of equipment utilized in various types of WMATA carrier transmission systems)	100+ 60+ 92+	pages (text) photographs tables of equipment specs (derived manufacture's spec sheet info/options, etc.)(WMATA will provide.)
1-8	<b>SYSTEM TROUBLESHOOTING CHARTS</b> (decision tree type flow charts, and horiz. symptom/test/result charts)	1+ 4+	page (text) charts
1-9	<b>SYSTEM/INSTALLATION DRAWINGS</b> (one complete set of system and installation drawings for the current version system, plus block and level diagrams for each prior version)	8+	drawings

OVERRIDING MINIMUM REQUIREMENT TOTALS

Total Page Requirement includes at least 90 full text pages, plus partial text pages; plus pages with photos, charts, tables, illustrations, and title pages	200 (or more)
Total Drawing Requirement, fold-out sizes	10 (or more)
Grand Total of Pages and Drawings Required (minimum acceptable count)	210

Note: The Engineer may allow minor variations to individual section minimum page requirements, when such actions are in the best interest of the Authority, so long as overriding minimum requirements are satisfied.

Table of Contents Outline with Minimum Content Requirements:  
 Fiber Optic System O&M Manual  
 (Volume A - FOS Systems Manual)

<u>SECTION</u>	<u>TITLE/CONTENTS</u>	<u>QTY</u>	<u>MAKEUP</u>
1-1	<b>INTRODUCTION</b> (scope of manual coverage, i.e. both types of fiber-optic systems installed in WMATA passenger stations)	1	page (text)
1-2	<b>SYSTEM DESCRIPTION</b> (detailed description of the latest system, with brief information about major differences in prior system installed in WMATA passenger stations.)	9+ 2+ 1+	pages (text) photographs illustration (sketch)
1-3	<b>SYSTEM SPECIFICATIONS</b> (complete detailed specifications for the latest system, with major differences for prior versions still in use)	1	table
1-4	<b>SYSTEM THEORY OF OPERATION</b> (system theory of operation in detail, covering the latest version of the WMATA Fiber-Optics System)	5+	pages (text)
1-5	<b>INSTALLED SYSTEM CONFIGURATIONS</b> (include written and photographic details covering all types of fiber optic systems in use)	3+ 15+	pages (text) photographs
1-6	<b>EQUIPMENT LIST</b> (separate lists for each configuration installed in WMATA passenger stations)	1+	page (text)
1-7	<b>EQUIPMENT CHARACTERISTICS</b> (including all models of equipment utilized in various types of WMATA fiber optic systems)	20+ 10+ 10+	pages (text) photographs tables of equipment specs (derived manufacture's spec sheet info/options, etc.)(WMATA will provide.)
1-8	<b>SYSTEM TROUBLESHOOTING CHARTS</b> (decision tree type flow charts, and horiz. symptom/test/result charts)	1+ 4+	page (text) charts
1-9	<b>SYSTEM/INSTALLATION DRAWINGS</b> (one complete set of system and installation drawings for the current version system, plus block and level diagrams for each prior version)	8+	drawings

OVERRIDING MINIMUM REQUIREMENT TOTALS

Total Page Requirement includes at least 60 full text pages, plus partial text pages; plus pages with photos, charts, tables, illustrations, and title pages)	125
Total Drawing Requirement, fold-out sizes	10
Grand Total of Pages and Drawings Required (minimum acceptable count)	135+

Note: The Engineer may allow minor variations to individual section minimum page requirements, when such actions are in the best interest of the Authority, so long as overriding minimum requirements are satisfied.

Table of Contents Outline with Minimum Content Requirements:  
Telephone System O&M Manual  
(Volume A - TEL Systems Manual)

<u>SECTION</u>	<u>TITLE/CONTENTS</u>	<u>QTY</u>	<u>MAKEUP</u>
1-1	<b>INTRODUCTION</b> (scope of manual coverage, i.e. all types of telephone systems installed in WMATA facilities) (WMATA will provide sections for Telecommunication Network and PABX System for insertion in this section.)	1	page (text)
1-2	<b>SYSTEM DESCRIPTION</b> (detailed description of the latest system, with brief information about major differences in prior system installed in WMATA facilities) (WMATA will provide sections for Telecommunication Network and PABX System for insertion in this section.)	9+ 2+ 1+	pages (text) photographs illustration (sketch)
1-3	<b>SYSTEM SPECIFICATIONS</b> (complete detailed specifications for the latest system, with major differences for prior versions still in use) (WMATA will provide sections for Telecommunication Network and PABX System for insertion in this section.)	1+	table
1-4	<b>SYSTEM THEORY OF OPERATION</b> (system theory of operation in detail, covering the latest version of WMATA telephone systems) (WMATA will provide sections for Telecommunication Network and PABX System for insertion in this section.)	5+	pages (text)
1-5	<b>INSTALLED SYSTEM CONFIGURATIONS</b> (include written and photographic details covering all types of telephone systems in use) (WMATA will provide sections for Telecommunication Network and PABX System for insertion in this section.)	3+ 15+	pages (text) photographs
1-6	<b>EQUIPMENT LIST</b> (separate lists for each configuration installed in WMATA passenger stations) (WMATA will provide sections for Telecommunication Network and PABX System for insertion in this section.)	1+	page (text)
1-7	<b>EQUIPMENT CHARACTERISTICS</b> (including all models of equipment utilized in various types of WMATA telephone systems)	8+ 8+ 8+	pages (text) photographs tables of equipment specs (derived manufacture's spec sheet info/options, etc.)(WMATA will provide.)
1-8	<b>SYSTEM TROUBLESHOOTING CHARTS</b> (decision tree type flow charts, and horiz. symptom/test/result charts)	1+ 4+	page (text) charts

1-9 **SYSTEM/INSTALLATION DRAWINGS** 8+ drawings  
 (one complete set of system and installation drawings for the current version system, plus block and level diagrams for each prior version) (WMATA will provide sections for Telecommunication Network and PABX System for insertion in this section.)

OVERRIDING MINIMUM REQUIREMENT TOTALS

Total Page Requirement includes at least 90 full text pages, plus partial text pages; plus pages with photos, charts, tables, illustrations, and title pages) 260+  
 Total Drawing Requirement, fold-out sizes 15+  
 Grand Total of Pages and Drawings Required (minimum acceptable count) 275+  
 Note: The Engineer may allow minor variations to individual section minimum page requirements when such actions are in the best interest of the Authority, so long as overriding minimum requirements are satisfied.

Table of Contents Outline with Minimum Content Requirements:  
 Mobile Radio System O&M Manual  
 (Volume A - MRS Systems Manual)

<u>SECTION</u>	<u>TITLE/CONTENTS</u>	<u>QTY</u>	<u>MAKEUP</u>
1-1	<b>INTRODUCTION</b> (scope of manual coverage, i.e. all types of mobile radio systems installed in WMATA facilities) (WMATA will provide brief section on Rail Car radios system.)	1	page (text)
1-2	<b>SYSTEM DESCRIPTION</b> (detailed description of the latest system, with brief information about major differences in prior system installed in WMATA facilities) (WMATA will provide brief section on Rail Car radios system)	9+ 2+ 1+	pages (text) photographs illustration (sketch)
1-3	<b>SYSTEM SPECIFICATIONS</b> (complete detailed specification for the latest system, with major differences for prior versions still in use) (WMATA will provide brief section on Rail Car radios system)	1+	table
1-4	<b>SYSTEM THEORY OF OPERATION</b> (system theory of operation in detail, covering the latest version of WMATA mobile radio systems) (WMATA will provide brief section on Rail Car radios system)	5+	pages (text)
1-5	<b>INSTALLED SYSTEM CONFIGURATIONS</b> (include written and photographic details covering all types of mobile radio systems in use) (WMATA will provide brief section on Rail Car radios system)	3+ 15+	pages (text) photographs
1-6	<b>EQUIPMENT LIST</b> (separate lists for each configuration installed in WMATA passenger stations and yards) (WMATA will provide brief section on Rail Car radios system)	1+	page (text)

1-7	<b>EQUIPMENT CHARACTERISTICS</b> (including all models of equipment utilized in various types of WMATA mobile radio systems)	8+ 8+ 8+	pages (text) photographs tables of equipment specs (derived manufacture's spec sheet info/options, etc.)(WMATA will provide.)
1-8	<b>SYSTEM TROUBLESHOOTING CHARTS</b> (decision tree type flow charts, and horiz. symptom/test/result charts) (WMATA will provide brief section on Rail Car radios system)	1+ 4+	page (text) charts
1-9	<b>SYSTEM/INSTALLATION DRAWINGS</b> (one complete set of system and installation drawings for the current version system, plus block and level diagrams for each prior version) (WMATA will provide brief section on Rail Car radios system)	8+	drawings

OVERRIDING MINIMUM REQUIREMENT TOTALS

Total Page Requirement includes at least 60 full text pages, plus partial text pages; plus pages with photos, charts, tables, illustrations, and title pages)	230+
Total Drawing Requirement, fold-out sizes	15+
Grand Total of Pages and Drawings Required (minimum acceptable count)	245+

Note: The Engineer may allow minor variations to individual section minimum page requirements when such actions are in the best interest of the Authority, so long as overriding minimum requirements are satisfied.

**1.12 TRAINING**

- A. The objective of the training program shall be to qualify WMATA training instructors, field engineers, and key supervisory personnel to train WMATA maintenance and operating personnel to properly operate, diagnose, troubleshoot and maintain the communications equipment and/or systems provided by, or affected by, work in this Contract.
- B. The Contractor shall provide training for Authority training instructors, engineers, key supervisory technical personnel, and a cadre of maintenance personnel. Training in operating and maintaining equipment shall be provided in accordance with these Specifications. Training shall consist of a combination of formal classroom instruction and hands-on equipment training. Classrooms and on-site training locations will be provided by WMATA. All test equipment and tools for training equipment installation and training course work shall be provided by the Contractor, (for both Contractor personnel and WMATA Trainee use) until training is complete.
- C. Scope of Training Program
  - 1. The training program shall be devoted to overall system functioning and instruction on key items of equipment. The training shall be a combination of formal and hands-on training, including demonstrations. Training shall be conducted at Authority training facilities.
  - 2. The Contractor shall provide the instruction and training sessions specified herein.
  - 3. As part of the Engineering Development Review, the Contractor shall submit a Training Concept Plan to the Authority for approval. It shall include the subject matter to be covered, a tabulation of the hours of instruction to be provided, and the equipment to be included in the training program. It shall include a list of proposed

Contractor training to be conducted at various Authority facilities and locations. The Authority will select training sessions from this list.

- D. Training Course Objectives
1. The Contractor shall develop an individual Training Course designed to cover basic maintenance of the Fiber Optic System using new Training Equipment Mockups supplied by the Contractor.
  2. The maintenance course shall provide each student with instruction designed to meet the following objectives:
    - a. Understanding of the basic overall operation of the Mockup as it relates to an equivalent installed Passenger Station Communications subsystem.
    - b. Understanding of the nature of each of the signal and power inputs and outputs of major Communications equipment items.
    - c. Knowledge of the location of all equipment test points and the best strategy for using the test points.
    - d. Familiarity with the Operation and Maintenance Manuals, and knowledge of how to contact the equipment manufacturers for parts, and information.
    - e. Qualification of the student to begin assuming maintenance (or operations) responsibilities for the system and equipment items.
- E. The Contractor's training program shall be conducted by fully qualified instructors. The instructors shall have thoroughly mastered the specific specialized subject matter involved and shall have the ability to impart technical information to others in easily understood terms. The Contractor shall provide a professional resume for each instructor for review and approval by the Authority. Contractor installation, repair and technical personnel shall also be provided to do installation tasks, with WMATA trainee participation (to the extent agreed to by the Engineer).
- F. Training Aids and Materials
1. The training shall be organized to make optimum use of Volume "B" O&M Manuals, Contract Specifications and Drawings, approved Progress Review material, approved Contractor Shop Drawings, and the test equipment furnished to the Authority, in accordance with other provisions of this Contract. The Contractor shall furnish all other required training aids and materials necessary for the training program.
  2. The Contractor shall provide copies of each Course Outline, copies of each Lesson Plan, copies of Instructor's Guide(s) and copies of Student Work Books. Operations and Maintenance Manuals, Volume "A" System Manuals and Volume "B" Equipment Manuals, furnished by the Contractor, shall be furnished to each student attending the Maintenance Courses, along with additional copies as required.
  3. Training materials, such as lesson plans, study guides, and student handouts, as well as training aids, such as transparencies, slides, photographs, dynamic mockups, models for hands-on demonstration training and hardware cut-aways, utilized in the courses shall become property of the Authority.
- G. WMATA requires the following training course materials to be delivered by the Contractor, according to the following specifications:
1. An instructor's guide, containing all the information and directions necessary for the instructor to make an effective presentation. It shall include adequate guidelines to conduct a comprehensive training program. Individual lessons within the course shall be organized as separate blocks (or modules) which may be taught individually. The Instructor Guide should contain, at a minimum:
    - a. Discussion of student prerequisites (if any);

- b. Program overview;
  - c. Statement of overall program goals;
  - d. Lesson plans (a session by session outline containing the following):
    - 1) Student learning objectives, stated in measurable terms;
    - 2) Overview of each lesson;
    - 3) Suggested instructional methods/ learning activities;
    - 4) Required equipment and/or resources.
2. Student work books, to include all materials for the student to interact in the learning situation. It shall contain, at a minimum:
- a. Program overview/introduction;
  - b. Statement of overall program goals
  - c. Learning objectives, stated in measurable terms, that specifically describe desired behaviors or knowledge to be gained;
  - d. A fully-developed prose treatment (not outline format) of content presentation, developed in the same modular format as the Instructor's Guide;
  - e. Illustrations, charts, or graphics, as needed to enhance text presentation;
  - f. Problems/questions related to lesson content, as appropriate.
3. Audio-visual aids, (handouts, transparencies, slides, films, and mock-ups used to conduct the Training Courses).
4. Supplemental materials, a functional mockup, or a functional representation, is required of any equipment item which requires theoretical discussion. This may be in the form of an animated schematic, a model of the equipment, an actual device, an interactive video training device, or a WMATA approved substitute. All mockups become the property of WMATA.
5. The Contractor shall deliver final copies to WMATA as follows:
- a. Two complete sets of training materials that are completely camera-ready. Camera-ready copy is defined as typewritten or typeset originals or high-quality copies from which further copies can be made with no noticeable decrease in copy quality.
  - b. Five copies of all student and instructor materials, to be used for archival purposes in the WMATA Technical Library.
- H. The Contractor shall meet the following specifications in instructional delivery.
- 1. A description of instructor qualifications, resume, curriculum vitae, or other similar credentials must be submitted to WMATA at least 60 days prior to the presentation of training. The description should document a thorough knowledge of the equipment being taught, an understanding of the adult learning process, and demonstrated experience in vocational instruction.
  - 2. The course shall include at least 4 hours of instruction for each major system, and at least 1 hour of instruction for each significant minor system/subsystem (course layout and time allotment shall be submitted for approval by the Authority at least 30 days prior to scheduled classes).
  - 3. For the purposes of course development and presentation, contractors should assume all WMATA students are high school graduates (or equivalent), and that maintenance personnel possess the ability to use basic hand tools and electronic test equipment, and that most trainees have some experience with the systems to be taught.
  - 4. Instructors shall include written and/or practical tests in the Training Courses. Whenever possible, a practical hands-on test shall be developed to demonstrate the transference of operational/ maintenance skills. Results and student evaluations will be provided to the Engineer on a confidential basis, for WMATA use.

### **1.13 SAMPLES**

- A. Samples For Review:
  - 1. Submitted to Engineer for review for the limited purpose of checking for conformance with information given and the design concept expressed in the contract documents.
  - 2. After review, produce duplicates and distribute in accordance with Submittal Procedures article above and for record documents purposes.
- B. Samples For Information:
  - 1. Submitted for the Engineer's knowledge.
- C. Samples For Selection:
  - 1. Submitted to Engineer for aesthetic, color, or finish selection.
  - 2. Submit samples of finishes from the full range of manufacturers' standard colors, textures, and patterns for Engineer selection.
  - 3. After review, produce duplicates and distribute in accordance with Submittal Procedures article above and for record documents purposes.
- D. Submit samples to illustrate functional and aesthetic characteristics of the Product, with integral parts and attachment devices. Coordinate sample submittals for interfacing work.
- E. Include identification on each sample, with full Project information.
- F. Submit the number of samples specified in individual specification sections, one of which will be retained by Engineer.
- G. Reviewed samples that may be used in the Work are indicated in individual specification sections.
- H. Samples will not be used for testing purposes unless specifically stated in the specification section.

### **1.14 DESIGN DATA**

- A. Submitted for the Engineer's review.
- B. Submit for information for the purpose of assessing conformance with information given and the design concept expressed in the contract documents

### **1.15 TEST REPORTS**

- A. Submitted for the Engineer's review.
- B. Submit test reports for information for the purpose of assessing conformance with information given and the design concept expressed in the contract documents.

### **1.16 CERTIFICATES**

- A. When specified in individual specification sections, submit certification by the manufacturer, installation/application subcontractor, or the Contractor to Engineer, in quantities specified for Product Data.
- B. Indicate material or Product conforms to or exceeds specified requirements. Submit

supporting reference data, affidavits, and certifications as appropriate.

- C. Certificates may be recent or previous test results on material or Product, but must be acceptable to Engineer.

#### **1.17 MANUFACTURER'S INSTRUCTIONS**

- A. When specified in individual specification sections, submit printed instructions for delivery, storage, assembly, installation, start-up, adjusting, and finishing, to Engineer for delivery to Authority in quantities specified for Product Data.
- B. Indicate special procedures, perimeter conditions requiring special attention, and special environmental criteria required for application or installation.
- C. Refer to Section 16707 - Quality Control, Manufacturers' Field Services article.

#### **1.18 MANUFACTURER'S FIELD REPORTS**

- A. Submitted for the Engineer's review.
- B. Submit report within 30 days of observation to Engineer for information.
- C. Submit for information for the purpose of assessing conformance with information given and the design concept expressed in the contract documents.

### **PART 2- PRODUCTS**

**NOT USED**

### **PART 3 - EXECUTION**

**NOT USED**

**END OF SECTION**

## SECTION 16707

### COMMUNICATIONS SYSTEMS QUALITY ASSURANCE & TESTING

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. These quality control (QC) system requirements define characteristics, in addition to those in Division 1 of the Specification, of the quality control system that must be implemented by the Contractor during the course of Communications System design, equipment procurement, factory testing, installation and acceptance testing.
- B. The Contractor shall provide and maintain a Quality Assurance Plan, and an Inspection and Testing Plan covering the equipment, materials, and services specified herein.
- C. The CQCS Quality Assurance Program, Quality Assurance Plan, and Inspection and Testing Plan, including related directives, procedures, processes, instructions, forms and schedules, shall be submitted to the Engineer for approval. The basis for approval shall be the Engineer's acceptance of a document describing how the Quality Assurance Program requirements, set forth herein, shall be met and the acceptance of the form and substance of each document submitted for approval. The approved program and plans shall be used by the Contractor in the performance of any inspection of the equipment, materials and services being furnished. If program/plans are returned as unacceptable, the Contractor shall revise and resubmit the Quality Assurance Program or plans to the Engineer within 30 calendar days.
- D. The basis for this quality control (QC) system requirements are the American National Standards Institute (ANSI) Standard ANSI/ISO/ASQC Q9002-1994 entitled "Quality Systems -Model for Quality Assurance in Production and Installation and Servicing.." Quality control systems based on other standards may also be acceptable provided they contain elements that meet these requirements.

##### 1.02 RELATED SECTIONS

- A. Division 1
- B. Division 16 - Communications Sections

##### 1.03 REFERENCES

- A. American National Standards Institute (ANSI) Standard ANSI/ISO/ASQC Q9002-1994

##### 1.04 DEFINITION OF TERMS

- A. Quality Assurance Program: The document containing the Contractor's quality-related policies, practices, procedures and methods, which are utilized to assure compliance with Contract Specifications.
- B. Quality Assurance Plan: A document detailing how the Contractor will implement the Quality Assurance Program

- C. Inspection and Test Plan: A document detailing how the Contractor will inspect and test Contract equipment, materials, workmanship, and services.
- D. Inspection: The physical act of verifying, by measurement and examination of the equipment, materials, workmanship, and services, that they conform to approved documents and established quality requirements.
- E. Audit: An examination of the Contractor's implementation of the approved Quality Assurance Program for the purpose of determining compliance with and conformance to the Quality Assurance Plan and other related documents.

#### **1.05 QUALITY POLICY**

- A. The Supplier shall establish and document policies to implement quality control systematically in a manner that meets these QC system requirements. These policies shall be revised or amended until they are accepted by the Engineer.

#### **1.06 QUALITY SYSTEM**

- A. The Contractor shall document and implement a quality control system consistent with the policies accepted by the Engineer. The quality system shall include:
  - 1. Written procedures and instructions governing the work covered by this contract.
  - 2. Effective and verifiable implementation of these procedures and instructions.
- B. Activities affecting quality shall be prescribed via documented instructions, procedures, or drawings of a type appropriate to the circumstances and shall be accomplished in accordance with these instructions, procedures, or drawings.
- C. Instructions, procedures, or drawings shall include appropriate measurable or otherwise verifiable criteria for determining that important activities have been satisfactorily accomplished.

#### **1.07 ORGANIZATION**

- A. The submitted Quality Assurance Program document shall be organized as follows:
  - 1. Name of Contractor and Contract
  - 2. Revision Dates
  - 3. Index
  - 4. Contents
- B. The Contractor shall identify the elements of its organization involved with this Contract, including subcontractors and Original Equipment Manufacturers (OEMs), and the scope of responsibility and authority of these parties.
- C. Interfaces with OEMs, subcontractors, and WMATA shall be identified and the scope of each group's responsibilities described
- D. The responsibility, authority and the interrelation of personnel who manage, supervise, perform and verify work affecting the quality of items intended for WMATA shall be defined, particularly for personnel who must exercise authority to:
  - 1. Initiate, recommend or provide solutions through designated channels to eliminate identified noncompliance or nonconformance,
  - 2. Control further processing, delivery or installation of items until the noncompliance or nonconformance has been corrected, and

3. Initiate action to prevent the occurrence of noncompliance or nonconformance.
- E. Inspection and testing functions shall have sufficient resources and organizational independence to perform their responsibilities. Except in-process monitoring, they shall not report to the same management as those who performed the work nor have had input as to how the work was accomplished or accepted.

#### **1.08 SCOPE**

- A. The Contractor shall provide a statement that identifies the functional areas of Contractor work and the locations where such work is performed. The Quality Assurance Program shall apply to all equipment, systems, and services included in these Specifications, except as otherwise stated. The Contractor's functional work area breakdown shall include, but shall not be limited to, management, engineering, procurement, manufacturing, installation, and inspection.

#### **1.09 SUBMITTALS**

- A. The Quality Assurance documents shall be submitted within 30 calendar days after Notice-To-Proceed. Contractor test and inspection procedures shall be added to the approved Quality Assurance Program within 30 days after they are developed. Details concerning fabrication processes for equipment and systems that require development shall be added to the approved Quality Assurance Program as the development work progresses (within 30 days after they are developed).

#### **1.10 DELIVERY, STORAGE AND HANDLING**

- A. The Contractor shall establish and implement measures for maintaining the integrity, security, and acceptability of items during receiving, handling, storage, movement or placement of items.
- B. The Contractor shall maintain packing and preservation of items to the extent necessary to ensure conformance with this contract until these items are installed. The packaging of items inspected at the receiving point shall be resealed upon completion of the inspection.
- C. The Contractor shall provide secure storage areas to prevent loss of, damage to, or deterioration of items pending their use:
1. Items of different types shall be segregated while in storage;
  2. Measures shall ensure that the shelf life of items which deteriorate over time are reported, and that those with expired shelf life are scrapped;
  3. Special environment, maintenance (when items are stored for long periods), and stacking limits required by the manufacturer shall be observed.
  4. In order to detect deterioration, the condition of items in storage shall be checked and assessed at appropriate intervals.
  5. Appropriate methods shall be established for authorizing receipt or release of items at these storage areas.
- D. Handling
1. The Contractor shall employ qualified personnel, methods and equipment to prevent damage during handling.
  2. Handling equipment and rigging shall be periodically inspected, maintained and tested. Load capacities or ratings shall be visible on the equipment; capacities and ratings shall not be exceeded.

3. Operators shall be trained, and, where required by local codes or elsewhere in this contract, certified. WMATA requirements and rules for use of handling equipment shall also be observed at all WMATA properties, leased premises, or construction sites.

## **PART 2 - PRODUCT**

### **NOT USED**

## **PART 3 EXECUTION**

### **3.01 QUALITY MANAGEMENT**

- A. The Contractor shall identify and describe the organizational units having responsibility and authority for development, implementation, and management of the Quality Assurance Program. Achievement of quality objectives shall be verified by individuals and organizations that are responsible for checking, inspecting, auditing, or otherwise verifying that the work has been performed satisfactorily.
- B. The Contractor shall identify the program for assuring that sufficient records are maintained to provide documentary evidence of the performance of activities affecting quality and for use in managing the Contract. Typical records shall include Quality Assurance plans, procedures, instructions, nonconformance or defect reports, corrective action reports, and such other quality-related documents as are specified in the Contract Specifications.
- C. The Contractor shall identify the program for verifying and determining the cause of unsatisfactory product or workmanship quality and for initiating necessary improvements and corrections to preclude repetition. The Contractor's program should extend, when necessary, to the performance of subcontractors and suppliers.

### **3.02 DESIGN (AND DEVELOPMENT)**

- A. The Contractor shall prepare and maintain a plan for inspecting the quality of engineering, development, testing, and documentation activities. The Contractor shall identify the procedures, practices, tables, charts and diagrams applicable to the effort.
- B. The Contractor shall document the engineering criteria applicable to the product being supplied. Include performance objectives, operating ranges and conditions, requirements for safety, reliability, availability, the requirements (codes, standards, and practices) for materials, fabrication, construction, testing, operation, maintenance, and quality assurance.
- C. Studies, to be conducted in support of the engineering (or development) activity, shall be identified by the Contractor. They shall include analysis of allowable "tradeoffs" and alternatives, identification of potential weaknesses, and the appropriate preventative engineering features, operating and maintenance practices, and safety precautions.
- D. The Contractor shall identify the program for assuring that specifications, drawings, and other engineering documents will delineate, as applicable:
  1. Materials and methods, including fabrication, construction, installation, inspection, maintenance cleaning, packaging, shipping, handling, and storage.
  2. Traceability of materials, parts, components, and processes through appropriate lot, piece part, serial, or other appropriate numbers.
  3. Product or workmanship acceptance criteria and the checkpoints during the work process for verifying compliance with the criteria.

- E. The Contractor shall identify the methods and procedures for defining and controlling engineering interfaces with other project participants and design organizations. The procedures shall cover the exchange of required engineering data, analysis and resolution of engineering interface problems.
- F. The Contractor shall identify procedures for controlling release of documents for authorized use.
- G. The Contractor shall identify procedures for documenting the reporting, verifying, analysis, and correcting of troubles that occur during development.
- H. Design criteria and input, including computer applications software, shall be identified, documented, and their selection reviewed by those responsible for the technical adequacy of the design. In all cases, the names of the preparer, checker, and the date the checker accepted the document shall be shown.
- I. Incomplete, ambiguous, or conflicting requirements shall be resolved by those who drew up the design criteria and input and those who approved their selection.
- J. The design input obtained from surveys of existing systems, structures, or facilities shall be documented and identified.
- K. Design output (calculations, specifications, and drawings) shall be documented as requirements in a clear, logical, and uniform manner.
- L. In all cases, the names of the preparer, checker and the date the checker accepted the document shall be shown.
- M. Where required by the applicable Code, design standard, or this contract, design output shall be certified and/or sealed by the appropriate professional practitioner.
- N. The calculation method or computer program shall be identified (including computer software version). The reference source of special, state-of-the-art, or experimental features that are not widely accepted in the railroad industry shall also be identified and those features briefly summarized.
- O. Where the design output is a computer or computer software, specifications, user manuals, and testing and validation files shall be provided. Where the contract conveys to WMATA the license to duplicate, upgrade, repair, and modify the computer or computer code, detailed schematic diagrams, specifications, any special tools, and working standards shall be provided to enable the exercise of the license.
- P. The design shall be verified to have met the requirements of this Contract. Design verification shall be documented and may take the form of design review, checking, alternative analysis or calculation, comparison with proven design, or performance of qualification tests and demonstrations. Design verification documentation. (including OEM equipment qualification testing) shall be made available to the Engineer upon request.
- Q. The Contractor shall establish and implement measures to identify, control, and assess the impact of proposed design changes (including those from the OEMs) on specified functional, safety, and quality requirements, and added cost and schedule changes are identified and justified.

- R. Design changes shall be reviewed, verified and approved in the same manner as the original version. The Contractor shall assign qualified personnel to review and coordinate design changes.
- S. The Contractor shall obtain the Engineer's approval of proposed changes prior to implementing these.

### **3.03 DOCUMENT CONTROL**

- A. The Contractor shall establish and implement measures to control reports, procedures, contract technical deliverable documents, OEM and subcontractor technical submittals, and other records and information it generates or receives that relate to equipment performance characteristics, qualification testing, factory testing, installation, inspection, and acceptance testing. This control shall ensure that:
  - 1. The latest, approved versions of documents or information described above are available where affected Supplier's activities are performed.
  - 2. Revised documents are redistributed to those who received the previous issue.
  - 3. Superseded or obsolete documents are promptly removed from areas of work and stations where controlled documents must be distributed.
  - 4. Changes are reviewed and approved by the same functions or organizations that performed the original review and approval or their designated successors.
  - 5. A means (such as a list or computerized database) to identify the current revision of instructions, procedures, drawings, specifications, or calculations is available.
  - 6. Communications (memorandums of meetings, requests for clarification, etc.) and reports are issued or responded to in a timely manner.
- B. The Contractor shall establish and implement measures to revise and maintain procedures and other records that relate to the performance characteristics, installation, inspection, and testing of components, equipment, or systems in an updated condition. Current as-built condition of equipment shall be retained on file.
- C. Purchasing documents shall contain data clearly describing the product ordered, including, where applicable:
  - 1. The type, class, style, grade, or other precise requirements,
  - 2. The title, number designation and revision of specifications, drawings, process requirements, inspection/test requirements and other relevant technical and quality control requirements, including requirements for approval or qualification of product, procedures, process or inspection equipment and personnel.
  - 3. The title, number and revision of any applicable technical and quality standards to be applied to the product.
  - 4. As a minimum, OEMs shall be required to furnish Certificates of Conformance to the design and manufacturing standards specified by the Supplier, together with the equipment supplied.

### **3.04 PROCUREMENT**

- A. The Contractor shall identify the procedures for controlling the receipt, inspection, testing, handling, storage, and distribution of received equipment and its protection from damage, deterioration, loss or substitution. Inspection instructions and test procedures shall provide for verification of characteristics required by the Contract Drawings and Specifications, and documentation of results.

- B. The Contractor shall identify the procedures for controlling purchased items that do not conform to Specifications. The procedures shall provide for prompt identification, documentation, segregation, technical review, and disposition of non-conforming items.
- C. The Contractor shall establish and implement measures for obtaining items and services from suppliers or subcontractors that conform with specified requirements:
  - 1. The Contractor shall select its OEMs, subcontractors and other sub-suppliers on the basis of their ability to meet specified requirements
  - 2. Any procurement requirement which differs from those in the selected OEM, subcontractor, or other sub-supplier's proposal or offer is resolved and the resolution incorporated into the purchase order or contract, and
  - 3. Records are maintained to show acceptability of the selected OEM, subcontractor, or other sub-supplier (where available, records of previously demonstrated capability and performance should be provided to show acceptability of the selected supplier).

### **3.05 MANUFACTURING, FABRICATION, AND ASSEMBLY**

- A. The Contractor shall identify the procedure and instructions that will be used to assure that fabrication, processing, and assembly operations are being satisfactorily performed.
- B. The Contractor shall identify the inspection and test plans that will be applied to all manufacturing activities for the purpose of verifying conformance to procedures and instructions.
- C. The Contractor shall identify the method employed for tracing the identity of materials and items throughout fabrication, processing, or assembly operations.
- D. The Contractor shall identify the procedures, instructions, and checklists for the control of the fabrication and assembly processes. This shall include such items as shop orders, process sheets, travelers, and inspection instructions, covering all mechanical, electrical, and metallurgical processes. Inspection instructions shall identify the nondestructive examination processes employed.
- E. The Contractor shall identify the methodology of the program including record maintenance.
- F. The Contractor shall identify the procedures for prompt identification, documentation, segregation, technical review, and disposition of non-conforming items.
- G. The Contractor shall identify the procedures and instructions for handling, preserving, packing, packaging, storing, and shipping items shipped to the construction site.

### **3.06 INSTALLATION**

- A. The Contractor shall identify the procedures, check off lists, and instructions governing receipt inspection of equipment on arrival at the construction site. The Contractor shall include in the procedures the control of non-conforming items.
- B. The Contractor shall identify the procedures for on-site configuration control. This shall include the control of drawings, specifications, work instructions, quality-control procedures, inspection instructions, and testing procedures, used in connection with installation.
- C. The Contractor shall identify the procedures and work instructions that apply to installation methods, tests, repairs and rework, cleaning and protection.

- D. The Contractor shall identify the inspections and tests to be performed to verify installation suitability.
- E. The Contractor shall identify the procedures for controlling the on-site identification, documentation, segregation, technical review, and disposition of non-conforming supplies or workmanship.

### **3.07 INSPECTION AND TESTING**

- A. The Contractor shall establish and implement a Unified Test Program that will ensure all communications and related systems, equipment, material and services, furnished during the performance of this Contract, meet the technical requirements and standards specified, as well as all performance criteria.
- B. As part of the Contractor's area of responsibility for the Unified Test Program, the Contractor will be required to:
  - 1. Develop a comprehensive Test Plan detailing methods and test procedures to be utilized to ensure compliance with all applicable specifications.
  - 2. Develop detailed test procedures for each individual test within each category of testing, except Authority tests.
  - 3. Submit the Test Plan (including Authority System Validation Tests, Substantial Completion Acceptance, and Final Acceptance Programs) and all test procedures to the Engineer for evaluation, review, and acceptance or rejection. Revise and resubmit until acceptance by the Engineer is received.
  - 4. Furnish personnel, calibrated test equipment, tools, and miscellaneous supplies as necessary to perform all tests and retests, and to maintain all systems and equipment during the test period and until acceptance by the Authority.
  - 5. Coordinate Unified Test Program activities with the schedules and activities of other contractors and with the Engineer, to avoid conflicts with Authority operational requirements.
  - 6. Perform tests and inspections as detailed in all approved test procedures.
  - 7. Evaluate test procedure and inspection results and documentation. Prepare detailed test evaluation reports, summary reports and progress reports.
  - 8. Submit all raw test data, test results, evaluations, and summary reports for evaluation, review and acceptance or rejection by the Engineer.
  - 9. Prepare and submit revised test procedures and test plans to correct procedural and technical errors or omissions discovered in those documents, after their initial Authority acceptance.
  - 10. Furnish corrective actions to effect Specification compliance, including: Remedy test program deficiencies, and system, equipment, material, workmanship, and documentation deficiencies promptly upon request by the Engineer.
  - 11. Perform retesting and additional inspections until successful results are obtained, evaluated, and accepted by the Engineer.
  - 12. Participate in Authority Pre-final Inspections, Substantial Completion (if any), and Final Acceptance activities. Clean the equipment and work site, secure the equipment, and remain responsible for prompt repair or replacement in the event of loss or damage until acceptance by the Authority is received. Furnish inventory services and demonstrate system or equipment operation in support of requests by the Authority. Provide support and access so that the Authority Engineers, Technicians, Mechanics and Inspectors can inspect and test any portion of the work during normal work hours.

13. Provide Unified Test Program reports on a monthly basis beginning within 30 days after the Engineer's acceptance of the Test Plan, and continuing until the final completion of all contract work.
- C. The performance of each task requirement shall be subject to the Engineer's acceptance of methods, procedures, and results, for Specification compliance, and as to scheduling for the benefit of the Authority.
- D. A Preliminary Test Plan shall be submitted to the Engineer for review. Subsequently, the Final Test Plan shall be submitted to the Engineer for review and acceptance or rejection. In the event of rejection or subsequent rejections, corrected re-submissions shall be delivered to the Engineer within 15 days after the receipt of each rejection. An accepted Test Plan shall be required prior to implementing any category of tests except for factory tests and inspections, installation and completion tests, inspections for cable, and associated terminal equipment, which may be accepted on an individual basis for equipment, and materials that are scheduled to be installed or delivered prior to NTP + ###.
- E. Detailed test procedures shall be submitted to the Engineer for review and acceptance or rejection. In the event of rejection or subsequent rejections, corrected re-submissions shall be delivered to the Engineer within 15 days after receipt of each rejection. Approved test procedures shall be required prior to commencing any associated test.
- F. Each individual test procedure shall include, but not be limited to: An outline of test objectives, detailed step-by-step procedures with required results and allowable tolerances for each measurement or observation, diagrams illustrating all required test set-ups, manufacturer and model number of each unit and accessory item of required test equipment, and further details as may be required by the Engineer to ensure that both Contractor and Authority field forces are presented with a totally comprehensive, understandable and accurate working procedure.
- G. The Contractor shall include complete and adequate safety procedures, warnings, and emergency instructions in Test Plans and test procedures, as appropriate. Test procedures shall also include complete examples of test Data Record Forms with required resultant values and allowable tolerances, in accordance with Specification requirements.
- H. The Authority reserves the right to perform additional non-destructive tests and inspections at any time during the course of the contract work. Results indicating deficiencies involving noncompliance with Specification requirements will be reported to the Contractor for corrective action.

### **3.08 DEFICIENCIES**

- A. If the Engineer determines from test data acquired from any category of test(s) that the system, equipment, materials, technical documentation, or services furnished do not conform to any Specification requirement(s), the Contractor shall recommend appropriate remedial action based on an analysis of test results within fifteen days after receipt of the Engineer's notice of deficiency. When such recommendations relate to engineering deficiencies, the Contractor shall, upon receipt of the Engineer's approval, make the necessary changes to all equipment and documentation of the type to be delivered or previously delivered (even if previously accepted) during the course of the Contract, at no additional cost to the Authority.
- B. When recommendations relate to other deficiencies such as quality control and installation workmanship, the Contractor shall correct all deficiencies at each location, at no additional

cost to the Authority. Retesting after the changes have been completed (Factory Tests and Inspections, Installation Completion Tests and Inspections, and Technical Documentation Verifications) shall be required in whole or part, as determined by the Engineer, at no additional cost to the Authority. If the timely correction of all deficiencies is not completed to effect Specification compliance, as evidenced by the Engineer's acceptance of retest results, the Engineer will initiate remedial actions to the benefit of the Authority. Such actions may include the exercise of warranty, correction of deficiency, delay of payments, disputes or default, and termination actions, in accordance with the General Provisions, or actions of benefit to the Authority, in accordance with any combination of these and other Specification provisions.

### **3.09 CATEGORIES OF TESTS**

- A. Tests and inspections shall be required in each of seven categories, as listed below:
  - 1. Factory tests and inspections, including factory certifications and factory calibration certifications.
  - 2. Installation completion tests and inspections.
  - 3. System and integration tests.
  - 4. System validation tests and evaluations (Authority Conducted Program).
  - 5. Substantial Completion acceptance tests and inspections (if any) (Authority Conducted Program).
  - 6. Technical documentation verification inspections.
  - 7. Final acceptance tests and inspections (Authority Conducted Program).
- B. Each test and inspection in each category shall be comprehensive, so that sufficient test result data and inspection result data is furnished to permit complete detailed examination and evaluation, as determined by the Engineer.
- C. Additional specialized testing shall also be furnished, as defined in individual system specification Sections .
- D. Retesting, and the acceptance or rejection of test results, documentation, and evaluations, shall be within the discretion of the Engineer.

### **3.10 FACTORY TESTS AND INSPECTIONS**

- A. All equipment and materials, including custom developed Additional Equipment and any custom developed Test Equipment, furnished in accordance with these Specifications, shall be subject at all times and during all stages of manufacture and assembly, to inspection, test, and rejection by the Engineer. The Engineer may elect to accept factory or Contractor certifications in lieu of complete test result data for certain items when, 1) a WMATA accepted factory test has been previously conducted on one or more production samples or identical deliverable products, 2) the same brand and model of the product to be furnished has proven reliable in Authority revenue service for one year or more, or 3) to simplify test program administration when not adverse to achieving Test Program objectives.
- B. Before offering items for inspection or test, the Contractor shall furnish a complete set of applicable drawings for Authority use including, but not limited to, schematics, wiring diagrams, major assembly drawings, manufacturing drawings for custom developed equipment, and detailed specifications for the equipment and materials to be tested.
- C. The Contractor shall submit Factory Test and Inspection Plans and Procedures to the Engineer for review. Tests required shall be performed at the point of manufacture and the

point of assembly before shipment to the field. The Contractor shall furnish additional testing by an independent testing laboratory if the manufacturer's Factory Test Plan or Procedures are determined by the Engineer to be inadequate to verify Specification compliance (a maximum of three major items may be designated by the Engineer for independent laboratory testing at no additional cost to the Authority).

- D. After the Engineering Development Review for each system has been submitted and approved by the Engineer, Factory Tests and Inspections shall be scheduled for major items, custom prototypes, and other items of equipment and material designated for such testing by the Engineer, to verify compliance with environmental criteria, quality assurance, specified performance, grade of components, reliability, and workmanship including manufacturing processes. The Contractor shall advise the Engineer, in writing, when manufacturing of equipment begins and again two weeks prior to date of scheduled inspection or tests.
- E. A "Report of Factory Visit" for the purpose of confirmation and subsequent agreement of any decisions made on site shall be prepared by the Contractor and submitted to the Engineer ten working days subsequent to each factory visit by the Contractor, Engineer, or designated Authority Representative. Each report shall include the purpose of the visit, summary of tests performed and decisions made or required prior to factory certification and shipment.
- F. Two copies of test results certified by the manufacturer or an independent laboratory shall be furnished to the Engineer for review and acceptance or rejection prior to shipment. Equipment shall not be shipped before the factory test results have been accepted by the Engineer. Optionally, the Authority may elect to accept Contractor certified test and inspection results in lieu of manufacturer or independent laboratory certified test results.
- G. A 200 hour burn-in period (power on - attended or unattended) shall be required for all units of electrically operated and powered custom-made major items of equipment prior to installation, in accordance with instructions from the Engineer. Each unit of custom made equipment shall be set up and powered on the Contractor's, Subcontractor's, or supplier's premises. Reports of such activity shall be furnished to the Engineer.
- H. The Contractor shall assemble all of the rack-mounted equipment for a Passenger Station Communications Equipment Room and test prior to shipment to the installation site.

### **3.11 INSTALLATION COMPLETION TESTS AND INSPECTIONS**

- A. Installation Completion Tests and Inspections shall be performed after installation to ensure that equipment and materials were not damaged in shipment and that they are properly installed and functioning in accordance with specified criteria, parameters and good commercial practice. Installation Completion Tests and Inspections shall consist of:
  - 1. Visual inspection with check-off lists to verify the following:
    - a. That full compliance with requirements detailed in the General Equipment and Material Standards and General Installation Standards sections of these Specifications has been met.
    - b. That only approved products have been used.
    - c. That Factory Tests and Inspections have been satisfactorily completed for major items, as required.
    - d. That inventory of major equipment and material items is available and accurate.
    - e. That equipment is installed in agreement with approved installation shop drawings.

- f. That wire and cable terminations as to location, cable identification, routing, color code, and workmanship have been identified.
  - g. That Time Domain Reflectometry (TDR) measurements of all coaxial and outside plant cables have been made. Printed TDR records of each coaxial and outside plant cable shall be delivered to the Authority to illustrate the length of cable run (proven by demonstrating an open and a short condition before final termination), and the absence of any detectable faults on each coaxial cable and each outside plant cable pair after installation of the cable.
2. Detailed testing shall be required to demonstrate that material and equipment installed meet the criteria and possess the characteristics and parameters contained in the Contract Specifications; including additional requirements and stated tolerances that are specified in Contractor engineering and product approval data submissions and in manufacturer's published specifications attributed to approved products.
- B. The testing of all items of equipment and material shall include electrical, mechanical, operational, and functional parameters. Such parameters include, but are not limited to: Levels of voltages, currents, power, distortion, noise, cross-talk, insulation resistance, continuity, attenuation (optical and electrical), physical strength, suitability of mounting method, paint and marking quality, graphics quality and style, location of operating controls and adjustments, and maintainability.
  - C. These tests shall be performed after the installation of material and equipment and shall be in addition to any Factory Tests and Inspections previously performed. The Contractor shall perform all necessary alignments, adjustments, and maintenance prior to requesting the scheduling of Installation Completion Tests and Inspections.
  - D. The Contractor shall advise the Engineer, in writing, two weeks prior to the date(s) of scheduled tests and inspections. The Engineer will witness these tests. Two certified copies of Installation Completion Test and Inspection data shall be submitted to the Engineer within seven (7) days after test completion for review and acceptance or rejection.

### **3.12 SYSTEM AND INTEGRATION TESTS**

- A. System and Integration Tests shall be on-site performance tests to verify that all operating parameters and functions perform as specified and that each system performs as specified in conjunction with each system or subsystem with which it interfaces. The Contractor shall demonstrate that all material and equipment elements of each installed system function together to meet the system criteria specified. Each system shall be powered a minimum of 48 hours prior to commencing system and integration tests. The Engineer shall be notified, in writing, seven (7) days prior to equipment being powered. Failures shall be recorded by the Contractor and findings furnished to the Engineer at the end of the 40 hours. The Contractor shall also include a description of corrective actions taken.
- B. The Contractor shall be responsible for meeting all System and Integration Test requirements including testing and documenting interface compatibility and integration with existing Authority-owned systems and equipment.
- C. Each and every interface shall be verified as to operation, function, level, and voltage. The Contractor shall test across the interface points; however, these tests shall only be made under the supervision of appropriate Authority personnel. When minor adjustment to, or reconfiguration of, existing equipment is required, the Contractor shall notify the Engineer, in writing, of the required adjustment or reconfiguration. Authority personnel will make the

adjustment or reconfiguration in the presence of the Contractor. The Contractor shall be responsible for the necessary adjustments or reconfigurations of Contractor-furnished equipment to ensure proper functioning, as specified.

- D. The successful completion of all specified Factory Tests and Inspections, and Installation Completion Tests and Inspections, including the correction of all outstanding discrepancies and subsequent retesting, is required as a prerequisite to System and Integration Tests.
- E. The tests will vary with each specific system. However, each test shall include all operating parameters and functions. Tests shall be conducted on a location-by-location basis with all failures and discrepancies noted. The Contractor shall not engage in further testing until the Engineer has verified that the Contractor has taken necessary corrective action with respect to those failures and discrepancies. The Contractor shall retest after each successive failure and corrective action to verify Specification compliance.
- F. The Contractor shall advise the Engineer, in writing, two weeks prior to the date(s) of scheduled tests. Prior to commencing the System and Integration Tests, the Contractor shall provide failures recorded and corrective action taken, at the conclusion of powering equipment a minimum of 40 hours. The Engineer will witness these tests. Two certified copies of System and Integration Test data sheets shall be submitted to the Engineer within seven (7) days after test completion for review and acceptance or rejection.

### **3.13 MEASURING AND TEST EQUIPMENT**

- A. The Contractor shall establish and implement measures for the selection, calibration, and control of measuring and test equipment (M&TE) used to determine conformance.
- B. M&TE of a range, accuracy, and sensitivity conforming with measurement tolerances specified within this contract shall be selected and used.
- C. Calibration procedures shall require M&TE identification and establish frequency of calibration, calibration method, acceptance criteria, records to be generated, and the action to be taken when results are unsatisfactory.
- D. M&TE shall be periodically calibrated using certified references traceable to the National Institute of Standards and Technology (NIST), to other nationally recognized standards when no such NIST standards exist, or to a documented standard acceptable to the Engineer when none of the preceding standards exist.
- E. The calibration of M&TE shall be checked at prescribed intervals if testing or inspection will continue over an extended period.

### **3.14 INSPECTION AND TEST STATUS**

- A. The Contractor shall establish and implement measures to identify and maintain the inspection and test status of systems, equipment or components until these are accepted by the Engineer, to ensure that only purchased items that have passed the required inspection and test have been used.
- B. The means for status identification shall be such that the surface of the item is not damaged nor its use impaired. Status identification may also be via inspection records, test software, physical location, or other suitable means, which indicate the conformance or nonconformance of these items with regard to inspection and tests performed.

### **3.15 CONTROL OF NONCONFORMANCE**

- A. The Contractor shall establish and implement measures to prevent the inadvertent use or installation of nonconforming items.
- B. Procedures shall provide for identification, segregation, documentation, evaluation, and disposition of nonconforming items, define the responsibility and authority for the disposition of nonconforming item.
- C. Nonconforming items shall be positively identified and the matter brought to the attention of Supplier's management representative, the Engineer, and the appropriate OEM, subcontractor or sub-supplier.
- D. The Contractor shall hold the nonconforming item from further work and, where possible, shall be physically segregated in an area clearly marked, until the responsible parties have provided for the disposition of the item.
- E. The disposition of a nonconforming item may be:
  - 1. Reworked (to meet original requirements)
  - 2. Accepted as-is
  - 3. Repaired (to meet an alternative criteria)
  - 4. Re-graded (for alternative use)
  - 5. Rejected, returned to vendor, or scrapped
- F. The Contractor shall obtain written approval from the Engineer prior to using a nonconforming item as-is or repairing it to be acceptable to a standard different from the original standard.
- G. Nonconforming items that have been repaired or reworked shall be re-inspected or retested by the party responsible for the original inspection or test in accordance with approved acceptance standards before being declared acceptable.
- H. The technical details of nonconformity that have been accepted as-is and of any repairs made shall be included in "as-built" documentation.
- I. Items for return to vendor shall be removed from the area of work and controls placed to prevent the reuse of the item or any part of it.
- J. Rejected or scrapped items shall be removed from the area of work and rendered unusable in a manner that prevents their inadvertent use.

### **3.16 CORRECTIVE ACTION**

- A. The Contractor shall establish and implement measures to:
  - 1. Investigate the cause(s) of noncompliance and nonconformance, and identify action(s) to prevent recurrence.
  - 2. Implement corrective action to minimize or eliminate noncompliance or nonconformance.
  - 3. Apply controls over the implementation of corrective action.
  - 4. Incorporate the preventive action into procedures.

### **3.17 QUALITY CONTROL RECORDS**

- A. The Contractor shall establish and implement measures to identify, collect, index, file, and store quality control records as required in the Special Conditions of this Contract.
- B. Quality control records shall be available at designated, controlled, but accessible areas at work locations. Procedures shall identify the responsible custodians for these records.
- C. Quality control records shall be stored and maintained in such a way that they are readily retrievable and provided with a suitable environment that minimize deterioration or damage, and prevent unauthorized alteration or loss.
- D. Quality control records shall be legible, reproducible, identifiable with the item involved, and contain the date of origination and identity of the originator, verifier, and/or responsible supervisor.
- E. Retention period for quality control records shall be defined, and shall be at least as long as the term required in the Special Conditions of this Contract. Quality control records shall be made available to WMATA or its representative throughout the retention period.

### **3.18 AUDITS**

- A. By WMATA
  - B. Quality audits may be conducted by WMATA or its representatives. Direct access to Contractor personnel, original records, items in process, and facilities where work is performed shall be provided by the Contractor. The Contractor shall ensure, via procurement documents, that such access are also provided by their subcontractors and suppliers.
    - 1. The Contractor shall provide a written response within 15 days after receipt of the audit report, fully describing the methods and timetable by which compliance will be achieved. Deficiencies shall be corrected within 30 days after receipt of the audit report.
    - 2. Any survey, audit or inspection performed by WMATA or its representatives shall not relieve the Contractor of any of the responsibilities under this contract.
- C. By The Contractor
  - 1. The Contractor shall carry out a comprehensive system of planned and documented audits to verify whether activities within its scope of responsibility are performed in compliance with applicable portions of this Quality Control system requirements, and to determine the effectiveness of quality control.
  - 2. Audits and follow-up actions shall be carried out in accordance with documented procedures and by qualified personnel. Audit schedules shall be established to ensure coverage of the scope of the quality control system at least once in the life of this Contract.
  - 3. Results of the audits shall be documented and brought to the attention of the personnel having responsibility in the area audited. Management responsible for the area shall take timely corrective action on the deficiencies found by the audit.

### **3.19 TRAINING AND PERSONNEL QUALIFICATION**

- A. The Contractor shall ensure that the Quality Policy are understood and implemented by all elements of its organization that affect the quality of the items or services provided to WMATA.
- B. When qualified personnel are required by this Contract, personnel qualification shall be based on an appropriate combination of education, training and experience. Where

required by the applicable code or standard, personnel qualification shall also be certified. Appropriate records of qualification, training and certification shall be maintained as quality records.

### **3.20 STATISTICAL TECHNIQUES**

- A. The Contractor shall identify any statistical technique to be used for sampling inspections or testing. Acceptance by means of representative sampling shall be in accordance with generally accepted statistical methods.

**END OF SECTION**

## SECTION 16708

### CORRECTION OF COMMUNICATIONS SYSTEMS DEFICIENCIES

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. Definitions: As used in this Section
- B. General Conditions
- C. Deficiencies of Accepted Communications System Materials, Equipment, Systems or Subsystems
- D. Pre-Acceptance Recognition of Deficiencies in Communications System Materials, Equipment, Systems or Subsystems
- E. Time for Performance, Contract Price
- F. Transportation Charges
- G. Failure to Correct
- H. Correction of Deficient Replacements and Re-performances
- I. Disassembly/Reassembly Expense
- J. Warranties

##### 1.02 RELATED SECTIONS

- A. All 16700 and 16800 - Series Sections

##### 1.03 DEFINITIONS: AS USED IN THIS SECTION

- A. Deficiency:
  - 1. Communications System materials or equipment will be regarded as having a deficiency if a type of material or equipment in like service accumulates a failure rate greater than five percent within a period of 24 months following final acceptance by the Authority.
  - 2. Communications System systems or subsystems will be regarded as having a deficiency if they exhibit any condition or characteristics which are not in compliance with the requirements and intent of this Contract anytime during a period extending for 24 months following their final acceptance by the Authority.
- B. Correction
  - 1. Correction of Communications System materials or equipment exhibiting a failure rate greater than five percent means taking of any and all actions necessary to correct the deficiencies, including removal and replacement of all pieces of material or equipment in like service in a manner satisfactory to the designated Resident Engineer.
  - 2. Correction of Communications System systems or subsystems exhibiting one or more deficiencies means taking any and all actions to eliminate any and all deficiencies in a manner satisfactory to the designated Resident Engineer.

#### **1.04 GENERAL CONDITIONS**

- A. The rights and remedies of the Authority provided in this Section:
  - 1. Shall not be affected in any way by any other provisions under this Contract concerning the conclusiveness of inspections and acceptance, and;
  - 2. Are in addition to and do not limit any rights afforded to the Authority by any other Section of this Contract.
- B. This Section shall apply only to those deficiencies discovered by either the Authority or the Contractor within 24 months after acceptance.
- C. The Contractor shall not be responsible under this Section for the correction of deficiencies in Authority-furnished property, except for deficiencies in installation, unless the Contractor performs or is obligated to perform any modifications or other work on such property. In that event, the Contractor shall be responsible for correction of deficiencies to the extent of such modifications or other work.
- D. The Contractor shall not be responsible under this Section for the correction of deficiencies caused by the Authority.

#### **1.05 DEFICIENCIES OF ACCEPTED COMMUNICATIONS SYSTEM MATERIALS, EQUIPMENT ,SYSTEMS OR SUBSYSTEMS**

- A. Notice of Deficiency to Contractor: If the Contracting Officer determines that a deficiency exists in any of the Communications System materials, equipment, systems or subsystems provided to the Authority under this Contract, he will promptly notify the Contractor of the deficiency, in writing, within 30 days.
- B. Recommendation for Correction: Upon timely notification of the existence of such a deficiency, or if the Contractor independently discovers a deficiency in accepted Communications System materials, equipment, systems or subsystems, the Contractor shall promptly submit to the Contracting Officer his recommendation for corrective actions, together with supporting information in sufficient detail for the Contracting Officer to determine what corrective action, if any, shall be taken. The recommendation shall be submitted to the Contracting Officer within 15 working days of notice of the deficiency.
- C. Direction to Contractor Concerning Correction of Communications System Deficiencies: Within 30 days after receipt of the Contractor's recommendations for corrective action and adequate supporting information, the Contracting Officer, at his sole discretion, will give the Contractor written notice not to correct the subject deficiency, or to correct or partially correct the subject deficiency within a reasonable time and at a specified location.
- D. Correction of Communications System Deficiencies by Contractor: The Contractor shall promptly comply with any timely direction by the Contracting Officer to correct or partially correct a Communications System deficiency, at no increase in the Contract price. The Contractor shall also prepare and furnish to the Authority data and reports applicable to any correction required under this Section (including revision and updating of all other affected data called for under this Contract) at no increase in the Contract price.
- E. Schedule of Deficiency Corrections: The Contractor shall prepare a Schedule of Deficiency Corrections and deliver it to the Authority for approval within 15 working days of discovery of a Communications System deficiency by the Authority.
- F. Modification of Contract with respect to Uncorrected Communications System Deficiencies: In the event of timely notice of a decision not to correct, or only to partially correct a

Communications System deficiency, the Contractor shall submit within 15 working days, a technical and cost proposal to amend the Contract to permit acceptance of the affected materials, equipment, systems or subsystems in accordance with the revised requirements, and an equitable reduction in Contract price shall promptly be negotiated by the parties and stated in a modification to this Contract.

**1.06 PRE-ACCEPTANCE RECOGNITION OF DEFICIENCIES IN COMMUNICATIONS SYSTEM MATERIALS, EQUIPMENT, SYSTEMS OR SUBSYSTEMS**

- A. If the Contractor becomes aware at any time before acceptance by the Authority (whether before or after tender to the Authority) that a deficiency exists in any Communications System materials, equipment, system or subsystems, he shall promptly correct the deficiency or, if he elects to invoke the procedures specified in Part 1.05, he shall promptly communicate information concerning the deficiency to the Contracting Officer in writing, together with his detailed recommendation for corrective action.

**1.07 TIME FOR PERFORMANCE; CONTRACT PRICE**

- A. In no event will the Authority be responsible for extension or delays in the scheduled deliveries or periods of performance under this Contract as a result of the Contractor's obligations to correct Communications System deficiencies, nor shall there be any adjustment of the delivery schedule or period of performance as a result of such correction of deficiencies, except as may be agreed to by the Authority in a supplemental agreement with adequate consideration.
- B. It is hereby specifically recognized and agreed by the parties hereto that this Section shall not be construed as obligating the Authority to increase the Contract price of this Contract.

**1.08 TRANSPORTATION CHARGES**

- A. When the Authority returns supplies to the Contractor for correction or replacement pursuant to this Section, the Contractor shall be liable for transportation charges up to an amount equal to the cost of transportation by the usual commercial method of shipment from the designated destination point under this Contract to the Contractor's plant, in addition to any charges specified in Part 1.08.B. The Contractor shall also bear the responsibility for the supplies while in transit.
- B. When compliance with the terms of this Section by the Contractor involves shipment of corrected or replacement supplies from the Contractor to the Authority, the Contractor shall be liable for transportation charges up to an amount equal to the cost of transportation by the usual commercial method of shipment from the Contractor's plant to the designated destination point under this Contract, in addition to any charges specified in Part 1.08.A. The Contractor shall also bear the responsibility for the supplies while in transit.

**1.09 FAILURE TO CORRECT**

- A. If the Contractor fails or refuses to:
  - 1. present a detailed recommendation for corrective action in accordance with Part 1.05,
  - 2. correct deficiencies in accordance with Part 1.05 C, or
  - 3. prepare and furnish data reports in accordance with Part 1.05 D., the Contracting Officer will give the Contractor written notice specifying the failure or refusal and setting a period after receipt of the notice within which it must be corrected.
- B. If the failure or refusal is not corrected within the specified period, the Contracting Officer may, by contract or otherwise, as required:

1. Obtain detailed recommendations for corrective action;
  - a. Correct the materials, equipment, systems or subsystems, or;
  - b. Replace the materials, equipment, systems or subsystems, and if the Contractor fails to furnish timely disposition instructions, the Contracting Officer may dispose of non-conforming materials, equipment, systems or subsystems for the Contractor's account in a reasonable manner, in which the Authority is entitled to reimbursement from the Contractor or from the proceeds for the reasonable expense of care and disposition, as well as for excess costs incurred or to be incurred, and;
2. Obtain applicable data and reports; and charge to the Contractor the cost occasioned to the Authority thereby.

**1.10 CORRECTION OF DEFICIENT REPLACEMENTS AND RE-PERFORMANCES**

- A. Any Communications System materials or equipment corrected or furnished in replacement, and any Communications Systems or subsystems revised pursuant to this Section shall also be subject to all the provisions of the Contract to the same extent as Communications System materials, equipment, systems or subsystems initially accepted, i.e., for a new 24-month period.

**1.11 DISASSEMBLY/REASSEMBLY EXPENSE**

- A. The Contractor shall be liable for reasonable cost of assembly/reassembly of larger items necessary to remove the materials or equipment to be inspected and/or returned for correction or replacement.

**1.12 WARRANTIES**

- A. All Communications System materials and equipment provided under this Contract shall be warranted for a period of 24 months beginning with final acceptance by the Authority.
- B. All subcontractors', manufactures', and suppliers' warranties and guarantees, expressed or implied, respecting any part of the Communications System work, and any materials or equipment used therein shall be deemed obtained and shall be enforced by the Contractor as the agent and for the benefit of the Authority without the necessity of separate transfer or assignment thereof. Furthermore, if directed by the Contracting Officer, the Contractor shall require such subcontractors, manufacturers and suppliers to execute such warranties and guarantees in writing to the Authority.

**PART 2 PRODUCTS**

**NOT USED**

**PART 3 EXECUTION**

**NOT USED**

**END OF SECTION**

## **SECTION 16710**

### **COMMUNICATIONS GROUNDING**

#### **PART 1 - GENERAL**

##### **1.01 SECTION INCLUDES**

- A. This section describes hardware, and installation methods that the Contractor shall use to insure the installation of a competent grounding system that will avoid/minimize ground-loops, and Electromagnetic Interference (EMI) problems in the operation of the communications systems installed under this Contract. In addition to the methods detailed in this Section, the Contractor shall insure that his crews adhere to all generally accepted installation practices that are meant to minimize interference between communications systems.
- B. Equipment and Rack Grounding.
- C. Cable Shield Grounding.

##### **1.02 UNIT PRICES**

- A. Unit Prices include all Required conduits and fittings, junction boxes, wiring, and cabling to provide grounding to the communications systems and facilities and incidental items, not specifically mentioned, but required for complete and proper system operation.

##### **1.03 RELATED SECTIONS**

- A. Section 16705 – Communications Standard Specifications - Equipment & Material.
- B. Section 16706 - Communications System Submittals & Services
- C. Section 16721 -Communications -Telephone System.
- D. Section 16723 -Communications -Garage Emergency Telephone System.
- E. Section 16727 -Communications -Passenger Emergency Reporting System.
- F. Section 16731 -Communications -Fire and Intrusion Alarm System.
- G. Section 16733 -Communications -Kiosk System.
- H. Section 16771 -Communications - Carrier Transmission System.
- I. Section 16776 -Communications - Fiber Optics System.
- J. Section 16791 -Communications - Mobile Radio System.
- K. Section 16820 -Communications - Public Address System.
- L. Section 16821 -Communications - Automatic Public Address Announcement System.
- M. Section 16851 -Communications - Closed Circuit Television System.

#### **1.04 REFERENCES**

- A. NFPA 130 - Standard for Fixed Guideway Transit Systems

#### **1.05 SUBMITTALS**

- A. Submit under provisions of Section 16706.
- B. Shop Drawings: Indicate electrical system wiring diagram.

### **PART 2 - PRODUCTS**

**NOT USED**

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. Ground Communication system and facilities, equipment and cables using a single-point grounding scheme. Each Communication Equipment Room will have a separate isolated ground bus bar designated as "communications ground."
- B. Unless otherwise specified, ground the shields of all single shielded communications cables, the shields of multi-conductor cables that have individual shielded pairs, and the inner shield of all double shielded communications cables and communications cables with separate shield and armor only at a single point and only to the "communications ground." These shields shall be electrically continuous throughout the cable length by bonding across all splices and terminations in equipment enclosures and junction boxes.
- C. Ground the outer shield of all double-shielded communications cables and the armor of all communications cables with separate shield and armor only at a single point in each cable section. Locate the single point ground at the end of the cable section nearest to the associated Communications Equipment Room. Ground outer shield or armor Cable sections originating at Communications Equipment Rooms to the "communications ground."
- D. Electrically isolate equipment racks and equipment cabinets from the building structure, adjacent equipment racks and equipment cabinets. Minimum resistance between adjacent equipment racks and equipment cabinets, and between equipment racks and equipment cabinets and the building structure, shall be 10 megohms. Individually wire each equipment rack and equipment cabinet to the communications ground, via the copper ground bus bar on the equipment rack and equipment cabinet, by a No. 6 AWG, stranded, insulated wire, Type XHHW.
- E. Wire each copper ground bus bar in the multi-section cable terminal housings of the Main Distribution Frame (MDF)/ MDF/Protector Cabinet and the systems distribution frames to the communications ground by a No. 6 AWG, stranded, insulated wire, Type XHHW.
- F. Electrically insulate all power conductors from equipment racks and equipment cabinets, with a separate power ground isolated from communications ground. Insulate Conduit containing power conductors running from ac distribution boxes to equipment racks, equipment cabinets, ac receptacle boxes on equipment racks and equipment cabinets from the equipment cabinet or equipment rack by means of short lengths of non-conducting conduit.

**END OF SECTION**

**SECTION 16711  
COMMUNICATIONS PARKING STRUCTURES**

**PART 1 - GENERAL**

**1.01 SECTION DESCRIPTIONS AND BASIC REQUIREMENTS / CONTRACTOR'S TOTAL SYSTEM RESPONSIBILITY**

**SYSTEM A. CLOSED CIRCUIT TELEVISION (CCTV)**

The design philosophy for the garage CCTV coverage is based on the following requirements: Vehicles can only enter the garage through entry lanes or illegally through exit lanes. At the entry point the licence tag number of the vehicle is recorded as the vehicle passes into the camera view. With the license tag and a clear image of the vehicle recorded, the vehicle is then tracked by entering and exiting camera views using camera long shots as it progresses through the levels of the garage. The long view cameras need to obtain a minimum of 85% coverage as the vehicle progresses through the garage. The combined views from all the cameras throughout the structure shall achieve 95% coverage of the garage public areas. Images of persons entering or exiting the coverage area shall be recorded by the long shot cameras. High resolution images of patrons entering and exiting via pedestrian walkways shall be recorded. Elevator lobbies which are often garage entry points shall also provide a high resolution image of pedestrians. Inside the elevators, activity is recorded using a covert or smoke detector camera. When a vehicle exits the garage through any exit lane or illegally through an entrance lane, a high quality video image that can be enhanced to identify the driver and license plate are to be recorded. Also recorded is any transaction with a gate attendant. Monitoring of all cameras shall be possible in the police room and remotely by means of the WMATA's existing Video Management System via the Local Area Network. The parking office shall have a monitoring console and shall be able to monitor gate activity and transactions by gate attendants.

**SYSTEM B. GARAGE FIRE AND INTRUSION SYSTEM**

WMATA FIA system is manufactured by Edwards and was installed by ADT. The design and installation of the FIA system is the contractor's full responsibility including NFPA requirements and any local occupancy permit requirement.

The contractor is responsible for providing, integrating and testing a fire and intrusion alarm system that is identical, compatible and fully integrated with the existing fire and Intrusion alarm system currently in operation throughout the Metrorail System. The new Fire and Intrusion equipment shall be integrated into the WMATA central monitoring facility at OCC (both JGB and Carman Turner Facility). This requires modifying the station FIA panel to provide new device loops, extending the new loops to and throughout the garage, providing new kiosk data files for the passenger station, and programming services to configure the central monitoring station at OCC with the new garage F&I alarm indications. The contractor is also responsible for modification of the Station F&I system to allow the kiosk to receive a garage fire and intrusion alarms.

**SYSTEM C. GARAGE TELEPHONE**

The contractor shall be responsible for design, installation and testing of the garage telephone network. The contractor shall design an extension of WMATA phone system to the garage. Multiline telephones are required in the police room, communications room and parking operations room. Single line telephones are required in all other service rooms. A single line wall mounted analog telephone and a fax machine is also required in the police room in addition to any VOIP phones.

Analog telephones are to be connected to the VOIP telephone system through appropriate interface devices. The interface devices shall be designed to provide analog dial-around service to an analog line if the LAN connection should fail. Safety critical telephones may require connection to a second LAN consistent with the configuration of the WMATA telephone system design.

#### **SYSTEM D. GARAGE EMERGENCY TELEPHONE SYSTEM (GETS)**

The contractor shall engineer, design, furnish, install and test the Garage Emergency Telephone System (GETS) for the Parking Structure. The Garage Emergency Telephone System shall provide WMATA patrons with the capabilities to report emergency situations in the parking structure to WMATA Transit Police Department (MTPD) located in MTPD Communications Center at both Jackson Graham Building and Carman Turner Facility.

Emergency telephones are to be installed throughout the garage at stair entrances at each level, elevator lobbies and as needed in the public areas so no distance is greater than 200 feet from a GETS phone. A call shall be initiated by pressing a button on the emergency telephone, activating a strobe light located above the telephone instrument. The phone shall capture the initiating line and dial or connect via LAN to a call station or console in the transit police dispatcher's office in JGB and CTF. If the line (or console) is busy or the call is not answered, the phone shall disconnect and automatically initiate a new call on the MTPD consoles or dial a number that will be provided during the design phase. When the police dispatcher answers the call, either location shall be displayed on the console screen or an announcement shall be provided giving the location of the GETS telephone that initiated the call. On IP based systems, a camera view of the area where the phone is located shall be displayed on the police console when available. As soon as the announcement has played (analog systems), the line shall be made available for full duplex communications and the police dispatcher can start a conversation with the patron who initiated the call. The police dispatcher shall be able to control the GETS instrument and strobe remotely using a telephone keypad or the console Graphical User Interface.

The existing GETS performs a self diagnostic test at a programmed time. The central GETS computer calls each GETS telephone instrument in the system and verifies the instrument is functioning properly and provides a printed report on demand. It shall be the contractor's responsibility to update the equipment at MTPD at both JGB and CTF which includes software database, consoles, VOIP equipment and processors. The contractor shall assure the computer is automatically testing the instruments installed under this contract.

#### **SYSTEM E. LOCAL AREA NETWORK**

The Contractor shall extend the WMATA LAN from the passenger station communications room to the garage communications room and install a LAN ethernet drops in the communications room, police room, garage operations office, elevator machine room and AEMS RTU location or generator.

A composite fiberoptic cable with both single mode and multimode strands is required between the passenger station communications room and the garage communications room. To extend the LAN, the contractor shall survey the existing LAN in the passenger station to determine if an upgrade to the existing data switches are required to facilitate the additional fiber feeds to the garage. Any upgrades or additional equipment required shall be designed and provided under the base contract.

The network shall be extended from the passenger station to the garage communications room. The garage communications room shall require a managed ethernet switch that can be remotely managed using WMATA's existing LAN management system. The LAN shall be connected by fiber optic cable to the passenger station LAN. The LAN shall be used to accommodate all the IP cameras, the Network Video Recorder/Server/Encoders, Video

keyboard controllers or Client Work Stations, PC connections, VOIP telephones, ethernet drops to the remote rooms and all analog telephones and GETS telephones via gateways. The various rooms in the garage may require more than one ethernet drop to accommodate the required connectivity depending on the contractor's design. Rooms with VOIP telephones require appropriate LAN drops.

Fiberoptic cable is required for long LAN runs or where the data rate exceeds 1 MB, however CAT-6 copper cable may be used for runs within the rating of the cable (usually under 300 meters). Contractor is responsible for the full functionality of the LAN. WMATA shall assist the contractor by providing IP addresses for the applicable devices. All LAN switches shall support 802.3af (power over ethernet), have dual power supplies, and have a minimum of two SX GBIC ports. Local power is required for any VOIP phone located over 300 feet from the LAN switch (or fed by fiber).

#### **SYSTEM F. PARKING ACCESS AND REVENUE CONTROL SYSTEM**

Each parking booth will be provided with equipment necessary for control of the entry/exit gates and revenue collection through a separate parking lot equipment contract. This equipment will be connected to the garage central processing computer located in the parking operations room. All conduits and network connectivity required shall be provided under this contract.

All booths shall have a pushbutton operated autodial telephone for the attendant to use for conversations with garage management. Booths shall have a silent alarm system with a pushbutton installed at a location that can be covertly operated during a robbery attempt.

Each exit lane shall be equipped with a Smart Trip sensor. Wiring for this sensor shall be extended to the passenger station kiosk and connected as directed to the revenue collection equipment.

Connectivity to entry/exit booths located away from the garage and or on adjacent parking lots installed under this contract are the responsibility of the contractor.

Conduit and cable for credit card readers shall be installed at each exit array.

#### **SYSTEM G. PUBLIC TELEPHONE SYSTEM**

Public telephone instruments and wiring shall be installed by the local telephone company (Verizon in most cases). The contractor is responsible for coordinating with the telephone company to determine the quantity and locations of public telephones. Contractor shall provide proven raceways with pull strings from specific telephone locations to the bell room. Conduit shall also be provided between the bell room to the telephone company interface point outside of the garage structure as agreed to by the telephone company. A sheet of 3/4" fire retardant plywood shall be provided on the wall in the bell room for Verizon demarcation block and protectors. Each pay telephone array shall have one additional conduit installed with a 110 volt circuit for future installation of devices for the hearing disabled.

#### **SYSTEM H. GARAGE RADIO SYSTEMS**

WMATA uses 2-way radio systems for operations, maintenance, security and police operations throughout the Metrorail system and connected structures including garages. The contractor shall assure 2-way radio communications is available throughout all levels of the garage. In areas where 2-way radio communications using the 490 MHz trunk radio system (CRCS) is not satisfactory, the contractor shall design and provide amplifiers, antennas, cabling or other equipment as necessary to enable satisfactory communications on the CRCS radio systems throughout all levels.

## **1.02 RELATED SECTIONS**

- A. Section 16703 - Communications Standard Specifications - Engineering Services
- B. Section 16704 - Communications Standard Specifications - Installation
- C. Section 16705 - Communications Standard Specification - Equipment & Material
- D. Section 16706 - Communications System Submittals & Services.
- E. Section 16707 - Communications Systems Quality Assurance & Testing
- F. Section 16710 - Communications Grounding.
- G. Section 16715 - Communications - Electrical Power Distribution.
- M. Section 16866 - Communications - Interface Criteria and Responsibilities

## **1.03 REFERENCES**

- A. National Electrical Code (NEC).
- B. Electronics Industries Alliance (EIA) Standard RS 170
- C. Federal Standard 595B, Colors Used in Government Procurement

## **1.04 DESCRIPTION OF WORK TO BE PERFORMED**

- A. The Contractor shall bear total system responsibility for all specified work, specified additions and changes to WMATA systems of any type (except Contract deliverables not requiring Contractor installation). The Contractor's total system responsibility includes engineering services per Section 16703, installation per Section 16704, testing per Section 16707, documentation, warranty, and other areas of responsibility which are subject to periodic review and acceptance by WMATA (as specified elsewhere). The Contractor has the responsibility to integrate the various necessary elements of Contract work so that overall specification performance goals are met.
- B. WMATA retains rights to review the Contractor's system and component configuration and products selected, and to accept or not accept for reasons of specification compliance or noncompliance. The Contractor shall remain responsible for providing an acceptable design and final product that meets the intent of this specification. The Contractor shall remain responsible for bearing any additional costs associated with changes necessary to satisfy the performance requirements of this specification.
- C. The Contractor shall design, furnish, install and test all communications cabling and conduit within the garage structure and between the Parking Structure Communications Room and the Metrorail Passenger Stations Communications Room necessary to support the systems and subsystems required by this specification.
- D. See Division 01 for Spare Parts Requirements.
- E. Training materials, maintenance manuals and technician training shall be provided in compliance with these provisions. See Division 01 for details.
- F. New and updated printed As-Built Drawing pages and CAD files shall be provided to reflect any changes made in the passenger station communications room. As-Built Drawings shall

be provided for the Garage communications system in both printed and electronic format. The contractor shall update the Passenger Station Kiosk Data Files to reflect the garage and any changes to the station FIA system.

## **1.05 SYSTEM PERFORMANCE REQUIREMENTS**

The Contractor shall be responsible for the overall performance of the all systems provided under this specification. The system performance requirements are designed to ensure the systems delivered under this specification meet the performance requirements of the Washington Metropolitan Area Transit WMATA.

### **A. Closed Circuit Television (CCTV)**

1. Elevator lobbies , passageways on all levels and entrances shall be monitored by CCTV cameras. All cameras shall provide image quality capable of recording images that can be electronically enhanced to identify facial features and license tags. Camera coverage outside of the garage structure is not required.
2. Color image cameras inside elevator cars shall be mounted in a concealed housing such as an artificial smoke detector and shall capture all activity in the elevator. High resolution detail is not required in the elevators.
3. Camera coverage of vehicle areas shall be minimum 85% and include all pedestrian and vehicle entry/exit points.
4. Wide Dynamic Range cameras are required anywhere lighting conditions are not consistent. This includes cameras subject to viewing headlights, general illumination lighting and views with light and dark scenes in the same view.
5. All cameras except covert cameras shall be high resolution day/night cameras.

### **B. Fire and Intrusion Alarm System (FIA)**

1. The contractor shall be responsible for designing and installing a garage FIA system that shall satisfy all local jurisdictional code requirements. Requirements include submittals of plans to the municipality as required for permits, demonstrations and any remedial work necessary to bring the system into code compliance for the municipal occupancy permit.
2. The system shall function similarly to the passenger station FIA system and provide detailed alarm annunciation to the head end system at JGB and CTF. The garage FIA system may be provided as an extension of the station FIA system if the local jurisdiction allows.
3. The Garage FIA system shall be interfaced with the Station FIA system to facilitate kiosk viewing and reset capabilities of alarms.

### **C. Telephone System**

The Contractor shall be responsible for the overall performance of the telephone extensions. The following overall system performance requirements are designed to ensure that telephone extensions delivered under these Specifications meet the performance requirements of the Washington Metropolitan Area Transit WMATA.

Regardless of the minimum requirements noted below, the telephone system shall provide clear and noise free communications with no degradation to volume or intelligibility. Contractor will not be responsible for line quality on existing analog circuits that were not provided under

this specification. Contractor will be responsible for demonstrating line quality to the point of interface with existing circuits.

VOIP telephones shall be fully compatible and interface with the existing WMATA telephone system.

**D. Garage Emergency Telephone System (GETS)**

The Contractor shall be responsible for the overall performance and interface of the Garage Emergency Telephone System (GETS), as specified herein. The following overall system performance requirements are designed to ensure that the GETS delivered under these Specifications meet the performance requirements of the Washington Metropolitan Area Transit WMATA.

**SYSTEM PARAMETER REQUIRED PERFORMANCE**

1. Emergency Telephone Input sensitivity: The Emergency Telephone microphone shall be sensitive to (accept) any normal speaking voice from a distance of 20 inches or less from in front of the microphone, while moving to positions up to 30 degrees off center in any quadrant.
2. Emergency Telephone Sound Pressure Level: The Emergency Telephone shall produce clear and continuous speech (to persons who are not significantly hearing impaired within the 300 to 3,600 Hz audio range) to a distance of up to 36 inches or less, while moving to positions 40 degrees off-center in any quadrant. Interfering signals, hum, or objectionable noise shall not be discernible to listeners during or between speech messages.
3. System Noise Noise from the Emergency Telephone speaker shall not exceed -45 dB below a 1 kHz test tone level when all system and equipment controls are operated to any possible combination of positions. Momentary switching transients may peak to -30 dB below a 1 kHz test tone level for a duration not to exceed 10 milliseconds.
4. Note: Persons not significantly hearing impaired within the 300 to 3,600 Hz audio range are defined for the purpose of these performance specifications as males or females with hearing capabilities that are normal, or slightly impaired to the extent that their response to audio tones in the 300 to 3,600 Hz frequency range is within -15 dB at all test frequencies, and averages within -10 dB of "NORMAL" standard values for their classification (sex, age, etc.) as defined in ANSI Standards.

**E. WMATA Radio Coverage**

Provide amplifiers, antennas, wiring as needed to extend off-air radio coverage of all WMATA frequencies within the CRCS radio system throughout all areas of the garage structure.

1. BDAs shall be located in a service area that is not subject to vandalism.
2. Donor antennas may be located off the parapet wall at the top of the elevator shaft at a location out of reach of the general public.
3. Antennas or radiating cable shall be installed in a manner that will avoid vandalism.
4. All exposed antenna cable except for service loops or radiating cable shall be protected by IMC or Rigid conduit depending on the risk of damage.
5. Radio coverage of at least 95% at DAQ 3.4 (Delivered Audio Quality) shall be

achieved in all public areas and service rooms.

#### **1.06 CUSTOM DEVELOPED AND CONTRACTOR MODIFIED OFF-THE-SHELF EQUIPMENT**

Commercially available off the shelf equipment shall be used for all applications unless otherwise unavoidable. Prior to proceeding with any design or fabrication of custom developed or modified equipment, the contractor shall attempt to locate alternative off the shelf equipment with an equivalent level of performance and provide WMATA engineer with sufficient data to determine if the substitution is acceptable. Only when equivalent equipment is not acceptable or completely unavailable shall the contractor proceed with design, fabrication and acceptance of custom developed or contractor modified equipment. Design and fabrication of custom developed equipment shall be included in the base contract cost. Reference Section 16707 for additional requirements relating to custom developed equipment.

#### **1.07 INTERFACE CRITERIA AND RESPONSIBILITIES**

The Contractor shall be responsible per Section 16866 for interfacing of the systems, subsystems, facilities and equipment that are provided under this Contract with the existing WMATA communications systems, subsystems, facilities, and with the facilities and equipment furnished by WMATA and other contractors.

Integrations services shall include but are not limited to integration with:

1. Video systems with WMATA's existing WEB based Video Management System and the Protect system and with GETS console at MTPD control center (when VIOP is used)
2. GETS system with the WMATA telephone system.
3. FIA system with the station FIA system and the central monitoring system at OCC and with the video system.
4. Garage LAN with the existing station LAN/WAN and with connected systems within the garage (AEMS, Elevator, Parking equipment, video system, VOIP gateways and telephones, ext)
5. Telephone systems with existing WMATA telephone system including any leased lines required.
6. Interfaces with local communications carriers (voice, data, RF, fiber, copper as applicable)
7. Garage radio system (if needed for coverage) with the WMATA CRCS radio system and legacy 160 MHz radio system.

#### **1.08 TEST PROGRAM AND TEST REQUIREMENTS**

##### **TEST RESPONSIBILITY TASKS**

- A. The Contractor shall develop and implement per Section 16707 a Test Program that shall ensure all communications and related systems, equipment, material and services, furnished during the performance of this Contract including integration with existing systems and integration with systems provided by others, meet all performance criteria of this specification as well as WMATA design criteria and standard specifications.
  1. Develop and submit for approval an overall Test Plan that includes a detailed testing schedule and identifies all test procedures.
  2. Develop and submit for approval detailed test procedures and data sheets for each

individual test. Pre-printed data sheets shall be generated for each location prior to testing and submitted for approval. Data sheets shall include the specified acceptable measurement range so the test technician can determine if the results are valid at the time of test.

3. Use only test procedures approved by WMATA during the execution of the testing program. Testing data shall be recorded on preprinted data sheets.
4. Provide qualified test personnel with calibrated test equipment, tools, and miscellaneous supplies as necessary to perform all tests and retests.
5. Provide WMATA representative with advance notice and facilities as required to observe all testing that WMATA representative elects to witness. WMATA representative shall reserve the right to not observe any particular test.
6. Review test data, correct deficiencies, perform any required retesting prior to submitting test data for review. Submit raw test data showing any corrective action and retesting on preprinted data sheets for review and acceptance by WMATA's Representative.

#### **1.09 TECHNICAL DOCUMENTATION**

The Contractor shall develop and utilize procedures with checklists to assure the following submittals are complete and accurate prior to submission.

- A. Shop Drawings - Engineering, As-Built, etc.
- B. Operations and Maintenance Manuals.
- C. Progress Schedule Submissions.
- D. As-Built Drawings - printed and electronic
  1. As-built drawings shall be submitted on CD formatted in AutoCAD and PDF.
  2. AutoCAD drawings shall be in vector line format. EXCEPTION: TIFF images may be utilized when vector line images are not available from manufacturers and specific product data or graphics must be scanned.
  3. AutoCAD As-built drawings of all field installed wiring shall be in vector format. The complete AutoCAD as-built drawing package shall be replicated and submitted in PDF format.
  4. Printed as-built drawings shall be provided with an additional copy provided in each garage communications room. Updated drawing pages shall be provided in any Passenger Station Communications Room where changes or modifications are made. Superseded drawings shall be marked, removed and archived as directed by WMATA's representative.
  5. A working set of drawings shall be maintained in the communications room at all times during construction and updated to reflect any changes made during the construction process.
- E. Test Procedures - Printed and Electronic
  1. One complete collection of all test procedures (after approval and acceptance) shall be provided electronically on CD in PDF format. Microsoft Word or WordPerfect shall

also be acceptable.

2. In addition to the complete test procedure collection noted above, PDF versions of individual test procedures shall be transmitted to WMATA's representative upon receipt of approval after WMATA review. E-mail is acceptable if the file size shall allow.
3. Printed versions of test procedure and test data shall be submitted for review.

#### **1.10 COMPLETION ACCEPTANCE**

- A. *Substantial completion inspection and acceptance shall be provided in compliance with these provisions. See Division 01 for details.*
- B. *Final Acceptance shall be provided in compliance with these provisions. See Division 01 for details.*

#### **1.11 MAINTENANCE REQUIREMENTS**

*Maintenance requirements shall be provided in compliance with these provisions. See Division 01 for details.*

#### **1.12 SUBMITTALS**

*Submittals shall be provided in compliance with these provisions. See Division 01 for details.*

#### **1.13 PRODUCT APPROVALS**

- A. Equipment to be installed under these Specifications (except for "WMATA Furnished" items and miscellaneous hardware), shall be submitted for approval by WMATA's Representative prior to purchase and installation.
- B. WMATA approval of a product that does not meet the specifications shall not relieve the contractor of any contractual obligations unless a deviation request is submitted with the product submittal.
- C. It is the responsibility of the contractor's QA team to assure contractual compliance of items submitted for approval. Items submitted that deviate from the requirements of this specification without an attached request for deviation may require replacement or modification at the contractor's expense regardless of WMATA approval status.

#### **1.14 COORDINATION**

Accomplishment of the work included in these Specifications requires the Contractor to coordinate activities with WMATA and other contractors. The contractor shall be responsible for:

- A. Coordination of work schedules with WMATA through the use of site specific work plans (SSWP). The SSWP is outlined in WMATA OAP 200-33 available on request. SSWPs must be submitted 45 days in advance for approval of work within MertoRail operating facilities or work that requires WMATA maintenance support.

- B. Coordination with WMATA's Representative to determine the location and availability of electrical power or other resources within WMATA owned facilities if needed.
- C. Coordination with WMATA's Representative and WMATA technicians to determine IP addresses for LAN equipment and the availability of telephone lines.
- D. Coordinate design with local fire authorities to ensure compliance with local fire codes, and to obtain all required permits and inspections. (Copies of all related documentation including an occupancy permit shall be furnished to WMATA's Representative within 3 working days of receipt.)

#### **1.15 OPERATIONS AND MAINTENANCE MANUALS**

See Division 01 for operation and maintenance manual requirements

#### **1.16 OPERATION AND MAINTENANCE TRAINING:**

See Division 01 for operation and maintenance training requirements.

#### **1.17 SPECIALIZED TOOLS AND TEST EQUIPMENT**

Provide all specialized tools and test equipment required to maintain, adjust, configure, repair or replace any portion of the communications system installed under this contract.

1. Provide all software with any required license. Install the appropriate software and databases on the communications room computer (provided by contractor in the garage communications room) and install cabling between the computer and the respective equipment.
2. Provide one additional notebook computer (DELL Latitude series) with all maintenance, adjustment and configuration software loaded. Provide all required databases, cables and adapters to interface with all installed equipment. Provide a suitable carrying case. Contractor to specify the appropriate Dell laptop. WMATA's Office of Information Technology (OIT) will, using project monies, procure the specified equipment and, upon delivery, turn over to the contractor all procured Dell equipment. The contractor will configure the computers to OIT's specifications and install the appropriate maintenance, adjustment and configuration software.
3. Specialized test equipment is considered anything other than a digital multi-meter.
4. Specialized tools are considered anything other than screwdrivers, pliers, standard wrenches (1/4" thru 3/4"), wire strippers and soldering iron.
5. All non-function-specific general use computers received and owned by WMATA shall be procured and processed per WMATA Published P/I (Policy and Instruction).
6. A licensed copy of all software and any configuration files required to repair, monitor, troubleshoot, maintain, program or make modifications to any of the systems installed under this contract shall be provided.

#### **1.18 GARAGE FARE COLLECTION FACILITY**

Provide conduits and UFT cabling as necessary for connection of revenue collection entrance and exit smart card targets between each gate array and the kiosk.

1. Cables from all booths may be consolidated in the garage communications room so a minimal conduit runs can be used between the garage and passenger station

kiosk.

2. Coordinate with the garage parking revenue equipment supplier to determine the quantity and type of UFT cables required.
3. Provide 2" conduit between each gate array booth and the garage communications room for future credit card equipment.

## **PART 2 - PRODUCTS**

### **2.00 GENERAL**

All components furnished in accordance with this Contract shall be:

- A. Clearly and permanently labeled with value, part number, manufacturer & model or otherwise identified to facilitate off-the-shelf procurement and replacement.
- B. All electrical, electronic and mechanical components shall be designed and selected to operate under normal conditions at not more than 80 percent of the manufacturer's maximum rating range.

### **2.01 TRANSFORMERS**

All transformers provided under this Contract shall be of air-cooled, dry type, unless otherwise approved by WMATA's Representative.

### **2.02 POWER SUPPLIES**

- A. Power supplies shall be for continuous duty and shall be rated at a minimum of 120 percent of maximum load at 50 degrees C.
- B. Power supplies not integral to other equipment shall be selected for mounting in a standard 19-inch equipment rack and shall be housed in a metal panel-chassis combination with no exposed electrical connections or wires. Appropriate type terminals shall be provided on the rear of the chassis for the connections of all external input and output power leads. An appropriate sized power cord (internally connected) may be provided for the input power leads. Exception: camera power supplies may be remotely mounted in equipment cases near the cameras.
- C. Power supplies shall be selected for natural convection cooling. No supplementary fans or other cooling devices shall be allowed.
- D. The power supplies shall not be damaged by a sustained input voltage varying from 0 to 150 percent of the rated input voltage. Power supplies shall have current limiting, which shall protect the power supplies from damage due to overload or short circuits. Over voltage protection shall be contained on those power supplies driving solid state circuitry.
- E. Unless otherwise specified, all redundant power supplies shall be diode coupled to the loads with the corresponding main power supplies.

### **2.03 CONNECTORS**

- A. Connectors shall be provided to connect wires and cables to equipment to permit easy removal of equipment for maintenance. In-line connectors may only be used when approved

by WMATA's Representative and shall be documented on As-Built drawings.

- B. Unless otherwise specified, connectors are not required for the termination to equipment which contains screw type terminals, distribution frames or protector blocks.
- C. Each connector shall be uniquely identified and marked in such a manner that they shall not be obscured or worn off in normal use.
- D. All conductors (including spares) within a cable that interfaces with a connector shall be terminated in the connector or folded back and protected with heat-shrink tubing and noted on the as-built drawings.
- E. All connectors which are not located within environmentally controlled rooms shall have a weatherproof classification.
- F. Connections installed in manholes, handholes, conduits, pipes, cable trays cable troughs or cable trenches (direct burial) are prohibited. Cables shall be extended outside the raceway and spliced or terminated in junction boxes.

#### **2.04 TERMINAL BLOCKS**

- A. All terminal blocks and terminal strips shall be rated for service at 300 volts minimum. All terminal blocks and terminal strips shall be of the appropriate current rating for corresponding terminated circuits. All terminals of the terminal blocks and terminal strips shall be sized to accept corresponding terminated wire and cable conductor sizes (gauges). Resistance of the terminals shall not exceed 0.0002 ohms.
- B. Unless otherwise specified, terminal blocks and terminal strips provided in junction boxes, equipment enclosures, system distribution frames, equipment cabinets, and termination facilities shall be of the modular, feed-thru type mounted to a metal channel or be of the single molded construction barrier type.
- C. Unless otherwise specified, the modular, feed-thru type terminal blocks and terminal strips shall have pressure clamp contact terminals suitable for solid and stranded wire. Type "66" blocks shall be used for telephone applications. Type "110" terminals shall be used for data and LAN terminations. Appropriate sized (length) continuous mounting channel shall be provided for each terminal block and terminal strip. Appropriate accessories (end sections, channel clamps, partitions, mounting hardware, etc.) shall be provided for each terminal block and terminal strip. Disconnect apparatus (without removing wires) shall be provided in the terminal assemblies of those terminal blocks and terminal strips, which are utilized in conjunction with protector block assemblies, or otherwise specified within these Specifications.

#### **2.05 PROTECTOR BLOCKS & TERMINALS**

- A. Unless otherwise specified, each protector block shall be selected for the termination of the appropriate number of pairs (minimum four conductors). The base of each protector block shall be constructed of molded fire-retardant thermoplastic and shall be equipped with four binding posts and four related screw-in arrester units. The binding posts shall be connected internally to the corresponding arrester units. Each binding post shall be equipped with two nuts and four beveled washers. A ground plate shall be provided on the face of the base of each protector block between the arrester units. The arrester units shall be 2-electrode gas type and provide 400 Vdc fail-short protection.

1. Cook Electric W492-LCGX (or WMATA approved equal).
  2. With 400 VDC gas style arresters.
  3. With required mounting hardware and appropriately sized enclosure.
  4. Porta Systems Model 24025-66-F66P (or WMATA approved equal).
  5. Three-element gas tube protector modules.
  6. 25 pair termination with 66 type clips for analog telephone.
  7. 110 type clips for LAN field connections to patch panels and subscriber outlets.
- B. Multiple protector blocks (two pair type) shall be provided and installed adjacent to each other (vertical rows) for the termination of multiconductor cables containing more than two pairs.
- C. Appropriate length brass or copper mounting and ground bar assemblies shall be provided for the installation and grounding of the protector blocks. Each mounting and ground bar assembly shall have a minimum of two binding posts with appropriate nuts and washers for the termination of ground wires. Appropriate hardware shall be provided to secure and ground the protector blocks to the mounting and ground bar assemblies. Appropriate mounting hardware shall be provided to install the mounting and ground bar assemblies.
- D. Unless otherwise specified, all wires and cables that enter/exit the Communications Equipment Rooms and remote ancillary buildings shall be terminated on protector blocks at both ends. Coaxial cables and triaxial cables are exceptions. Contractor shall select appropriate devices to protect LAN data cables in a manor that does not degrade the bandwidth.

## **2.06 DISTRIBUTION FRAMES**

- A. Distribution frames including the MDF/Protector Cabinet shall consist of the required multisection cable terminal housings, top and bottom assemblies for each housing, a hinged end section at both ends of the distribution frame, a lift-out door for each housing, and a fungus resistant solid plywood backboard in each housing. Each housing of the distribution frame shall contain four distribution rings to permit neat installation of wires and cables within the housing. All multisection cable terminal housings, including the top and bottom assemblies, the door, and the end sections, shall have a baked enamel gray color finish. In the event *distribution frames* are not available that meet this standard, an alternate shall be submitted for approval along with references with contact information, identifying users of the proposed product in the telecom industry.
- B. Each of the cable terminal housings shall be equipped with the required number of three-element gas tube protector modules with 66-type clips for termination of all conductors of the cable provided for the separate communications systems.
- C. All cables and wires that are to be installed to/from the distribution frames shall enter/exit through the top and bottom assemblies of the housings. Appropriate connectors and protected passages for the cables and wires shall be provided.
- D. As a minimum, each multisection cable terminal housing shall have a ground bus bar installed near the bottom on the plywood backboard, consisting of a 6.0-inch by 0.25 inch by 0.5-inch copper bar. The ground bus bar shall be drilled and tapped for the required ground

connections within each housing. The ground bus bar shall be electrically isolated from the distribution frame enclosures.

## **2.07 FUSES AND CIRCUIT BREAKERS**

All equipment shall be protected by fuses or circuit breakers of the appropriate size. Fuses and circuit breakers shall be readily accessible, surface mounted, on all equipment. Fuse wire within the equipment shall not be acceptable.

## **2.08 WIRES AND CABLES**

- A. Only continuously extruded outer jackets free of PVC and PVC-based compounds shall be furnished on cables provided in this Specification. Exceptions may be allowed by WMATA's Representative when such cable is not commercially obtainable from equipment manufacturers, and when appropriate to avoid potential electrical signal mismatching, or to otherwise improve system performance or reliability. Exceptions shall be allowed for small diameter cables which is anticipated to be submerged in water.
- B. All single conductor wire and individual conductors of multiconductor cables shall be copper and shall be insulated.
- C. Unless otherwise specified, all multiconductor cables installed within WMATA railroad right-of-way shall contain a metallic shield and a corrugated metallic tape armor. The shield and armor shall be separated by an inner jacket.
- D. Multiconductor cables containing more than two conductors (or fibers) shall contain a minimum of 20 percent spare conductors or two spare conductors (or fibers), (two spare pairs if composed of twisted pairs), whichever is greater.
- E. All wires and cables shall be marked with approved tags at both ends. Telephone wires may be marked in pairs at the end of the twist. Markings shall include nomenclature and destination of the wire or cable.

## **2.09 OUTSIDE PLANT CABLE**

- A. Essex CASPIC-F+M 19 AWG. (or WMATA approved equal).
- B. Filled, shielded telephone cable with mechanical protection, sized as required.
- C. Conductors: Solid annealed copper conductors insulated with color coded polyolefin, standard telephone color code, twisted into pairs.
- D. Core covering: Non-hygroscopic dielectric tape.
- E. Shield: Inner polymer coated .2mm aluminum and outer polymer coated .15mm steel. Interstices of the shielding system flooded with waterproofing compound.
- F. Mechanical Protection: .15mm corrugated steel shield, flooded both sides.
- G. Outer Jacket: Black, low-density, high molecular weight polyethylene.
- H. Shall meet REA Specification PE-39.

## **2.10 INSIDE PLANT CABLE**

- A. If not in conduit, plenum approved cable shall be provided. Plenum cable shall meet the low-smoke/low flame characteristics required by UL to be classified for installation in air handling plenums without conduit.
- B. If installed in conduit, plenum approved cable not required.
- C. Minimum three twisted pairs, 22 AWG. solid copper conductors with overall shield and single polyethylene jacket.
- D. Shall conform to the National Electrical Code requirements.
- E. In cases where specific cables shall be subjected to water damage, PVC cable may be used with permission of WMATA's Engineer.

## **2.11 25-PAIR/22 AWG. TIE CABLE**

- A. Anixer Model No. E-002522AAC (or WMATA approved equal).
- B. 25 pair, 22 AWG. single jacketed, shielded telephone cable.
- C. Solid copper conductors, insulation with standard telephone color code, twisted into pairs.
- D. Core covering: Non-hygroscopic dielectric tape.
- E. Shield: .008 inch corrugated, copolymer coated aluminum.
- F. Jacket: Black polyethylene.
- G. Shall meet REA Specification PE-22.

## **2.12 GROUNDING**

- A. Communications systems and facilities, equipment and cables shall be grounded using a single point grounding scheme. Each Communications Equipment Room shall have a separate isolated ground bus bar designated as "communications ground." Please reference Section 16710 for additional grounding requirements.
- B. Unless otherwise specified, the shields of all single shielded communications cables, the shields of multiconductor cables with individually shielded pairs, the inner shield of all double shielded communications cables and communications cables with separate shield & armor, shall be grounded only at a single point and only to the "communications ground." These shields shall be electrically continuous throughout the cable length by bonding across all splices and terminations in equipment enclosures and junction boxes. Cable sections originating at Passenger Station Communications Equipment Rooms shall have the shield or armor grounded to the passenger station "communications ground."

## **2.13 JUNCTION BOXES**

- A. Junction boxes shall be constructed of 12-gauge stainless steel or fiberglass, except for sizes 24-inch x 36-inch and smaller, which may be constructed of 14-gauge stainless steel or fiberglass. Boxes shall have all seams welded. The boxes shall be finished to be a NEMA

Type 4 rating with the door/cover gasket with an oil resistant gasket material and adhesive. Boxes within the railroad right of way in areas where reflection may distract a train operator shall be painted with ANSI 61 gray paint after priming or shall be a phosphatized surface with ANSI 61 gray polyester powder coating applied. Associated hardware shall be constructed of stainless steel. Junction boxes shall be sized to provide ample space for terminating the wires and cables installed at each location, including terminal blocks and considering the minimum bending radii of cables. Junction boxes exposed to the weather shall have all wire entrances protected from weather and dust with a weather-tight connector, and shall be equipped with a drain plug. EXCEPTION: Junction boxes in environmentally controlled (heated and air conditioned) rooms may be galvanized steel.

- B. Junction boxes shall be furnished and installed complete with terminals, fittings, mounting brackets, cable supports and all other necessary hardware. All conductors within a junction box (including spares) shall be terminated on terminal blocks. Junction boxes to be used only for the pulling of cable do not require terminals.
- C. All boxes shall be mounted plumb and level and shall be rigidly anchored to the supporting surface. Machine-bolt type expansion anchors shall be used to fasten boxes to concrete surfaces where inserts are not otherwise provided. In no case shall bolts of less than 0.25 inch diameter be used. Stainless steel spacers shall be used on bolts to provide a 0.25 inch air space between boxes and mounting surfaces.
- D. All boxes shall have an embossed metal tag on the cover. To identify the service of the circuits in the box, as approved by WMATA's Representative.

#### **2.14 CONDUIT**

- A. All conduit, except as noted, shall be intermediate metal conduit (IMC). Conduit fittings selected shall have removable covers shall be complete with gaskets and blank covers.
- B. Flexible conduit shall be provided where specifically required.
- C. Rigid non-metallic conduit shall be provided only where specifically required by these Specifications. Minimum schedule 40 shall be used in concrete encased duct banks. Schedule 80 shall be used for non-concrete encased runs when approved.

#### **2.15 HARDWARE**

- A. Unless otherwise specified, all mounting hardware (screws, nuts, bolts, straps) shall be stainless steel or brass. Appropriate type mounting hardware shall be provided for the corresponding supporting surfaces.
- B. Brackets installed in tunnel or outdoor areas shall be stainless steel or hot dipped galvanized after fabrication in accordance with ASTM A386.
- C. Non metallic mounting hardware may be used for radiating antenna cable installation.

#### **2.16 COMMUNICATIONS DUCTBANK**

- A. The Contractor shall design, furnish and install a communications ductbank between the Parking Structure Communications Room and the Passenger Station Communications Room. The communications ductbank shall accommodate all Parking structure Communications cabling requiring connection to existing WMATA facilities. The ductbank shall also accommodate cabling required for the Parking Access and Revenue Control

System, LAN/WAN and a minimum of two empty 4-inch ducts shall be provided for future use. The communications ductbank shall be a minimum size of six, 4-inch ducts with one duct assigned exclusively for Fire and Intrusion Alarm cabling. The Contractor shall be responsible to determine the method of transition from the parking structure to the station. A minimum of two 2" conduits shall also be provided between the garage operations room and the passenger station kiosk for fare collection use. It is the contractor's responsibility to determine the quantity and sizes of conduits required. Conduit size and quantity may not be less than the minimum requirements. The adopted method shall be approved by WMATA's Representative in addition to all required approvals by the State and local Department of Transportation, the County and any other authorities having jurisdiction. The ductbank shall include the following major items:

1. Manholes, Precast or Cast-in-Place Concrete.
  2. Handholes, Fiberglass reinforced polymer concrete.
  3. Reinforced Concrete Encased PVC Ducts.
  4. Rigid Galvanized Steel Conduits.
  5. Galvanized Steel Pull Boxes
- B. Related Work Specified Elsewhere:
1. NOT USED
  2. Concrete Reinforcement: Section 03200.
  3. Cast-in-Place Concrete: Section 03300.
  4. Precast Concrete: Section 03400
  5. Raceways, boxes and cabinets: Section 16130.
- C. Communications ductbanks shall be constructed using appropriately sized precast or cast-in-place manholes and handholes spaced at maximum intervals of 400 feet unless otherwise prevented by a highway, railroad or other feature that would limit or prevent access. The construction materials shall meet the requirements specified and shall fully comply with applicable loading requirements for the planned locations of the manholes and handholes. Manholes and handholes shall be fitted with appropriately rated covers and be located with regard for accessibility with the Parking Structure in operation. Manholes shall be equipped with lifting rings, pulling eyes, steps, drainage sump, ground rod hole and surface mounted channel inserts on the two sides perpendicular to duct entrances. Manhole and handhole covers shall be installed flush with the finish grade or pavement and oriented so the steps can be used from the top of the collar to the bottom of the vault.
- D. The ducts shall be Schedule 40 PVC with reinforced concrete encasement. To the extent practical, the ducts within the ductbank shall be installed without bends except for building entrances and with a slight slope toward the adjoining manholes or handholes to promote drainage. Any 90 degree bends in the underground ductbank shall utilize wide-sweep elbows in compliance with the NEC. The ductbank shall be installed at a minimum depth of 30 inches below finished grade and in locations subject to highway vehicular traffic the minimum depth shall be increased to satisfy the requirements of appropriate jurisdictions. Any exposed conduits required to complete the ductbank route between the parking structure and the

passenger station shall be heavy duty galvanized steel with appropriately sized galvanized steel pull boxes located as required to facilitate cable installation. Duct entrances into buildings and manholes shall be equipped with conduit seals and duct entrances into buildings shall be equipped with cable seals. Each duct shall be assigned a conduit number with a prefix "C" to identify it as a communications conduit. The numbers shall be shown on design drawings and non-corrosive, metallic tags with the conduit numbers shall be affixed to the structure near the entrances of ducts into buildings, manholes and handholes.

- E. Multiple interduct runs shall be used in larger conduits to provide future raceways if less than 50% of the conduit's capacity is used. If interduct is used in a conduit to protect a small cable, the maximum quantity of interduct runs shall be installed in the conduit to maximize the future availability of the conduit.

## **2.17 SYSTEM (A) CCTV EQUIPMENT**

- A. Cameras shall meet or exceed the picture quality as specified herein as required with resolution appropriate for their intended purpose.
- B. Cameras shall be day/night NTSC with Wide Dynamic Range. Camera shall produce high resolution color images when lighting is adequate for color images and switch to high resolution black and white images when lighting is less than adequate for color images. Camera shall maintain high resolution video of dark objects and very light objects or background when both are in the same frame.
  - 1. PTZ cameras - Camera - Pelco Spectra III w/ environmental dome - Pelco model SD53CBW-PG-E1 (or WMATA approved equal)
  - 2. Fixed cameras -
    - a. Camera - Pelco CCC1390-H6 (or WMATA approved equal)
    - b. Lens - Pelco 13VDIR7.5-50 (or WMATA approved equal)
    - c. Dome enclosure - Pelco DF5-PG-E1 (or WMATA approved equal)
  - 3. 1/3 inch Super Wide Dynamic Range SIMD imagery
  - 4. Day/Night NTSC High Resolution with WDR
  - 5. Smoke Detector "covert" Cameras for elevator cars (Kalatel GBC-SD-850-P3 or WMATA approved equal)
- C. Noise: Operation of any aspect of the system shall not produce any discernible noise on the CCTV monitor. The signal-to-noise ratio under all transit system operating conditions shall be degraded by no more than 3 dB.

### **2.17.1 (A) FIXED LENS CAMERA WALL MOUNTS**

- A. Supports DF5 Dome Cameras
- B. Finish: gray

### **2.17.2 (A) FIXED LENS CAMERA CEILING MOUNT**

- A. Pelco Model No. BB5-PCA-GY (or WMATA approved equal).
- B. Supports DF5 Dome Cameras

- C. Finish: gray

**2.18 (A) 19-INCH CCTV MONITOR**

- A. Dell Model No 1907 FP or Pelco Model PMCL-219 (or WMATA approved equal).  
Note: WMATA's preferred supplier is Dell. Samsung monitors are also acceptable when LiveWave systems are used.
- B. Resolution: 1280 X 1024.
- C. 110 Vac operation.

**2.19 (A) NETWORK VIDEO RECORDER, ENCODERS AND KEYBOARD**

The NVR equipment listed is for reference only to demonstrate the components required to construct a complete system. A client workstation may be used instead of a keyboard controller video display console and workstation. The video encoder, server and network video recorder may be combined. There are no requirements to solely use the manufacturer listed, however the equipment selected by the contractor must interface with the cameras required in this specification and with WMATA's First-View monitoring system in use by OCC and MTPD.

- A. Keyboard controller (WMATA approved ).
- B. Network Video Recorder - Dell Server class computer with redundant power supplies (or WMATA approved ).
- C. Video display Console - Dell or (WMATA approved )
- D. Video Encoder - capable of video codecs including both M-JPEG and ASP compliant MPEG-4 JPEG or MPEG. Must communicate directly with existing First View video management.
- E. Workstation - Dell Optiplex (or WMATA approved )
- F. WMATA standard components are provided by Smiths Detection-LiveWave
- G. The system shall provide low latency video distribution and camera control over IP networks (under 60 ms) with support for video data scaling, compression and frame rate adjustments for low bandwidth connections
- H. The software shall provide full screen software multiplexer displays with intuitive drag & drop of any networked camera feed or device (1, 4, 9, 16, 32) and video sequencer capabilities to program camera sources,
- I. The system shall support map interfaces with the ability to select cameras and pop-up video windows.
- J. The system shall connect to a variety of high-quality video storage options (DAS/NAS/SAN) with both on-site and off-site recording and playback of archived video via standard Windows Media Player.
- K. Each server shall support at least 500 simultaneous users of real time video and use a distributed server architecture to enable thousands of video channels and users to be added to the system.
- L. The system shall include free and unlimited user/client licenses. No per seat licenses are

or proprietary software or hardware required to access system.

- M. The system shall include a modular design enabling easy integration and customization options to be added.
- N. The system shall be able to integrate with advanced sensors for chemical detection (CWA and TIC) with proven commercial deployments.
- O. The software shall be a mature COTS product that has been commercialized for at least 5 years with documented deployments in major transit systems, homeland security and military operations. At least 5 references shall be provided and will be validated.
- P. The system must provide a Software Development Kit SDK to allow future customer and third party extension and integration of the system. This SDK must be computer language and operating system agnostic.
- Q. The system shall be compatible with the PROTECT programs CBEIMS software for advanced alerts from PROTECT managed CWA sensors.
- R. The system shall have the capability of creating a video alert window on alarm. Video associated with any alarm will "pop up" in a matrix screen as a visual alert to console operators.
- S. The system must integrate with the FIA panel and GETS to provide incident based markers on the recorded video and provide video of incident areas along with the alarm annunciation at MTPD consoles.

## **2.20 (A) COAXIAL VIDEO CABLE**

- A. Belden Type 1153A (or WMATA approved equal).
- B. 75-ohm impedance.
- C. Double shielded with foil wrap and copper braid.
- D. Attenuation (at 10 MHz): 0.66 dB/100 ft. (nominal).
- E. Type: RG-11/U.
- F. Teflon jacket.

## **2.21 (A) FIBEROPTIC CABLE**

- A. Composite, Armored composite Single-mode/ Multimode between the passenger station communications room and the garage communications room. Minimum fiber count 12 single mode and 12 multimode fibers.
- B. Fiberoptic cables to cameras shall have minimum one spare strand to each camera.
- C. All fiberoptic strands including spare strands shall be terminated with SC type connectors on fiber patch panels. Patch panels are not required at camera locations. Some cameras require ST connectors.

- D. All strands shall be labeled at both ends indicating usage and destination.

**2.22 (A) TWO-CONDUCTOR SHIELDED POWER CABLES**

- A. Belden Type 83321 (or WMATA approved equal).
- B. 18 AWG conductors.
- C. 600V UL rated Class-1.
- D. TFE Teflon insulation (No PVC).

**2.23 (A) CCTV CAMERA POWER DISTRIBUTION PANEL**

- A. AC Power Distribution modules by APC, Rurman Pluzzi Engineering or TrippLite providing superior surge and lightning protection will be acceptable.
- B. Ten 120 Vac Receptacles (NEMA 5-15R), 12-amp service.
- C. Common and Differential Mode EMI/RFI Filtering.
- D. UL approved.
- E. 19-inch rack mount when used in the communications room. Surface mount acceptable in equipment cases.
- F. Includes 20-amp circuit breaker.

**2.24 (A) FIBER OPTIC VIDEO TRANSMITTERS AND RECEIVERS**

- A. International Fiber Systems (IFS)
- B. American Fibertek Inc. Model 20 Series.
- C. Force, Incorporated Model 2792.
- D. Lascomm Model 145/195.
- E. Transition Networks Model J/VD series.
- F. Philips Model TC4641/TC4642
- G. Other manufacturers and product variations will be considered based on warranty, performance, interface requirements and environmental limitations.
- E. Format: NTSC video format.
- F. ST connectors.

**2.26 (A) GARAGE FURNITURE**

- A. The contractor shall provide furniture in the garage communications room, the police room and the parking operations office.
- B. Communications Room Furniture
  1. Step Ladder (Werner Pro 6206 Granger 3W 141 or WMATA approved equal)
  2. Stool (SAFCO 3401 Granger 4KH38 or WMATA approved equal)
  3. Work Bench (Edsal BML7236T Granger 1PB59 or WMATA approved equal)

- C. Police room and Parking Office Furniture
  - 1. Desk (MBI DP6030-PU Granger 1JU34 or WMATA approved equal)
  - 2. Chair (Global 2239-6 Granger 1BP63 or WMATA approved equal)
  - 3. Fax Machine - police office only (Canon LC 2060)

**2.27 (B) FIRE & INTRUSION ALARM (FIA) SYSTEM EQUIPMENT**

WMATA has installed a standardized FIA system throughout the entire Metrorail system with central monitoring stations at JGB and CTF. The WMATA FIA system is model EST3 manufactured by Edwards and was installed by ADT. Design and installation of the FIA system shall remain the contractor's full responsibility including any local requirements required for occupancy permitting.

Portions of the equipment noted below may or may not be required depending on jurisdictional requirements. Designer may elect to extend new zones from the existing station FIA system if allowed by the local jurisdictional authority.

Other components not identified below may be required.

**2.28 (B) EDWARDS 3000 CABINET, CHASSIS AND 3-RCC7R BATTERY CABINET**

- A. Manufacturer: Edwards Systems Technology
  - 1. Part No. 3-CAB21B (or WMATA approved equal), including the following:
  - 2. Part No. Edwards-CAB21DR door assembly kit (or WMATA approved equal).
  - 3. Part No. 3-CHAS7 chassis assembly mounting various rail modules (or WMATA approved equal).
  - 4. Part No. 3-RCC7R Battery Cabinet 24 Vdc, 50 amp/hour batteries. (2/12 V batteries) (or WMATA approved equal).
    - a. Battery: Sealed lead-acid or nickel cadmium type. Provide sufficient capacity to operate the complete alarm system in normal or supervisory (non-alarm) mode for a period of 24 hours. Following this period of operation on battery power, the battery shall have sufficient capacity to operate all components of the system, including all alarm indicating devices in alarm or supervisory mode for a period of 15 minutes.

**2.29 (B) CENTRAL PROCESSING UNIT MODULE**

- A. Manufacturer: Edwards Systems Technology
- B. Part No. 3-CPU1 (or WMATA approved equal), including the following:
- C. Provides all input and output processing for each FIA control unit. Up to 64 nodes interconnect on a peer-to-peer multi-priority token ring protocol network.
- D. Part No. 3-RS 232 Communication Card (or WMATA approved equal).

1. Provides a port for downloading the network programming into the 3-CPU1. Supports connection to a printer and/or an external command center.

E. Part No. 3-RS 485B Network Communication Card (or WMATA approved equal).

1. 3-CPU1 interfaces to the remote annunciator in the Kiosk and other Network Nodes, via the Network Communication Card. Supports a Class B (Style 4) or a Class A (Style 7) circuit.

### **2.30 (B) PRIMARY POWER SUPPLY**

A. Manufacturer: Edwards Systems Technology

B. Part No. 3-PPS/M (or WMATA approved equal).

C. Provides all power for all modules and accessories.

D. Charges the batteries and sends fault status conditions to the 3-CPU1.

1. Power Input 120 VAC, 3.0A, 50/60 Hz.

2. Output Totals Internal DC 24 Vdc @ 7.0 A Max, Auxiliary DC Two 24 Vdc @ 3.5 Max.

### **2.31 (B) MAIN LIQUID CRYSTAL DISPLAY MODULE**

A. Manufacturer: Edwards Systems Technology

B. Part No. 3-LCD (or WMATA approved equal).

C. Local Annunciator and user control interface in the FIA control unit.

1. Eight (8) lines by 20 characters graphic LCD display-168 characters.

2. Uses queues to sort events (i.e. Alarm, Supervisory, Trouble and Monitor).

### **2.32 (B) SIGNATURE DRIVER CONTROLLER MODULE**

A. Manufacturer: Edwards Systems Technology

B. Part No. 3-SDDC (or WMATA approved equal).

C. Dedicated microprocessor control.

1. Loops alarms in less than 750 ms.

2. Supports up to 250 Intelligent Signatures Detectors and 250 Intelligent Signature Modules.

3. Ground fault detection by loop and by Signature Module Circuit.

### **2.33 (B) SECURITY / ACCESS CONTROL MODULE**

- A. Manufacturer: Edwards Systems Technology
- B. Part No. 3-SAC (or WMATA approved equal).
- C. Provides two (2) RS-485 Class "B" communication circuits that link the Edwards-3000 to all field installed "smart readers" 3-CRC interfaces. The 3-SAC continuously polls all 3-CRC interfaces on each 2-wire circuit and reports any status or communication faults changes to the 3-CPU1.

**2.34 (B) MODEM COMMUNICATOR**

- A. Manufacturer: Edwards Systems Technology
- B. Part No. 3-MODCOM (or WMATA approved equal).
- C. The 3-MODCOM is a combination digital dialer/modem utilized by the Edwards 3000 system, to communicate to industry standards digital dialer receivers for status reports.  
The 3-MODCOM also communicates via an integral modem to computers equipped with a 3-ACDB (Access Controlled Database Program) for downloading user access levels. The 3-MODCOM is a dual-line capable digital dialer V.32bis 14.4K full duplex modem.

**2.35 (B) INTELLIGENT PHOTOELECTRIC SMOKE DETECTOR**

- A. Manufacturer: Edwards Systems Technology
- B. Part No. Edwards-PS (or WMATA approved equal).
- C. The Edwards-PS is a Signature Series Intelligent Photoelectric type smoke detector that communicates status changes to the Edwards 3000 FIA system via the 3-SDDC polling circuits.
  - 1. Photoelectric- Light Scattering Principle or Particle Detection.
  - 2. 300 to 4000-ft/min air velocity range.
  - 3. Five user programmable sensitivity levels.
  - 4. 20 user programmable pre-alarm levels.
  - 5. Automatic day/night sensitivity selection.
  - 6. Standard Detector Base SIGA-SB (or WMATA approved equal).

**2.36 (B) PHOTOELECTRIC SMOKE/HEAT DETECTOR**

- A. Manufacturer: Edwards Systems Technology
- B. Part No. Edwards-PHS (or WMATA approved equal).
- C. The Edwards-PHS is a Signature Series Intelligent Photoelectric smoke and fixed-temperature heat multisensor detector that communicated status changes to the Edwards 3000 FIA System via the 3-SDDC polling circuits.

1. Photoelectric- Light Scattering Principle or Particle detection and 135 degree fixed heat detection.
2. Standard 900 sq. Ft spacing.
3. Five user programmable sensitivity levels.
4. Automatic day/night sensitivity selection.

#### **2.37 (B) DUCT SMOKE DETECTOR HOUSING**

- A. Manufacturer: Edwards Systems Technology
- B. Part No. Edwards-DH (or WMATA approved equal).
- C. The Edwards-DH is a duct detector housing that accommodates the installation of one Signature Series Intelligent Photoelectric type smoke detector and standard base. The Edwards-DH mounts in the field on air ducts and utilizes various length sampling tubes, as required, to sample air for possible smoke detection.
  1. Edwards-PS Photoelectric Smoke Detector (or WMATA approved equal).
  2. SIGA-SB detector base (or WMATA approved equal).
  3. Series 6261 sampling tubes (8, 24, 42, 78, 120 inch lengths).

#### **2.38 (B) INTELLIGENT HEAT DETECTORS**

- A. Manufacturer: Edwards Systems Technology
- B. Part No. Edwards-HFS (or WMATA approved equal).
- C. The Edwards-HFS is a Signature Series Intelligent Heat Detector that communicates status changes to the Edwards 3000 system via the 3-SDDC polling circuit. The Edwards-HFS is uniquely addressed and identified at the FIA control unit.
  1. Edwards-HFS is a 135 degree fixed heat detector.
  2. 4900 sq. Ft spacing at 10 ft ceiling height.
  3. SIGA-SB detector base (or WMATA approved equal).

#### **2.39 (B) INTELLIGENT HEAT DETECTOR**

- A. Manufacturer: Edwards Systems Technology
- B. Part No. Edwards-HRS (or WMATA approved equal).
- C. The Edwards-HRS is a Signature Series Intelligent Heat Detector that communicates status changes to the Edwards 3000 system via the 3-SDDC polling circuit. The Edwards-HRS is uniquely addressed and identified at the FIA control unit, the Edwards-HRS is a fixed and rate-of-rise heat detector.

1. 135 degree fixed and 15-degree/min. rate of rise heat detector.
2. 4900 sq. Ft spacing at 10 ft ceiling height.
3. SIGA-SB detector base (or WMATA approved equal).

#### **2.40 (B) INPUT MODULES**

- A. Manufacturer: Edwards Systems Technology
- B. Part No. SIGA-CT1/2 and MCT2 (or WMATA approved equal).
- C. The SIGA input modules are used to make connection to hard-wired, non-addressable devices like waterflow detectors, valve switches, suppression systems.
- D. Multi-application Class "B" input modules used to monitor various fire and supervisory devices.
  1. The SIGA-CT1 monitors one (1) input circuit, and the SIGA CT-2 and MCT2 each monitor two (2) input circuits.
  2. 47k ohm EOL resistor
  3. UIO series motherboard ("M" series only) (or WMATA approved equal).

#### **2.41 (B) CONTROL RELAY MODULES**

- A. Manufacturer: Edwards Systems Technology
- B. Part No. SIGA-CR and MCR (or WMATA approved equal).
- C. The SIGA-CR and MCR are multi-application commendable output relay modules. These modules are used to control activation and de-activation of various output functions, such as, fan shut down, escalator shutdown, elevator recall, DTS. SIGA-UIO Series Motherboard (or WMATA approved equal).

#### **2.42 (B) UNIVERSAL I/O MODULE MOTHERBOARD**

- A. Manufacturer: Edwards Systems Technology
- B. Part No. SIGA-U106 and U102R (or WMATA approved equal).
- C. The SIGA-U106/2R are motherboards that provide mounting and wire terminations for SIGA "M" series modules. The SIGA-U106 supports up to six modules, and the U102R has the capacity for up to two (2) modules.
- D. Locations: Communication Equipment Room, and Ancillary locations. (Edwards-MFC-A cabinet).

#### **2.43 (B) ADDRESSABLE MANUAL PULL STATIONS**

- A. Manufacturer: Edwards Systems Technology

- B. Part No. Edwards-278 (or WMATA approved equal).
- C. The Addressable manual Pull Station communicates status changes to the Edwards 3000 FIA system via the 3-SDDC polling circuit. Function: Double-Action, single stage alarm.

**2.44 (B) 12/24 VDC POWER SUPPLY**

- A. Manufacturer: Altronix.
- B. Part No. OLS75 (or WMATA approved equal).
- C. The Power Supply provides 24VDC at 2.5 amps for ancillary building "Smart Reader" application. The OLS75 shall supply power for the SPX 2000, HID 5355, and other required accessories in ancillary buildings applications. Functions: Filtered and Regulated 24VDC.

**2.45 (B) STAINLESS STEEL ENCLOSURE**

- A. Manufacturer: Hammond.
- B. Part No. 1414N4PHSSK (or WMATA approved equal).
- C. This enclosure provides a housing in ancillary buildings for, "Smart Readers", OLS75 Power Supply, SPX 2000, Electronic Toggle Relay and the Edwards-SEC2 Dual Input Security Module. Functions: NEMA 4, Stainless Steel, hinged door.

**2.46 (B) DUAL INPUT SECURITY MODULE**

- A. Manufacturer: Edwards Systems Technology
- B. Part No. Edwards-SEC2 (or WMATA approved equal).
- C. The Dual Security Module is used to monitor intrusion devices, such as, door contacts and duress buttons.
- D. The SEC2 monitors two (2) input circuits. Functions: Normally open or Closed contact operation.

**2.47 (B) DIGITAL KEYPAD (DUMB READERS)**

- A. Manufacturer: Securitron.
- B. Part No. DK-26SS (or approved equal).
- C. The Digital Keypad is a programmable intrusion alarm shunt keypad that will be used for all "Dumb Reader" applications.
  - 1. 59 programmable user codes.
  - 2. Momentary and latching capability.
  - 3. Non-volatile memory.

#### **2.48 (B) MAGNETIC DOOR CONTACTS**

- A. Manufacturer: Sentrol.
- B. Part No. 2507A (or WMATA approved equal).
- C. The Magnetic Door Contact shall be used for door intrusion detection in most applications.
- D. The 2507A provides a SPDT (Single Pull Double Throw) contact for connection to either a SEC2 Module.
  - 1. Functions: SPDT contact.
  - 2. Wide Gap distance (approx 3").
  - 3. Stainless Steel Cable.

#### **2.50 (B) RAIL MOUNTED TERMINAL BLOCK**

- A. Manufacture: Weidmuller.
- B. Part No. 0412860000 (or WMATA approved equal).
- C. The Rail Mounted Terminal Blocks shall be installed in all Communication Equipment Rooms Distribution Frames.
  - 1. Clamping Type: Screw Clamp.
  - 2. Series: SAK Series.
  - 3. Wire size: # 22...12AWG.
  - 4. Current: 10 A.
  - 5. Voltage: 300 V.
  - 6. Special Req. 2 StB.

#### **2.51 (B) PROTECTOR BLOCKS**

- A. Manufacture: Reliable Electric Co.
- B. Part No. Model No. 361VSR2 (or WMATA approved equal).
- C. Arrester Type: Gas.
- D. Connector Type: Type 66 Quick-Clip.
- E. Stackable.

**2.52 (B) 3/4" PLYWOOD MOUNTING BACK BOARD**

- A. 3' x 3' x 3/4" Fire Retardant Plywood.

**2.53 (B) VARIOUS ELECTRICAL ACCESSORIES**

- A. Manufacture: West Penn.
- B. Part No. 60980 (or WMATA approved equal).
- C. The West Penn wire shall be used for all new hard-wired device cabling, such as, door contacts and request to exit devices.
  - 1. No. Of Conductors 1 pair.
  - 2. AWG Size 18 Solid.
  - 3. Tunnel Tested Yes.
  - 4. Temp. Range -10°C to 75°C.
  - 5. Voltage 300 V.

**2.54 (B) VARIOUS ELECTRICAL ACCESSORIES**

- A. Manufacture: West Penn.
- B. Part No. 60991 (or WMATA approved equal).
- C. This West Penn wire shall be used for all new SLC (Signaling Line Circuits) cabling to Intelligent Signature Series devices such as, smoke detectors, heat detectors, modules.
  - 1. No. Of Conductors 1 pair.
  - 2. AWG Size 16 Solid.
  - 3. Tunnel Tested Yes.
  - 4. Temp. Range -10°C to 75°C.
  - 5. Voltage 300 V.

**2.55 (B) VARIOUS ELECTRICAL ACCESSORIES**

- A. Manufacture: West Penn.
- B. Part No .60993 (or WMATA approved equal).
- C. This West Penn wire shall be used for all new 24 VDC power cabling, such as, annunciators and reader interfaces.
  - 1. No. Of Conductors 1 pair.

- 2. AWG Size 14 Solid.
- 3. Tunnel Tested Yes.
- 4. Temp. Range -10°C to 75°C.
- 5. Voltage 300 V.

**2.56 (B) VARIOUS ELECTRICAL ACCESSORIES**

- A. Manufacture: West Penn.
- B. Part No. D990 (or WMATA approved equal).
- C. This West Penn wire shall be used for all new RS485 data lines, such as, annunciators reader interfaces.
  - 1. No. Of Conductors 1 pair.
  - 2. AWG Size 16 Solid.
  - 3. Temp. Range -20°C to 75°C.
  - 4. Voltage 300 V.

**2.57 (B) VARIOUS ELECTRICAL ACCESSORIES**

- A. Manufacture: Superior/Essex.
- B. Part No. Filled ASP.
- C. The cable shall be used to interconnect ancillary locations to stations, where no interconnection currently exists.
  - 1. No. Of Conductors 6 pair.
  - 2. AWG Size 19.

**2.58 (B) VARIOUS MOUNTING HARDWARE**

- A. Manufacture: Various manufactures.
- B. Part No. Assorted.
- C. The contractor shall indicate and provide documentation on all mounting hardware, fittings and conduit etc. to WMATA for acceptability in this contract.

**2.59 (C) GARAGE TELEPHONE SYSTEM EQUIPMENT**

**2.60 MULTI-LINE AND SINGLE LINE VOIP TELEPHONE INSTRUMENT**

- A. Cisco, Polycom or other compatible VOIP instrument. (Or WMATA approved equal).
- B. Desk type,

1. Multi-line
  2. DTMF emulating keypad
  3. fully modular.
  4. Built-in speaker/microphone for hands free two-way conversation
  5. Capable of initiating conference calling, call transfer and call forwarding features.
- C. Wall mounted Single-line DTMF emulating keypad, fully modular
- D. IP Addressable

**2.61 SINGLE-LINE ANALOG WALL TELEPHONE INSTRUMENT**

- A. Cortelco, Product No. 2554-BE (or WMATA approved equal).
- B. Fully Modular.
- C. Beige.
- D. DTMF Keypad.

**2.62 (D) GARAGE EMERGENCY TELEPHONE SYSTEM (GETS) EQUIPMENT**

The GETS telephone system is described as follows:

**2.63 (D) EMERGENCY TELEPHONE**

- A. Vandal-Proof Products, Inc. Model No. T2100 (or WMATA approved equal).
- B. Fully ADA compliant as specified in ADAAG 4.10.14 and ASME 17.1.
- C. 3/4 inch "PUSH FOR HELP" call button.
- D. Red LED for "CALLING" light.
- E. Green LED for "RECEIVING" light.
- F. Grade 2 Braille and raised lettering to aid sight impaired persons in identifying the Emergency Telephone.
- G. Full duplex speakerphone
- H. Ability to record two different voice messages.
- I. Programmable from any touch-tone telephone (password protected).
- J. Equipped with four number autodial capability, and monitor the progress of incoming and outgoing calls.
- K. Hang up after called party hangs up or after a remotely

programmable period of time, whichever comes first.

- L. Power Requirement: 5 to 25 VDC.
- M. Face Plate: 304 brushed stainless steel.
- N. Auxiliary Output Contacts: Two normal open contacts.
- O. Surface Mount Enclosure: Stainless Steel 16 GA. Vandal-Proof Products, Inc Model No. AE740 vandal resistant hooded enclosure.

**2.64 (D) BLUE AREA LIGHT WITH STROBE WALL MOUNT**

- A. Vandal-Proof Products, Inc. Model No. A703SLB Area Light with Strobe Wall Mount (or WMATA approved equal).
- B. Blue Light remains illuminated at all times.
- C. White Strobe Light Flashes upon Call Activation.
- D. Shock and Vibration Resistant Filaments.
- E. Power Requirements: 120 VAC 5 Amps.
- F. Expected Life: 50,000 hours.
- G. 6"x6"x6" Steel Enclosure.

**2.65 (D) POWER DISTRIBUTION MODULE**

- A. Vandal-Proof Products, Inc. Model No. A705 (or WMATA approved equal).
- B. Input Voltage: 120 VAC.
- C. Telephone Line inputs: 8 RJ11.
- D. Telephone Line/24 VDC outputs: Quick Release type for Tip-Ring and Plus-Minus 24 VDC.

**2.66 (D) FOUR PAIR 22 AWG CABLE**

- A. Belden Cable Part No. 88757 (or WMATA approved equal).
- B. Four-Pair, 22-AWG, Unshielded Twisted Pair (UTP).
- C. Conforms to NEC CMP Category five.
- D. NEC Plenum Rated.
- E. Insulation (non-PVC) FEP Teflon (or WMATA approved equal).
- F. Jacket, (non-PVC), Teflon (or WMATA approved equal).

**2.67 (D) 25 PAIR CABLE TERMINAL HOUSING**

- A. Porta Systems, Model 24025-66-F66P.
- B. Three-element gas tube protector modules.
- C. 25-pair termination.
- D. With 66-type clips.

**2.68 (D) 12 PAIR CABLE TERMINAL HOUSING**

- A. Reltec, Model No. 3650 housing with six (6) three-element gas tube protector modules (each module protects two pairs), Model 1304VSR2 (or WMATA approved equal).
- B. 12-pair termination.
- C. With 66-type clips.

**2.69 (D) 12 PAIR 19 AWG TIE CABLE**

- A. Superior Model TEL G 194 (or WMATA approved equal).
- B. 12 pair, 19 AWG, single jacketed, shielded telephone cable.
- C. Solid, bare copper conductors, solid high-density polyethylene insulation with standard telephone color code, twisted into pairs.
- D. Core filling: ETPR compound.
- E. Core covering: Non-hygroscopic dielectric tape.
- F. Shield: .008 inch corrugated, copolymer coated aluminum.
- G. Armor: Corrugated bare 6 or 7-mil copper alloy 194 tape (TEL G194) applied longitudinally over the core.
- H. Jacket: Black polyethylene.
- I. Shall conform to and meet the requirements of ANSI/ICEA S-84-608-1988 and REA-PE-39.

**2.70 (E) LOCAL AREA NETWORK**

- A. The Local Area Network at the Passenger Station shall be extended to the garage. The LAN shall be used to facilitate connectivity of the Network Video Recorder, the parking operations computer, AEMS, the FIA system (if a separate system is installed), the police room desktop PC, VOIP telephones and media gateways.
- B. The LAN shall be connected to the passenger station LAN by using the composite fiber optic cable. The contractor shall be responsible for determining if single mode or multimode fibers are appropriate based on distance between the garage communications room and passenger station communications room.
- C. At locations where the passenger station has a fiber switch with spare GBIC ports, the fiberoptic connection may be made to the existing fiber switch. If a fiber switch does not

exist or does not have sufficient spare capacity, the contractor shall provide a 1 GB managed fiberoptic switch Cisco model 3760G-24 Port (or WMATA approved equal) in the passenger station communications room.

- D. 48 port managed switches Cisco model 3750G-48PS (or WMATA approved equal) shall be furnished and installed for each LAN shall be installed in the garage communications room. This switch shall accept a SX-GBIC fiberoptic input and shall provide 48 copper ethernet ports. Additional 24 and 48 port switches may also be used to accommodate cameras. Inputs or chaining of switches shall be accommodated via fiber optic connection.
- E. Category 6 cabling shall be used to extend ethernet service from a RJ-45 patch panel located in the garage communications room to wall mounted RJ-45 connections at remote locations which shall include the elevator machine room, the police room, the parking operations room, the location of the AEMS RTU and the communications room desk area.
  - 1. Police room (2 drops - PC & VOIP telephone)
  - 2. Parking operations room (as required for - Parking equipment computer, VOIP telephone, video monitoring station and Network Video Decoders if needed)
  - 3. Communications room desk area (1 drop - PC)
  - 4. Elevator machine room (1 drop - future)
  - 5. AEMS location (1 drop - AEMS)
  - 6. Use Standard EIA/TIA T568B pinouts
- F. Commercially manufactured jumpers shall be used to connect equipment within the racks. Custom jumpers may be acceptable with WMATA's representative approval to promote a neater installation.
- G. WMATA shall provide IP addresses for any connected equipment.
- H. All strands of the composite fiber cable shall be terminated on patch panels. A fiberoptic patch panel sized to accommodate the composite tie cable and all camera fibers shall be provided in the garage communications room. The existing fiber patch panel in the passenger station communications room may be only used if sufficient spare space is available for the tie cable plus at least 10 unused spaces. Contractor shall provide an appropriate sized fiber patch panel in the passenger station communications room if the existing panel does not have sufficient spare capacity.
- I. Terminate all fiber connections using type SC ends unless otherwise approved by WMATA's engineer.
- J. All cables (fiber and copper) shall be labeled at both ends of the run (at the station or destination end and at the patch panel).
- K. All cable drop numbers shall be recorded into an AutoCAD document. This document shall be included in the as-built electronic deliverables. A printed copy shall be maintained in the permanent room set of communications room drawings.

- L. All copper drops shall be tested and certified to meet or exceed ISO 11801:2002. Certified test data shall be submitted to WMATA's engineer for review.
- M. All fiber cable terminations shall be tested and certified to meet or exceed ANSI/TIA/EIA-526-14A [B14], method B; and ANSI/TIA/EIA-526-7 [B15], method A . Certified test data shall be submitted to WMATA's engineer for review.
- N. RJ-45 patch panel assignments for the Secure Operational LAN shall be segregated together as much as is possible.

#### **2.71 (H) GARAGE SUPPLEMENTAL RADIO**

- A. The contractor shall test all Public areas and service rooms for WMATA radio system coverage utilizing a WMATA provided portable radio on the CRCS frequencies.
- B. Provide amplifiers, cabling and antennas as needed to achieve 95 percent radio coverage in all areas of the garage.

### **PART 3 EXECUTION**

#### **3.00 GENERAL**

- A. All design, installation, testing and training shall be conducted in compliance with these specifications.
- B. Unless otherwise specified, communications, electronics and electrical installations shall be governed by the provisions of the "National Electrical Code, Standard of the National Board of Fire Underwriters for Electrical Wiring and Apparatus." And any local or jurisdictional codes. All provisions of this code must be considered applicable, whether specifically mentioned in the body of these Specifications or not.
- C. Unless otherwise specified, all wiring in structures that is external to equipment enclosures and racks, shall be installed in suitable Intermediate Metal Conduit (IMC), or shall be installed in existing cable tray, underfloor duct, or racked to existing channel inserts, if space is available and assigned by WMATA's Representative. All conduit and cable installations shall be subject to the approval of WMATA's Representative.
- B. Existing embedded conduit shall be assigned for use by the Contractor when not reserved for other requirements. Conduit cleaning, the construction of conduit extensions or rearrangements, cable rerouting, and the construction of conduit plant to enclose all remaining wiring shall be furnished by the Contractor. Surface conduit construction shall not be permitted in most public areas of stations or in a few other places. Core boring of structures may be required to obtain means of passage during conduit plant construction. Core boring of a concrete member shall be performed only if the structural integrity of the concrete member is not compromised. The location of embedded items, such as post tensioning tendons, steel reinforcement, conduit and cables shall be determined by the contractor and core boring shall be performed without damage to embedded items.
- C. Inside diameters of conduit shall be determined by the Contractor, based on the National Electric Code, using the appropriate fill factors for the class of service and number and size of conductors. The proposed conduit sizes shall be submitted to WMATA's Representative for approval. Conduits smaller than 0.75 inch shall not be used.

- D. All exposed conduit runs shall be installed parallel to walls, floors and ceilings, whenever possible, except where pitch is required for proper drainage. Conduits shall be rigidly supported at intervals not to exceed eight feet. Standard one-hole, malleable iron galvanized pipe straps of the proper size shall be used for single conduit runs on concrete surfaces. Where conduits are supported on concrete surfaces, stainless steel machine-bolt type expansion shields and bolts of the proper size shall be used. Standard conduit elbows or field bends are permitted; they shall not be less than the minimum radius, as required by the National Electrical Code.
- E. Conduits shall be connected to equipment metal enclosures using two locknuts and a bushing, except where conduit hubs are provided. Where enclosures, fittings with openings, or boxes of any type are installed in locations determined by WMATA to be subject to moisture, watertight conduit fittings shall be used. Watertight covers with seals shall be provided, and approved sealant applied to openings to effectively prevent the entry of moisture.
- F. All conduit entering Communications Equipment Rooms of passenger stations and parking structure shall be sealed. Watertight conduit and cable seals shall be used where the building or structure penetration is at a lower elevation than the manhole or below the water table.
- G. All terminal ends of conduits shall be provided with insulated metallic bushings.
- H. Whenever a conduit or exposed cable enters or leaves a box, it shall be permanently tagged, external to the box, with a plastic tag approved by WMATA's Representative. The tags shall be permanently stenciled or stamped with a number which shall identify the conduit or cable with an assigned circuit. Metallic tags shall be attached with stainless steel wire, straps or screws as applicable.
- I. All conduits installed shall be free of burrs and other sharp edges throughout the entire length. Conduit fittings or boxes shall be installed in conduit runs, where required, to limit the number of bends to a maximum of three 90-degree bends or equal. All conduits used shall be thoroughly cleared by pulling through a mandrel tool, and shall be blown clean by forcing compressed air through the run before wires or cables are pulled.

### **3.01 CUTTING AND PATCHING**

- A. All necessary cutting and patching of existing construction shall be provided by the Contractor for the installation of the equipment, conduit and cables.
- B. All cuttings shall be of the appropriate required sizes and shapes for the materials, conduits, cables and equipment to be installed. All cuttings shall be performed using the appropriate type of tools and equipment for the corresponding surfaces and material. The locations, sizes, shapes, and methods of performance for all cuttings shall be subject to approval by WMATA.
- C. All patching shall match existing adjacent construction to the satisfaction of WMATA, using the best possible workmanship of the various trades involved. All required material, compounds, sealants and hardware for all patching shall be provided. Fire wall integrity shall be maintained in appropriate construction.
- D. Removal and reinstallation of any existing items (i.e., platform tiles, manhole covers) to accomplish the installations shall remain the responsibility of the contractor. Replacement shall be provided for any removed items that are damaged or missing during the

performance of work, at no additional cost to WMATA. Replacements shall be identical in manufacture and type to the damaged or missing items.

- E. When it is necessary to cut reinforcing steel, the contractor shall provide engineering certification that the structure has not been weakened.

### **3.02 EQUIPMENT MOUNTING**

Unless otherwise specified, equipment shall be anchored to the concrete walls, floors, or ceilings by stainless steel machine-bolt type expansion shields and 0.5 inch minimum diameter bolts. The number of bolts shall be adequate to provide a rigid and safe support. Where required, concrete bases or pedestals shall be provided by the Contractor with anchor bolts cast in place for the mounting of equipment. All equipment shall be mounted plumb and level.

### **3.03 PAINTING**

All painted areas damaged in route to, or at the installation site, shall be repainted with matching colors by the Contractor. The surfaces of equipment and material not accessible after mounting shall be painted prior to installation.

### **3.04 WIRE AND CABLE INSTALLATION**

- A. Powdered soapstone or other suitable lubricating medium non-injurious to insulation shall be used, if required, when pulling wire cables in conduits or ducts.
- B. Each conduit, duct and pipe shall be cleaned before installing cables therein. The conduits, ducts and pipes shall be maintained in a clean and dry condition during the installation process up to and including the time which each conduit, duct and pipe is sealed.
- C. Wires and cables shall not cross one another when they are pulled into a conduit nor shall the conductors be pulled tight or kinked in conduit fittings or boxes.
- D. Cables shall be laid, not pulled, into trays or in troughs. Cables shall be installed with a minimum amount of crossover in the trays and troughs and shall not be placed tightly around bends. Where cables enter or leave trays via conduits, such conduits shall be rigidly affixed and supported at their ends by suitable brackets and conduit straps from the sides of the trays.
- E. Wires, cables and individual cable conductors shall be permanently tagged with plastic tags at each entry to and exit from all equipment terminal blocks. Tags shall be permanently marked to identify the system in which the cable and conductor is used. Fiberoptic cables shall have tags installed periodically along any exposed run. Tags and markings shall be subject to the approval of WMATA's Representative.
- F. All cable pairs, including spares, shall be terminated on connectors, protectors, or line terminating blocks on the MDF.
- G. The Contractor shall seal all openings through which cable, conduit and cable trays pass. The material used to seal the openings shall be furnished and installed by the Contractor. It shall be a fire retardant, non-toxic material and shall comply with the local fire prevention code.

- H. All exposed wires and cables entering or leaving equipment housing or junction boxes shall be protected from abrasion by sharp metallic edges. Chase nipples shall be provided in openings having conduit hubs. Chase nipples and locknuts shall be provided in drilled or punched openings.
- I. The Contractor shall seal all openings in equipment enclosures and junction boxes where exposed cables enter the enclosure or box. A pliable sealing compound made expressly for the purpose shall be furnished and installed after the cables are in place.
- J. Nylon straps shall be furnished and installed for bundling and cabling of conductors where two or more single conductors of the same circuit are run exposed in cable trays or in cable troughs. Straps shall be installed approximately every five (5) feet along the cable run. Wires of multiconductor cables exposed by the stripping of the cable jacket for termination shall be trimmed in a neat, workmanlike manner and tied approximately every three inches with nylon straps. Care shall be taken in terminating or splicing cable. Removal of insulation shall be done in a manner which does not nick the conductor material. In no case shall the conductor be kinked or bent at sharp angles. Smooth bends shall be utilized. Stainless steel or Aluminum cable ties shall be used where exposed to sunlight or the ties are the cable support system. A cable tie tool shall be used to install the nylon ties and to cut the ends to avoid sharp edges.
- K. All cables and wires installed in environmental air plenums, cable vaults, and under passenger station platforms shall be placed in appropriately sized electrical metallic tubing (IMC) unless otherwise specified.
- L. Appropriate channel inserts, arms and insulators shall be provided to support cables in the manholes of the duct bank.
- M. Dewatering and removal of all dirt and trash from trenches, manholes, pull chambers, cable troughs, surface trenches, conduit and duct banks shall be the contractor's responsibility during, the installation of cables. All trash and debris shall be removed after the cable installation has been completed and before closing.
- N. Fiberoptic cables shall be terminated in communications rooms on appropriate sized fiberoptic patch panels.
- O. If inter-duct is used for fiberoptic cable installation in ductbanks, multiple innerduct tubes shall be installed in the conduit to facilitate future use of the conduit. Innerduct is not required for one fiberoptic cable in an appropriate sized conduit. New technology innerduct products are commercially available that shall provide future capacity with reduced installation effort and may be used with WMATA's representative approval.

### **3.05 (A) PARKING STRUCTURE EQUIPMENT ROOM CCTV INSTALLATION**

- A. The Contractor shall design, install and test a CCTV system that satisfies the intended system use as noted in the design philosophy in this specification.
- B. Install one Network Video keyboard console or client workstation with 19" monitor(s) in the parking operations room on the desk provided under this contract and connect the viewing system to the Network Video Recorder via LAN connections. The parking office viewing station shall be configured to monitor all cameras observing entry/exit lanes and booths.

- C. Install Network Video Recorder and support equipment (video encoders, memory modules or recording media, programming and maintenance console, keyboard, monitor, ext) on 19" racks in the garage communications room. The garage communications room shall be equipped with any accessory needed to configure, troubleshoot or maintain the NVR system. In lieu of installing the keyboard and monitor in the racks, the workbench maintenance PC may be configured to include all support functions.
- D. Connect all networked video equipment home runs to the garage LAN through an appropriately sized RG-45 patch panel. RG-45 Jumpers between equipment located within the communications room racks may be used as required by the equipment manufacturer and design documents.
- E. The garage police room shall be equipped with a desk, chair and a PC based camera viewing station with a 19" desk top monitor and appropriate software to view any image recorded on the network video recorder and control any PTZ camera in the garage. The PC based viewing station shall function as a regular PC computer when not being used to view video. The PC shall be connected to the NVR by means of a LAN connection.
- F. Provide WMATA's engineer with all software license, log-on identifications and passwords.
- G. Each exit booth and entry lane and all other garage access points shall be monitored by a CCTV camera. This is in addition to the 85% coverage requirement.
- H. All camera video output shall be connected to the Network Video Recorder. The video recorder shall be set to record appropriate quality video for 30 days before overwriting the oldest files.
- I. Contractor shall consult WMATA's engineer during camera design and layout to assure the intent of garage CCTV monitoring is achieved with the minimal quantity of cameras.
- J. CCTV camera video signal shall be transported over fiber optic cable. Exception: video feeds of less than 150 feet from the garage communications room containing the NVR or video encoder room may utilize coaxial cable transmission. IP cameras may utilize cat-6 cable provided the cable run is within the range as specified by the manufacturer and all EMI interference is mitigated.
- K. Elevators shall be equipped with a camera concealed within a housing resembling a smoke detector.
- L. The garage communications room shall be equipped with a workbench mounted PC based video maintenance and viewing station with a 19" desk top monitor. Appropriate software shall be installed to view any camera in the garage system or any image recorded on the network video recorder and control any PTZ camera in the garage. Any additional software required for programming, troubleshooting or maintenance of the Garage Video System shall be provided and installed. The PC shall be interconnected to the video equipment. In cases where interconnection to the equipment can only occur during programming or test modes, permanently installed cables from the equipment location to the PC location shall be installed between the PC and the equipment port and clearly tagged at both ends. The PC shall be connected to LAN. Equipment that is configurable from the PC via the LAN connection will not require redundant cabling.
- M. Bathroom hallways shall have camera coverage.

### 3.06 (B) FIRE AND INTRUSION ALARM SYSTEM INSTALLATION

- A. The Contractor shall install a Fire and Intrusion Alarm System in the Parking Garage in accordance with NFPA National Fire Codes, requirements of local jurisdictions, the Contractor's WMATA approved design and the manufacturer's instructions. Any conflicting requirements shall be resolved to the satisfaction of WMATA's Representative.
- B. If an independent system is provided, the FIA Power disconnect switch shall be installed in the Garage Communications Room on the same wall with the FIA Control Unit and shall be wired to the feed side of the incoming power in such a way to permit power to be removed from Communications Room feeder disconnect switch without interrupting the FIA power.
- C. Intrusion Detectors Installation Requirements - For doors leading from a non-protected area to a protected area, the bypass (or dumb) keypad shall be installed on the wall adjacent to the door lock assembly on the unprotected area side. The protected areas shall include the garage service and equipment rooms, elevators and all attendants booths. Keypads shall be installed on elevator service rooms, communication rooms, power and generator rooms, parking office and police office. Entries into protected areas shall provide a searchable marker on the CCTV video recording for the camera with the closest view of the area.
- D. Elevator Intrusion Interface - The Contractor shall coordinate with the elevator contractor and install conductors and conduit to interconnect the Fire and Intrusion System Control Unit to the FA/FIB to the elevator Junction Box in the Elevator Machine Room. The contractor shall insure connections are made to the elevator intrusion switches
- E. If required by the local jurisdiction, a Graphic Fire Annunciator Panel/Cabinet shall be installed on the outside wall of the Garage Police Room. The Contractor shall install the conduit and circuits as necessary from, the Common Control Unit to the graphic annunciator panel to permit activation of the LEDs of the Annunciator Panel. If an intelligent display is permitted and the contractor elects this option, the display shall be installed in a likewise manner as the graphic annunciator. The contractor shall be responsible for providing tamper proof protection for the display unit.
- F. The Contractor shall program and install the additional modules in the Passenger Station FIA Common Control Unit and provide any additional cabling and conduit for displaying the Garage FIA alarms. The Contractor shall provide any required additional wiring between the Station Common Control Unit, the F&I Interconnect Wall Terminal and the TC/Comm Interface Cabinet in the Station Communications Room for the transmission of Garage FIA alarms to WMATA's Operations Control Center via the passenger station Data Transmission System. Contractor is responsible for connectivity to the terminals on the E-Rack in the station Train Control Room. Any changes and additions to the Data Transmission System shall be performed by others; However, the Contractor shall participate in end-to-end testing of the alarm transmissions and be responsible for any required remedial work in his installations. All work within the Passenger Station shall be subject to the approval and under the supervision of WMATA's Representative.
- G. All cabling, connections, terminal boxes, terminals, 3/4 inch EMT metallic diameter or larger surface conduit (with pressure fittings throughout) between all equipment and between equipment and FIA devices of all types, installation of power disconnect switch equipment and any other installation work and testing and technical documentation services necessary to the completion and functioning of this entire Fire and Intrusion Alarm System as specified, shall be furnished by the Contractor.

### 3.07 GARAGE TELEPHONE

- A. The telephone extensions shall provide telephone service in service and equipment rooms and areas within the Parking Structure. Telephone switching functions shall be provided by the existing telephone processing equipment in WMATA's Jackson Graham Building and at the Carman Turner Facility. Telephone circuits shall be connected to WMATA's telephone system as VOIP extensions through the LAN/WAN which shall be extended from the passenger station under this contract.
- B. Single-line wall-mounted analog telephone extensions shall be provided in the Electrical Room, the Generator Room, the Elevator Machine room, the Elevator Pit and any other rooms or areas within the Parking Structure considered necessary by WMATA's Representative. A full featured desk type VOIP telephone shall be provided in the Garage Police Room, the Parking Operations Office and in the Garage Communications Room.
  - 1. Analog telephone instruments located in the Garage shall have a dedicated Cat-6 cable from the telephone location to the Garage Communications Room (no bridge cable taps shall be permitted).
  - 2. Analog telephones instruments located in the Garage shall be wired to the protector cable terminals located in the Garage Communications Room.
  - 3. Wall-mounted type telephone instruments shall be mounted to NEMA 12 enclosures. The Contractor shall furnish and install an appropriately sized connecting block in the NEMA 12 enclosure.
  - 4. The multi-line VOIP telephone instrument in the Garage Police Room, communications room and parking operations office shall be installed on top of a desk in a location approved by the Engineer. The Contractor shall install a standard surface mount RJ-45 connecting block at floor level near the approved location.
  - 5. A spare cat-6 cable shall be routed from each analog telephone location to the garage communications room MDF and terminated on a 110-block terminal strip. Three feet of cable shall be coiled in the telephone junction box for future use.
- C. All copper telephone and data wiring shall terminate on the distribution frame before connecting to equipment in the communications room. Voice wiring shall terminate on 66-blocks. Data wiring shall terminate on 110-blocks. Additional terminals and protector blocks shall be added as needed to the Metrorail Passenger Station Communications Equipment Room.
- D. Analog telephones and GETS shall be connected to the LAN by means of media gateways located in the garage communications room. The analog emergency modem port or dial around ports of each media gateway which is used during LAN failures shall be connected to separate analog telephone circuits in the passenger station communications room via the 25-pair cable.
- E. A 25-pair, 19 AWG. cable shall be provided between the Garage Communications Room and the Passenger Station Communications Room. The Contractor shall determine and provide cable routing within the Passenger Station without the use of surface mounting of cables or conduits in public areas of the station.

- F. The Contractor shall tag all telephone extension cables and stencil all termination cabinets.
- G. One analog wall telephone and an analog RJ-11 surface mounted connector for a fax machine shall be installed in the police room in addition to the VOIP multiline telephone. The wall mounted analog telephone and fax line shall be cross connected in the garage communications room and routed through the multiconductor copper cable to the passenger station communications room. WMATA's engineer shall provide direction on connection points to the existing WMATA's telephone system.

### **3.08 (D) GARAGE EMERGENCY TELEPHONE SYSTEM**

The GETS system shall include the following equipment installation:

- A. Emergency Telephones (located at the entrances to the stairs and near elevator lobbies in the parking structure and as needed so walking distance to a GETS instrument is no greater than 200 feet from any public area within the garage).
- B. Blue Emergency Telephone Locator Lights and White Strobe Lights (one for each Emergency Telephone)
- C. Power distribution module (located in the parking garage communication equipment room).
- D. Media Gateways (located in the parking garage communication equipment room).
- E. Cabling and termination equipment for connections to WMATA's Carrier Transmission System and Local Area Network.
- F. Any necessary additions or modifications to the GETS System to properly interface with the existing WMATA's telephone system and personal computer and software located in the Jackson Graham Building and Carman Turner Facility.
- G. The Emergency Telephones shall provide a fully automated, touch of a button means for emergency communications between WMATA patrons and the Transit Police Dispatcher with easy to understand instructions in English and braille.
- H.  pressing the momentary contact pushbutton switch on the Emergency Telephone shall illuminate a red indicator marked "CALLING" and start the white strobe light. When the call is answered by MTPD a green indicator marked "RECEIVED" shall illuminate and the pre-recorded message shall play for both the caller and MTPD. If the pre-programmed telephone number is busy or not answered after 30 seconds, the Emergency Telephone shall hang up and dial the number again. This process shall continue until the call is answered. WMATA's existing telephone system shall be programmed to roll-over to the second MTPD number, in the event that the primary number is busy.
- I. An Emergency Telephone call is terminated when MTPD hangs up (goes on-hook), or after the pre-programmed time out has expired - whichever occurs first. This shall cause the Emergency Telephone to hang up (go on-hook) or to be reset. When the call is terminated the white strobe light shall be extinguished. An Emergency Telephone call can not be terminated by any action taken at the Emergency Telephone.
- J. When a call is placed to the Emergency Telephone from the MTPD office, the Emergency Telephone shall be programmed to answer the call and hang up if no keystrokes (via the touch-tone pad) are entered after it has answered an incoming call. MTPD may then enter a

silent monitor mode by entering the proper code number via the touch-tone pad on the telephone.

- K. The blue colored Emergency Telephone Location Lights are normally illuminated (steady on) and are intended to help identify the Emergency Telephone locations to WMATA patrons. When the call button is pressed on the Emergency Telephone, it shall cause the white light to strobe until the call is completed.
- M. The power distribution module shall provide 24 volts DC power to the Emergency Telephones from 120 volts AC.
- N. Telephone Media Gateway Installations:
  - 1. The telephone media gateways shall be used to convert dedicated PABX extensions to Internet Protocol compatible with the existing WMATA's telephone system. Media gateways shall have a dial-around feature installed that shall dial an analog telephone number if the LAN system is not able to complete the transmission.
  - 2. If more than one Emergency Telephone on a media gateway is activated while in the dial-around mode, each Emergency Telephone -except the first one activated- on that media gateway shall receive a busy signal requiring the units to redial until the outgoing line becomes available.
- O. Computer Supervision System and Software Installation:
  - 1. The existing WMATA MTPD personal computer and software shall provide diagnostic testing of all Emergency Telephones and provide printed test results. The existing software shall call each telephone instrument and test whether the Emergency Telephone is receiving power, the integrity of the telephone circuit, the Emergency Telephone circuitry, and the Emergency Telephone microprocessor for proper operation.
  - 2. Updates to the existing software shall be made to incorporate all new Emergency Telephones into the diagnostic system.
  - 3. When IP based GETS are installed and MTPD consoles are available, the database shall be updated to reflect all of the GETS instruments in the garage.
- P. The Contractor shall furnish install and test all instruments, equipment racks, media gateways, LAN interfaces, power supplies, terminals, hardware, protector blocks, enclosures, connecting blocks, wiring and cabling, conduits and fittings, and make all the connections and cross-connections required for a complete and operational installation of the Garage Emergency Telephone System (GETS). This includes all required installations within the passenger station limits, along the right-of-way and in the parking structure. All spare pairs in cables shall be terminated. If future levels of the parking structure are not built under this contract, the Contractor shall terminate the cabling for any noted future level Emergency Telephones and Blue Area /Strobe Lights in appropriate junction boxes as near as practical to the anticipated riser locations for the future level installations. Equipment for the future levels installations shall be packed for storage and stored in the Parking Garage Communications Room.
- Q. Emergency Telephone Instrument Installation:
  - 1. The Contractor shall install the Emergency Telephones and Blue Area and Strobe Lights near the entrance to each stairwell and near each elevator lobby and as

required in public areas so no walking distance is greater than 200 feet from a GETS instrument. The Contractor shall install conduit and a dedicated 4-pair cable from each Emergency Telephone located at entrances to each stair well on each level to the Garage Communications Equipment Room (no bridge cable taps shall be permitted). In the communications room, two of the pairs shall be terminated on the distribution frame through protector blocks for voice and power and the other two pairs in each cable shall be terminated on the distribution frame and marked as spares.

2. The Contractor shall install the required conduit and connect the Blue Area and Strobe Lights to the nearest emergency 277 VAC source using a 277 to 120 VAC transformer supplied by the Contractor. The transformer shall be installed in an appropriately sized stainless steel box and shall be mount under the associated Blue Area and Strobe Light.
3. The Contractor shall install the required conduit and connect the Strobe Lights to the Emergency Telephone's Auxiliary contacts.
4. The Contractor shall install 19-inch equipment racks as required in the Parking Garage Communications Equipment Room. The Contractor shall install the power distribution modules and media gateways (one set for each level of the parking structure) on the 19-inch equipment racks.
5. The Contractor shall program the Emergency Telephone to dial 40000 when the "PUSH FOR HELP" button is pressed.
6. The Contractor shall record a voice message on each Emergency Telephone to identify its location (i.e. "Phone number 6, north side stairwell, level number 4"). The voice message to be programmed into each telephone shall be approved by the Engineer, prior to being programmed. Each voice message shall be scripted and submitted to WMATA's Representative for approval.

R. Passenger Station Installation

1. The Contractor shall install a minimum sized 25 pair 19 AWG cable from the Parking Garage Communications Equipment Room Distribution Frame GETS cable terminal housing to the Passenger Station Communications Equipment Room Distribution Frame GETS cable terminal housing.
2. The Contractor shall terminate the GETS Emergency Telephone media gateway dial around lines in the terminal block in the Contractor provided Distribution Frame of the Passenger Station Communication Equipment Room and extend the wiring to an appropriately sized interface terminal block. WMATA shall provide location information for Cross-connections between the interface terminal block and the existing telephone system.

S. Jackson Graham Building/ Carman Turner Facility Installation:

1. Contractor is responsible for updating configuring the existing GETS diagnostic PC to incorporate all of the GETS instruments installed under this contract into the daily testing software.
2. GETS telephone numbers required for programming the database shall be provided to the Contractor by WMATA's Representative. Contractor shall provide WMATA's

representative with a matrix similar to Table 3.2-1 detailing each GETS telephone instrument location for WMATA to populate with telephone numbers.

3. Any central office telephone switch equipment modifications or adjustments shall be performed by WMATA personnel. All modifications or upgrades to the GETS PC shall remain the responsibility of the contractor.

**Table 3.2-1**  
**EMERGENCY TELEPHONE NUMBER ASSIGNMENTS FOR PARKING Structure GETS**  
**EXAMPLE**

LOCATION	TELEPHONE NUMBER	Media Gateway IP Address
Level 1 - Northeast Stair		
Level 1 - Southwest Stair		
Level 1 - Elevator Lobby		
Level 2 - Northeast Stair		
Level 2 - Southwest Stair		
Level 2 - Elevator Lobby		

### 3.10 (E) LOCAL AREA NETWORK

- A. The Local Area Network from the Passenger Station shall be extended to the garage.
  - 1. The Network Video Recorder, the parking operations computer, the police room desktop computer and computer wall jacks in the AEMS room, generator room, communications room, VOIP phones and elevator machine room, AEMS, GETS and telephones via media gateways shall be connected to the LAN.
- B. WMATA shall provide IP addresses for all connected equipment.
- C. Coordinate with WMATA's Engineer before connecting the new LAN extensions to the active WMATA LAN equipment .
- D. Installation shall follow the following standards:
  - 1. If any data switches are needed to support new construction, the contractor shall identify and provide equipment as is needed. Equipment proposed other than the Cisco switch/router as specified shall be submitted for WMATA - OIT review and approval prior to procurement.
  - 2. Cat-6 LAN drops shall be tested and certified using an OIT approved Cat-6 cable tester.
  - 3. Cat-6 LAN drops shall be labeled and dressed in a professional manner and subject to WMATA -OIT inspection and approval. Failure to pass WMATA - OIT inspection will require the contractor to remedy the cable installation to meet WMATA - OIT approval at the contractor's cost.
  - 4. Fiber terminations shall be on a contractor recommended and WMATA - OIT approved fiber patch panel.
  - 5. Cat-6 terminations shall comply with the eia/tia 568B termination standard.
  - 6. The contractor shall provide all fiber or Cat-6 patch cables required for patching. Cables shall be of an appropriate length for use with the patch panel.

### 3.11 (H) SUPPLEMENTAL RADIO COVERAGE

- A. CS radio equipment shall be installed as needed to provide supplemental coverage in areas where off air service is not available within the garage structure.

Contractor shall select antennas, amplifiers and other equipment as needed to achieve required radio coverage.

**END OF SECTION**

## SECTION 16715

### COMMUNICATIONS ELECTRICAL POWER DISTRIBUTION

#### PART 1 - GENERAL

##### 1.01 SECTION DESCRIPTION AND BASIC REQUIREMENTS

- A. The Electrical Power Distribution System provides power distribution from the 3-phase, 4-wire, 120/208 Vac, primary power feed to the communications systems. The Electrical Power Distribution System described herein includes the following facilities:
  - 1. 120 Vac Emergency Power (from station UPS) for communications equipment in the Communications Equipment Rooms, and Kiosks.
  - 2. -48 Vdc power for communications equipment in the Communications Equipment Rooms.
- B. The 120 Vac Emergency Power Distribution System described herein includes for each Passenger Station, but is not limited to, the following components:
  - 1. In the Communications Equipment Room:
    - a. Power Distribution Panelboard.
    - b. AC Power Receptacles.
- C. In the Kiosk - AC Power Receptacles.
  - 1. Required conduits and fittings, junction boxes, feeder wires, branch circuit wiring, and cabling to apportion the 120 Vac power to the communications systems and facilities equipment.
- D. The -48 Vdc Power Distribution System described herein includes, but is not limited to, the following components:
  - 1. -48 Vdc Power Supply(s).
  - 2. -48 Vdc Status Panel.
- E. The -48 Vdc Power Distribution System provides fail-safe service by load-sharing several power supplies. Power supplies may be removed from the active -48 Vdc Power Distribution System for repair, or added for increased capacity, without disrupting communications services.
- F. The Status Panel provides voltage and current metering for the -48 Vdc Power Distribution System. The Status Panel also distributes -48 Vdc power to the Telephone (TEL), Carrier Transmission System(CTS) and Fiber Optic System(FOS) Systems equipment racks or, as needed, to any other communications equipment racks requiring a source of -48 Vdc power.

##### 1.02 SECTION INCLUDES

- A. Power Distribution Panelboard.
- B. AC Power Receptacles.
- C. -48 VDC Power Supply(s).
- D. -48 VDC Status Panel.

### **1.03 UNIT PRICES**

- A. Unit Prices include all Required conduits and fittings, junction boxes, feeder wires, branch circuit wiring, and cabling to apportion the 120 VAC power and –48VDC power to the communications systems and facilities and incidental items, not specifically mentioned, but required for complete and proper system operation.

### **1.04 RELATED SECTIONS**

- A. Section 16706 - Communications System Submittals & Services.
- B. Section 16707 - Communications Systems Quality Assurance & Testing
- C. Section 16710 - Communications Grounding.
- D. Section 16721 -Communications Telephone System.
- E. Section 16771 -Communications Carrier Transmission System.
- F. Section 16776 -Communications Fiber Optics System.
- G. Section 16851 -Communications Closed Circuit Television System.

### **1.05 REFERENCES**

- A. National Electrical Manufacturers Association (NEMA) Standard Publication 250-1997, Enclosures for Electrical Equipment (1000 Volts Maximum).
- B. NEMA Standard AB-1, Molded Case Circuit Breakers and Molded Case Switches
- C. National Electric Code (NEC).
- D. Insulated Cable Engineers Association (ICEA) S-95-658/NEMA WC70, Nonshielded 0 - 2kV Cables; ICEA S-96-659/NEMA WC71, Nonshielded 2001 - 5kV Cables; ICEA S-93-639/NEMA WC74, Shielded Power Cables 5 - 46 kV; ICEA S-94-649, Concentric Neutral Cables Rated 5 - 46 kV; ICEA S-97-682, Utility Shielded Power Cable Rated 5 - 46 kV; ICEA S-105-692, 600V Single Layer Thermoset Insulated Utility Underground Distribution Cable; and ICEA S-81-570, Direct Burial, 600V, Ruggedized Insulation.

### **1.06 SYSTEM DESCRIPTION**

- A. Description: The Communication Electrical Power Distribution provides power distribution from the 3-phase, 4-wire, 120/208 VAC, primary power feed to the communications systems.
- B. Capacity:
  - 1. The Power Distribution Panelboard shall be sized to provide separate power circuits to each freestanding or wall-mounted equipment rack and cabinet, and any other equipment requiring an ac circuit feed. The Panelboard shall also include at least 20% unused (spare) circuit-breaker spaces.

2. The AC Power Disconnect Switch shall be rated to switch the calculated worst-case ac current load, plus 50% spare capacity.
  3. The Communications Equipment -48 Vdc Power Supply shall be rated to provide the calculated worst-case dc current load, plus 100% spare capacity.
  4. The -48 VDC Power System Status Panel shall be chosen to be fully compatible with the -48 Vdc Power Supply throughout its rated operating range.
- C. The -48 VDC Power Distribution System provides fail-safe service by load-sharing two, or more, power supplies. At least one power supply may be removed from the active -48 VDC Power Distribution System for repair, or added for increased capacity, without disrupting communications services.
- D. The Status Panel provides voltage and current metering for the -48 VDC Power Distribution System. The Status Panel also distributes -48 VDC power to the Telephone System (TEL), Carrier Transmission System (CTS) and Fiber Optic System (FOS) Systems equipment racks or, as needed, to any other communications equipment racks requiring a source of -48 VDC power.
- E. The GETS system includes an existing personal computer (PC) (located in the Jackson Graham Building) equipped with software to interrogate the Emergency Telephones and telephone circuits to assure reliable emergency communications. The PC software also provides for remote programming of the Emergency Telephones in the parking garages.

#### **1.07 SUBMITTALS**

- A. Submit under provisions of Section 16706.
- B. Shop Drawings: Indicate electrical characteristics and connection requirements, including system wiring diagram.
- C. Product Data: Provide showing electrical characteristics and connection requirements for each component.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.
- E. Calculate full load ac power requirements per branch circuit and shall configure each panelboard for an optimum phase load balance. Submit the calculations to the Engineer for approval. The calculations shall indicate the full load ac power requirements for each item of equipment connected to each branch circuit.

#### **1.07 QUALIFICATIONS**

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Supplier: Authorized distributor of specified manufacturer with minimum three years documented experience.
- C. Installer: Service facilities within 50 miles of Project.

## **1.08 MAINTENANCE SERVICE**

- A. Furnish service and maintenance of Electrical Power Distribution System until Final Completion.

## **PART 2 - PRODUCTS**

### **2.01 POWER DISTRIBUTION PANELBOARD**

- A. Manufacturers:
  - 1. Square D Co., Model No. NQOD424L100CU (or approved equal).
- B. Type: NQOD, 3-phase, 4 wire, 120/208 Vac, main lugs only with isolated solid neutral bus and a ground bus.
- C. Enclosure: NEMA Type 12 surface mounting and surface screw front cover with hinged door and flush lock.
- D. Minimum Ratings:
  - 1. Capacity: 20 single-pole branch circuit breakers.
  - 2. Panel Amperage: 750,000.
  - 3. Power Requirements: Main Lugs, 100 Amps.
  - 4. Minimum Circuit Breakers: 16 single-pole NEMA Standard AB-1.

### **2.02 TERMINAL SUPERVISOR'S AC POWER DISCONNECT SWITCH**

- A. Manufacturers:
  - 1. Square D Co., Model No. H221NAWK, (or approved equal).
- B. Minimum Ratings:
  - 1. Type: NEMA Type 12 surface mounting and surface screw front cover with hinged door and flush lock.
  - 2. Amperage Rating: 30 Amps.

### **2.03 10 - OUTLET AC POWER RECEPTACLE**

- A. Manufacturers:
  - 1. Wiremold Company, Multi-outlet System/Plugmold 2000, Series GB, Model No. 20GB506, (or approved equal).
- B. Minimum Ratings:
  - 1. Pre-wired receptacles on 6-inch centers.
  - 2. 3-wire circuit, insulated ground conductor.
  - 3. Receptacles grounded to raceway.

### **2.04 6-OUTLET AC POWER RECEPTACLE**

- A. Manufacturers:
  - 1. Wiremold Company, Multi-outlet System/Plugmold 2000, Series GB, Model No. 20GB306, (or approved equal).
- B. Minimum Ratings:

1. Pre-wired receptacles on 6-inch centers.
2. 3-wire circuit, insulated ground conductor.
3. Receptacles grounded to raceway.

## **2.05 DUPLEX AC POWER RECEPTACLE**

- A. Manufacturers:
1. Arrow Hart Division, Cooper Industries, Model No. IG5362 with Model No. IG8248 wall plate, (or approved equal).
- B. Minimum Ratings:
1. Rated for 20 Amps, 125 VAC.
  2. Isolated ground receptacle.
  3. Color: Orange.

## **2.06 WIRE**

- A. Manufacturers:
1. Triangle PWC, Inc., Everene, Model No. USE/RHW, (or approved equal).
- B. Minimum Ratings:
1. Insulation Type: Cross-linked Polyethylene in accordance with ICEA S-95-658/NEMA WC70, ICEA S-96-659/NEMA WC71, ICEA S-93-639/NEMA WC74, ICEA S-94-649, ICEA S-97-682, ICEA S-105-692, and ICEA S-81-570.
  2. Conductor: 12 AWG or larger Class B stranded copper.
  3. Voltage Rating: 600 volts.

## **2.07 GROUND CLAMP**

- A. Manufacturers:
1. Wiremold Company, Multi-outlet System/Plugmold 2000, Model No. 2009, (or approved equal).
- B. Ratings:
1. Compatible with Plugmold 2000.
  2. For use on multi-outlet systems.
  3. Plated.

## **2.08 COMMUNICATIONS EQUIPMENT -48 VDC POWER SUPPLY**

- A. Manufacturers:
1. Power Conversion Products, Model No. PS-19 shelf complete with PCP Model No. MOD-4812 rectifier modules (quantity of 2 per shelf), (or approved equal).
- B. Minimum Ratings:
1. Input: 95-130 VAC, 60-Hz (nominal), Power Factor: PF>90%.
  2. Output: -48 VDC, 24-amp (load sharing).
  3. Alarms: Rectifier Output Failure indicator with Form "C" alarm contacts.
  4. High dc voltage shutdown.
  5. Mounting: 19-inch rack complete with 23-inch rack mount adapters and hardware.

## **2.09 -48 VDC POWER SYSTEM STATUS PANEL**

- A. Manufacturers:
  - 1. Power Conversion Products, Mini Load Center Model No. MDM-48-75, complete with 6 appropriately-sized alarm breakers, (or approved equal).
- B. Minimum Features:
  - 1. Metering: Voltage and current.
  - 2. Alarms: High/low dc voltage Form-C contacts.
  - 3. Alarm breaker power distribution center: 6-position
  - 4. Mounting: 19-inch rack complete with 23-inch rack mount adapters and hardware.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. Calculate full load ac power requirements per branch circuit and configure each panelboard for an optimum phase load balance.
- B. Communications Equipment Room
  - 1. Surface mount the completely assembled Communications Equipment Room Power Distribution Panelboard adjacent to the Communications Equipment Room feeder disconnect switch. Install power feeders (power phases, neutral and equipment ground) from the Communications Equipment Room feeder disconnect switch to the Communications Equipment Room Power Distribution Panelboard using appropriately sized steel conduit and make the necessary connections.
  - 2. Install an ac power receptacle strip on each equipment rack and in each equipment cabinet. Install the required mounting hardware to secure the ac power receptacle strips to the equipment racks and cabinets. Install a ground clamp in each raceway of the ac power receptacle strips to ensure that the raceway base is grounded to the equipment rack or cabinet. The ac power receptacle strips shall be installed so that they do not create obstructions to mounted equipment within the equipment racks and equipment cabinets and so that all outlets are accessible.
  - 3. Install the branch circuit conductors (power phases and neutral) from the Communications Equipment Room Power Distribution Panelboard to each ac power receptacle strip on the equipment racks and in the equipment cabinets, using appropriately sized rigid steel conduit.
  - 4. Install branch circuit conductors (power phases, neutral and equipment ground) from the Communications Equipment Room Power Distribution Panelboard to the Power Isolation Transformer of the passenger station Closed Circuit Television System using appropriately sized rigid steel conduit. Install branch circuit conductors (power phases and neutral) from the Power Isolation Transformer to the Closed Circuit Television Camera Power Distribution Panel(s) using appropriately sized rigid steel conduit.
  - 5. Install and wire the -48 VDC Communications Equipment Power Supplies and status panel in the telephone equipment rack. The -48 VDC power supplies shall be paralleled for load sharing operation.
  - 6. Install the appropriate wiring to distribute -48 VDC power from the power distribution center in the status panel to the following locations within the Communications Equipment Room:
    - a. Fuse, Alarm and Distribution Panel(s) in the CTS equipment rack(s).
    - b. Fuse, Alarm and Distribution Panel(s) in the FOS equipment rack(s).
    - c. Fuse, Alarm and Distribution Panel in the TEL equipment rack.

- C. Kiosk
  - 1. Install the duplex receptacles, associated enclosures and cover plates within the Kiosk cabinetry of the passenger station Kiosk. Install the required mounting brackets and hardware to secure the enclosures of the duplex receptacles to the Kiosk structure and/or Kiosk cabinetry. The duplex receptacles shall be installed so that they do not create obstructions to mounted equipment within the Kiosk cabinetry and so that all receptacles are accessible.
  - 2. Install branch circuit conductors (power phases, neutral and equipment ground) using appropriately sized, flexible, metallic conduit from the Kiosk Emergency Panelboard to the duplex receptacles within the Kiosk. Install the required conduit fittings, hardware, junction boxes, connectors and grounding hardware, and make the necessary connections.
  
- D. Dispatcher's Room
  - 1. Surface mount the Dispatcher's Facility ac power disconnect switch and panelboard in the vicinity of the Dispatcher's Facility. The Contractor shall install power feeders (power phases, neutral and equipment ground) from the Communications Equipment Room feeder disconnect switch to the Dispatcher's Facility ac power disconnect switch, and from the disconnect switch to the panelboard. Install appropriately sized rigid conduit, the required conduit fittings and hardware, and make the necessary connections. The power feeders to the Dispatcher's Facility ac power disconnect switch shall be connected to the Communications Equipment Room feeder disconnect switch at the input side.
  - 2. Install branch circuit conductors (power phases and neutral) from the Dispatcher's ac power panelboard to the ac receptacles in the Dispatcher's Facility using appropriately sized rigid conduit. Install the required conduit fittings, hardware, junction boxes, terminals, connectors, grounding hardware, and make the necessary connections and cross-connections.
  
- E. Grounding
  - 1. Electrically insulate all conduits from equipment racks and equipment cabinets; power ground shall be separate and isolated from the communications ground. Conduit containing branch circuit conductors shall be insulated from the equipment racks and cabinets by means of short lengths of non-conducting conduits.
  - 2. Provide short lengths of flexible metallic conduit in the equipment cabinets and on the equipment racks between the non-conducting conduit and the ac power receptacle strips. Each branch circuit shall contain a separate neutral conductor to the Communications Equipment Room Power Distribution Panelboard.

### **3.02 MANUFACTURER'S FIELD SERVICES**

- A. Prepare and start systems under provisions of Section 16707.
- B. Supervise final wiring connections and system adjustments.

### **3.03 ADJUSTING**

- A. Adjust operating Products and equipment to ensure smooth and unhindered operation.

### **3.04 DEMONSTRATION**

- A. Demonstrate operation and maintenance of Products to designated WMATA personnel two weeks prior to date of Substantial Completion.
- B. Demonstrate Project equipment by a qualified person who is knowledgeable about the Project.
- C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with designated WMATA personnel in detail to explain all aspects of operation and maintenance.
- D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at equipment location.
- E. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.
- F. Demonstrate system operation
- G. Conduct walking tour of Project and briefly describe function, operation, and maintenance of each component.

**END OF SECTION**

## SECTION 16721

### COMMUNICATIONS - TELEPHONE SYSTEM

#### PART 1 - GENERAL

##### 1.01 SECTION DESCRIPTION AND BASIC REQUIREMENTS

- A. The Telephone and Data System is part of the WMATA telecommunications network. Its purpose is to provide telephone service to WMATA personnel in selected locations within, and associated with, the passenger station and data circuits between the Jackson Graham Building and the passenger stations. The Telephone System is not intended to provide telephone service to passengers.
- B. The Telephone System provides telephone service at selected locations along the right-of-way, in selected rooms and areas within the passenger station, and in selected ancillary buildings associated with the passenger station. Telephone switching functions are provided by the existing Rolm CBX in the Jackson Graham Building. Telephone circuits are connected to the Rolm CBX via the Carrier Transmission System and the Fiber Optic System. All telephone instruments are wired to the Communications Equipment Room using a dedicated cable pair. The Telephone System includes two subsystems: The Wayside Telephone System and the Passenger Station Telephone System.
- C. The Wayside Telephone System includes all telephone instruments wired to the Passenger Station Communications Equipment Room using outside plant cable. All wayside telephone circuits are terminated on protector blocks and terminal blocks at the Main Distribution Frame and at the Wayside Telephone Instrument locations. The Wayside Telephone System includes, but is not limited to, the following:
  - 1. Telephone instruments installed in selected remote ancillary buildings outside the passenger station limits.
  - 2. Telephone instruments installed in Emergency Trip Station (ETS) enclosures along the right-of-way.
- D. The Emergency Trip Station telephones are grouped into circuits. Inbound and outbound Emergency Trip Station telephones at the same location are wired to the same group circuit. No more than four Emergency Trip Station telephones are wired to any one circuit.
- E. The Passenger Station Telephone System includes, but is not limited to, telephone instruments installed in selected rooms, areas within the passenger station, and ancillary buildings within the limits of the passenger station. Passenger station telephone instruments are wired to the Communications Equipment Room using inside plant cable, and are terminated on terminal blocks at the Main Distribution Frame.
- F. The Communications Equipment Room shall be provided with the following equipment for the operation of the Telephone System:
  - 1. Key telephone equipment to perform key hold and lamp functions for multi-line telephone instruments.
  - 2. A redundant single-frequency ringing generator to provide ringing current for the telephone instruments.
  - 3. A 23-inch equipment rack to be used to mount telephone equipment and a -48 Vdc power supply facility. (See Section 16715 - Communications Electrical Power Distribution)

- G. A cable terminal housing equipped with terminals and protectors shall be located in the Bell System Room. A 25-pair, 22-AWG cable shall be provided between the passenger station Bell System Room and the passenger station Communications Equipment Room to accommodate interconnects between WMATA facilities and leased lines.
- H. Dustproof Dual Tone Multiple Frequency (DTMF) single-line telephone instruments shall be located in Emergency Trip Station enclosures installed along the right-of-way and at each end of the station platforms. The Emergency Trip Station telephones are normally used for either Emergency or Maintenance purposes. Emergency Trip Station telephones shall function as extensions off of the Rolm CBX in the Jackson Graham Building.
- I. In the event of an emergency, the ETS telephone instrument in the vicinity of the incident will be used to contact the Operations Control Center. Depressing the "0" button shall be recognized by the Rolm CBX as an Emergency Trip Station Emergency Communications call. The call is automatically switched by the Rolm CBX to a telephone instrument in the Operations Control Center assigned to respond to that specific area of the rapid rail system.
- J. All other telephone instruments operate as standard off-premise extensions of the Rolm CBX in the Jackson Graham Building.

#### **1.02 SECTION INCLUDES**

- A. Telephone instruments at selected locations along the right-of-way, in selected rooms and areas within the passenger station, and in selected ancillary buildings associated with the passenger station.
- B. Telephone instruments at selected remote ancillary buildings outside the passenger station limits.
- C. Telephone instruments in Emergency Trip Station (ETS) enclosures along the right-of-way.
- D. Key telephone equipment.

#### **1.03 UNIT PRICES [THESE ARTICLES MAY NOT BE APPLICABLE UNDER CURRENT CONTRACTING PRACTICE.]**

- A. Unit Prices include all equipment racks, terminals, hardware, protector blocks, enclosures, connecting blocks, wiring and cabling, conduits and fittings, all the connections and cross-connections required for a complete operational installation of the Telephone System and incidental items, not specifically mentioned, but required for complete and proper system operation.

#### **1.04 RELATED SECTIONS**

- A. Section 16705 - Communications Standard Specifications - Equipment & Material.
- B. Section 16706 - Communications System Submittals & Services.
- C. Section 16707 - Communications Systems Quality Assurance & Testing.
- D. Section 16710 - Communications Grounding.
- E. Section 16715 - Communication Electrical Power Distribution.

- F. Section 16771 - Communications - Carrier Transmission System.

#### **1.05 REFERENCES**

- A. National Electrical Manufacturers Association (NEMA) Standard Publication 250-1997, Enclosures for Electrical Equipment (1000 Volts Maximum).
- B. Code of Federal Regulations, Title 7, Agriculture, Subtitle B, Regulations of the Department of Agriculture, Chapter XVII - Rural Utilities Service, Department of Agriculture, Part 1755 - Telecommunications Standards and Specifications for Materials, Equipment and Construction, Section 1755.390, RUS Specification for Filled Telephone Cables.
- C. National Electric Code (NEC).
- D. American National Standards Institute (ANSI)/Insulated Cable Engineers Association (ICEA) S-84-608-1994, Telecommunications Cable, Filled Polyolefin Insulated Copper Conductor.

#### **1.06 SYSTEM DESCRIPTION**

- A. Description: Provides telephone service to WMATA personnel in selected locations within, and associated with, the passenger station and data circuits between the Jackson Graham Building and the passenger stations.
- B. Capacity:
  - 1. The Key System shall be sized to provide multi-line telephone service to each of the Kiosks in the Station.
  - 2. Single-Line Wall Telephone shall be provided in Train Control, Communications, and other frequently occupied rooms in a passenger station, as well as in Traction Power Substations, and other frequently occupied facilities along the rail right-of-way.
  - 3. Single-Line Desk Telephones shall be provided in End-Of-Line Station Terminal Supervisor's Offices.
  - 4. Multi-Line Telephones shall be provided in each Passenger Station Kiosk.
  - 5. Emergency Trip Station Telephones shall be provided in Traction Power Substations and at Emergency Trip Station locations along the rail right-of-way.
  - 6. Emergency Telephones shall be installed in Area of Rescue Assistance Rooms.
  - 7. A dual 5-way Active Data Bridge shall be installed in the 19-inch CTS Rack in the Passenger Station(s).
- C. Emergency Trip Station telephones are grouped into circuits. Inbound and outbound Emergency Trip Station telephones at the same location are wired to the same group circuit. No more than four Emergency Trip Station telephones are wired to any one circuit.
- D. A cable terminal housing equipped with terminals and protectors shall be located in the Bell System Room. A 25-pair, 22-AWG, cable between the passenger station Bell System Room and the passenger station Communications Equipment Room shall provide interconnects between WMATA facilities and leased lines.

#### **1.07 SYSTEM PERFORMANCE REQUIREMENTS**

- A. The following overall system performance objectives are applicable to WMATA's existing Telephone System, and shall be maintained when performing the work in this Contract.

1. Frequency Response: (end-to-end) 300 Hz to 3000 Hz, maximum 6 dB at 3000 Hz.
2. Maximum Loss: shall not exceed 8.5 dB at 1000 Hz (from Communications Equipment Room to telephone instrument).
3. Noise Objective: 20 dBrnC with 30 dBrnC maximum noise terminated into 900-ohm impedance.
4. Loop Resistance: shall not exceed 1300 ohms (terminated into a short circuit).
5. Loop dc Current: not less than 23 mA.
6. Balance Ratio: not less than -50 dB.

#### **1.08 SUBMITTALS**

- A. Submit under provisions of Section 16706.
- B. Shop Drawings: Indicate electrical characteristics and connection requirements, including system-wiring diagram.
- C. Product Data: Provide showing electrical characteristics and connection requirements for each component.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

#### **1.09 QUALIFICATIONS**

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Supplier: Authorized distributor of specified manufacturer with minimum three years documented experience.
- C. Installer: Service facilities within 50 miles of Project.

#### **1.10 MAINTENANCE SERVICE**

- A. Furnish service and maintenance of Telephone System until Final Completion.

### **PART 2 - PRODUCTS**

#### **2.01 KEY SHELF ASSEMBLY WITH POWER SUPPLY**

- A. Manufacturer:
  1. Plant, Model No. 584C (or approved equal).
- B. Description: Key System shelf with power supply for KTU cards.
- C. Capacity: 13 KTU Cards (18-pin).
- D. Accessories:
  1. 4517 Interrupter.
  2. PE 1204 Power Supply.
  3. A75A-SE connector cable.

- E. Ratings:
  - 1. Power Input: 120 VAC.
  - 2. Mounting: 23-inch rack

## **2.02 KEY TELEPHONE KTU CARD**

- A. Manufacturer:
  - 1. Plant, Model No. PE400H Key Telephone Unit (KTU) Card (or approved equal).
- B. Description: Plug-in circuit card for Key System.
- C. Provides 1A2 functions for multi-line telephone instruments.

## **2.03 REDUNDANT RINGING GENERATOR WITH AUTOMATIC TRANSFER ASSEMBLY**

- A. Manufacturer:
  - 1. Peco Model No. PEC 3877 (or approved equal).
- B. Mounting Frame: Part No. 6064108S.
- C. Mounting: Adapter brackets to fit in 23-inch equipment rack, Model No. 4320554.
- D. Monitor and automatic transfer circuitry to provide contact closure to the Technical Control Facility when a transfer occurs.
- E. Ratings:
  - 1. Two 50 Watt ringing generator modules, Part No. 63134035S.
  - 2. Input: -48 VDC
  - 3. Output: 105 VAC, 20 Hz signal.
  - 4. Output Waveform: Sinewave.
  - 5. Frequency Stability: 0.33 Hertz or 1% whichever is greater.
  - 6. Harmonic Distortion: Less than 5% at 53.1 Vdc input and full rated resistive load.

## **2.04 MULTI-LINE TELEPHONE INSTRUMENT**

- A. Manufacturer:
  - 1. Cortelco Model No. 2830 (or approved equal).
- B. Ratings:
  - 1. Color: Beige.
  - 2. Type: Desk.
  - 3. Keypad Type: DTMF.
  - 4. Capacity: 10 Lines.

## **2.05 SINGLE-LINE DESK TELEPHONE INSTRUMENT**

- A. Manufacturer:
  - 1. Cortelco Model No. 2500-BE (or approved equal).
- B. Ratings:
  - 1. Color: Beige.
  - 2. Type: Desk.

3. Keypad Type: DTMF.

## **2.06 SINGLE-LINE WALL TELEPHONE INSTRUMENT**

- A. Manufacturer Cortelco Model No. 2554-BE (or approved equal).
- B. Ratings:
  1. Color: Beige.
  2. Type: Wall.
  3. Keypad Type: DTMF.

## **2.07 EMERGENCY TRIP STATION TELEPHONE INSTRUMENT**

- A. Manufacturer:
  1. Gai-Tronics Model No. K93112 (or approved equal)
- B. Face plate of heavy gauge steel, corrosion resistant, dustproof.
- C. Handset: Cradle of cast aluminum with nylon coating with heavy duty handset cord of appropriate length to fit into enclosure.
- D. With 4-position terminal block and gas discharge tube surge protector.
- E. With protector blocks and Weidmuller AKZ 2.5 terminal blocks, as required.
- F. Compatible with the Emergency Trip Station enclosures..
- G. Ratings:
  1. Type: Analog Telephone Instrument with electronic ringer
  2. Keypad Type: DTMF covered with protective seal.

## **2.08 EMERGENCY TELEPHONE INSTRUMENT**

- A. Manufacturer:
  1. Gai-Tronics Model No. 283 (or approved equal).
- B. Description: Analog telephone Instrument with hands-free, one button automatic dialing.
- C. Constructed of bright yellow, high impact, glass reinforced polyester.
- D. Remotely programmable, programmable disconnect, auto answer and remote diagnostics to verify operational integrity.

## **2.09 PROTECTOR BLOCKS**

- A. Manufacturer:
  1. Reliable Electric (RELTEC) Model R128VSR2 (or approved equal).
- B. With required mounting hardware and appropriately sized enclosures.
- C. Ratings:
  1. Type: 350-400 VDC gas style arrestors.

## 2.10 OUTSIDE PLANT CABLE

- A. Manufacturer:
  - 1. Essex Model No. CASPIC-F 22-AWG (or approved equal).
- B. Description: Filled, shielded telephone cable with mechanical protection, sized as required.
- C. Construction: Meets Code of Federal Regulations, Title 7, Subtitle B, Chapter XVII, Part 1755, Section 1755.390.
- D. Ratings:
  - 1. Conductors: Solid annealed copper conductors insulated with color coded polyolefin, standard telephone color code, twisted into pairs.
  - 2. Core covering: Non-hygroscopic dielectric tape.
  - 3. Shield: Inner polymer coated .2mm aluminum and outer polymer coated .15mm steel. Interfaces of shielding system flooded with waterproofing compound.
  - 4. Outer jacket: Black, low density, high molecular weight polyethylene.

## 2.11 INSIDE PLANT CABLE

- A. Manufacturer:
  - 1. Remeo Stock No. 725020 (or approved equal).
- B. If not in conduit, plenum approved cable shall be provided. Plenum cable shall meet the low-smoke/low-flame characteristics required by UL to be classified for installation in air handling plenums without conduit.
- C. If installed in conduit, plenum approved cable not required.
- D. Ratings
  - 1. Size: 3-twisted pairs.
  - 2. Gauge: 22-AWG
  - 3. Conductors: Solid copper with overall shield and color coded ECTFE insulation.
  - 4. Jacket: Fluoropolymer/co-polymer.
  - 5. Conforms to the National Electrical Code requirements

## 2.12 25 PAIR/22 AWG TIE CABLE

- A. Manufacturer:
  - 1. Superior Model TEL G 194 (or approved equal).
- B. Ratings:
  - 1. Size: 25 pair.
  - 2. Gauge: 22-AWG.
  - 3. Conductors: Solid, bare copper conductors, solid high-density polyethylene insulation with standard telephone color code, twisted into pairs.
  - 4. Core filling: ETPR compound.
  - 5. Core covering: Non-hygroscopic dielectric tape.
  - 6. Shield: .008 inch corrugated, copolymer coated aluminum.
  - 7. Armor: Corrugated bare 6 or 7-mil copper alloy 194 tape (TEL G194) applied longitudinally over the core.
  - 8. Jacket: Black polyethylene.

9. Conforms to ANSI/ICEA S-84-608-1994 and Code of Federal Regulations, Title 7, Subtitle B, Chapter XVII, Part 1755, Section 1755.390.

### **2.13 25 PAIR CABLE TERMINAL HOUSING**

- A. Manufacturers:
  1. Reltec, Model No. 36526VSR2 (or approved equal).
- B. Description: Three-element gas tube protector modules.
- C. Ratings:
  1. Size: 25-pair termination.
  2. Clips : 66-type.

### **2.14 FUSE, ALARM AND DISTRIBUTION PANEL**

- A. Manufacturer:
  1. Hendry Model No. HMW 06020-05 (or approved equal).
- B. Description: Distribution panel designed for -48 Vdc power supply distribution.
- C. Ratings:
  1. Mounting: Universal 19-inch or 23-inch relay racks.
  2. Fuse Positions: Minimum of 10.
  3. Panel Load Minimum: 40 amps.
  4. Alarm Circuit: visual alarm indication(s) and external alarm contacts.
  5. Fuses:
    - a. Appropriate type GMT complement panel alarm circuitry/visual indication(s).
    - b. Each fuse shall be appropriately rated for the corresponding equipment to which it distributes power.
    - c. Quantity of fuses to be provided within each fuse panel shall correspond to the number of equipment items requiring -48 VDC power within the associated equipment rack.

### **2.15 SMADS-DIGITAL CABLE**

- A. Manufacturer:
  1. Okonite Model No: 261-40-2204 (or approved equal).
- B. Ratings:
  1. Configuration: 4-pair individually shielded twisted pairs.
  2. Conductors: Stranded, 20-AWG, copper.
  3. Jacket: Okozel (No PVC).

### **2.16 ACI/RDDS (REMOTE DIGITAL DISPLAY SYSTEM) CABLE**

- A. Manufacturer:
  1. Okonite Model No: 261-40-2212 (or approved equal).
- B. Ratings:
  1. Configuration: 12-pair individually shielded twisted pairs.
  2. Conductors: Stranded, 20-AWG, copper.

3. Jacket: Okozel (No PVC).

## **2.17 DUAL 5-WAY ACTIVE DATA BRIDGE**

- A. Manufacturer:
  1. Tellabs 4445A (or approved equal).
- B. Description: Dual five-way Balanced Active Data Bridge.
- C. Ratings:
  1. Power Requirement: -48 Vdc.
  2. Port Impedance: 600 ohm.
- D. Each transformer-coupled port adjustable from -10 to +10 dB.

## **2.18 DATA BRIDGE MOUNTING SHELF**

- A. Manufacturer:
  1. Tellabs Type 10 Part Number 1011 (or approved equal).
- B. Description: Wire Wrap Mounting Shelf.
- C. Ratings:
  1. Mounting: standard 19-inch equipment rack.
  2. Accepts up to 11 standard Tellabs Type 10 or Wescom modules.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. Telephone Instrument Installation
  1. Telephone instruments located in the service rooms and ancillary buildings within the passenger station limits shall have a dedicated 3-pair cable from the telephone location to the passenger station Communications Equipment Room (no bridge cable taps shall be permitted).
  2. Wire the telephone instruments located in the service rooms and ancillary buildings within the passenger station limits to Main Distribution Frame terminal blocks in the Communications Equipment Room using shielded inside plant telephone cable. Ground the inside plant cable shield at the Main Distribution Frame.
  3. Each Wayside telephone instrument shall have a dedicated cable pair from the telephone location to the passenger station Communications Equipment Room. Wayside telephones shall be wired to protector blocks at both the telephone instrument location and at the Main Distribution Frame in the Communications Equipment Room. Wayside telephones shall be wired using filled, armored, outside plant telephone cable.
  4. Install the Emergency Trip Station (ETS) telephone instruments along the right-of-way, including at the ends of each platform, and in the ETS enclosures. Install protector blocks and terminal blocks in each ETS enclosure and terminate the ETS telephone instruments. Terminate all ETS telephone instruments to protector blocks in the Main Distribution Frame.
  5. Mount the wall-mounted type telephone instruments, except for the Emergency Telephones, to a NEMA 12 enclosure. Install an appropriately sized connecting block in each NEMA 12 enclosure. In remote locations, install a protector block and

- ground bar assembly in each NEMA 12 enclosure. All cable pairs of outside plant cable shall be terminated to protector blocks.
6. Install the multi-line telephone instrument in the Kiosk on the counter top of the Kiosk cabinetry in a location approved by the Engineer. Install a 25-pair multi-conductor paired cable from the terminal block in the Kiosk Cable Termination Rack to the Kiosk multi-line telephone instrument.
  7. Install the telephone instrument in the Terminal Supervisor's Office on top of the desk in a location approved by the Engineer. Install a standard surface mount 4-conductor connecting block at floor level near the approved location for the Terminal Supervisor's telephone instrument.
  8. In the "Area of Rescue Assistance" label the NEMA 12 enclosures with "FOR WMATA USE ONLY" with letters one inch high.
  9. Program the Emergency Telephone to dial the telephone number provided by the Engineer.
- B. Passenger Station Communications Equipment Room installation
1. Install a 23-inch equipment rack with a Fuse, Alarm and Distribution Panel in the passenger station Communications Equipment Room.
  2. Install the Redundant Ringing Generator and Key Telephone Equipment on the 23-inch equipment rack.
  3. Cross-connect all telephone circuits to Carrier Transmission System channels.
- C. Jackson Graham Building Installation
1. Connect the appropriate assigned telephone extensions of the existing Rolm CBX to the appropriate channels of the Carrier Transmission System terminal assemblies in the Jackson Graham Building .Refer to Section 16771, Communications -Carrier Transmission System for channel assignments.
- D. Passenger station Bell System Room Installation
1. Install a cable terminal housing in the Bell System Room of the passenger station in location approved by the Engineer. Install and terminate a 25-pair cable from the cable terminal housing in the Bell System Room to the Main Distribution Frame in the Communications Equipment Room.
- E. SMADS-Data System Installation
1. Set the Office Channel Unit Data Port (OCUDP) in Digroup "B", channel 1 in the Passenger Station(s) CTS and the Jackson Graham Building CTS to 19.2 Kbps.
  2. Connect the (SMADS-Data System) DSU with a 4-shielded pair cable from the Kiosk to Digroup "B", channel 1, via the MDF in the Communications Equipment Room of the passenger station(s).
- F. ACI/RDDS (Remote Digital Display System) cable plant (end-of line passenger station only)
1. Install two 12-pair, 20 AWG cables between the Main Distribution Frame within the Communications Equipment Room and the Terminal Supervisor's Room. This cable shall provide support for the ACI/RDDS Terminals. Terminate the cable to a terminal block within the Main Distribution Frame. Install a junction box with terminals in the Terminal Supervisor's Room. Terminate the cables to terminals in the junction box and clearly tag and identify these cables as being for ACI/RDDS use. Extend six pairs of one ACI/RDDS cable to the desktop dual RJ-11 surface mounted jack installed in the Terminal Supervisor's Room at a location approved by the Engineer.
- G. Automatic Energy Management System (AEMS) Installation

1. Install a 5-way Active Data Bridge in the 19-inch CTS Rack in the passenger station(s). Connect the output of the 5-way bridge at the passenger station, via the MDF, to a 4W-E&M channel card in Digroup "B" Channel 24. Connect four ports of each 5-way bridge, via the MDF, to RTU's in rooms and/or areas as indicated by the Engineer. The connections from the Data Bridge to the RTU's shall be no less than 3-pair shielded, 19-AWG cables. Outside of the passenger station limits armored, direct burial type cables shall be used.
  2. Use an existing port on a 9-way bridge installed in the Communications Equipment Room of the Jackson Graham Building, or furnish and install a new 9-way bridge. Connect one of these ports via the CDF, to 4W-E&M channel cards in the Jackson Graham Building CTS Terminals: Digroup "B", Channel 24 of the associated passengers station(s).
- H. Circuit Identification
1. The Contractor shall tag all telephone and data cables. The Contractor shall stencil all termination cabinets.

### **3.02 MANUFACTURER'S FIELD SERVICES**

- A. Prepare and start systems under provisions of Section 16707.
- B. Supervise final wiring connections and system adjustments.

### **3.03 ADJUSTING**

- A. Adjust operating Products and equipment to ensure smooth and unhindered operation.

### **3.04 DEMONSTRATION**

- A. Demonstrate operation and maintenance of Products to designated WMATA personnel two weeks prior to date of Substantial Completion.
- B. Demonstrate Project equipment by a qualified person who is knowledgeable about the Project.
- C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with designated WMATA personnel in detail to explain all aspects of operation and maintenance.
- D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at equipment location.
- E. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.
- F. Demonstrate system operation.
- G. Conduct walking tour of Project and briefly describe function, operation, and maintenance of each component.

### **3.05 TABLES**

#### **TABLE 3.05-1**

AUTOMATIC ENERGY MANAGEMENT SYSTEM (AEMS) RTU LOCATIONS

[ ]	[ ]	[ ]
Traction Power Substation [ ]	Traction Power Substation [ ]	Traction Power Substation [ ]
South AC Switchboard Room [ ]	South AC Switchboard Room [ ]	South AC Switchboard Room [ ]

**TABLE 3.05-2**

PASSENGER STATION  
TELEPHONE INSTRUMENTS  
WITHIN PASSENGER STATION LIMITS

INSTRUMENT LOCATION	INSTRUMENT TYPE
Kiosk	Multi-line Desk
Mechanical Rooms	Single-line Wall
Communications Equipment Rooms	Single-line Wall
Train Control Rooms	Single-line Wall
Operations Rooms	Single-line Wall
Maintenance Rooms	Single-line Wall
Cleaners/Water Service Rooms	Single-line Wall
Wall Trainperson's Rooms	Single-line Wall
Terminal Supervisor's Rooms	Single-line Desk
A.C. Switchboard Rooms	Single-line Wall
Electrical Cabinet Rooms	Single-line Wall
Chiller Room	Single-line Wall
Police Service Rooms	Single-line Wall
Escalator Pit(s)	*Wiring/termination only
Elevator Machine Rooms	Single-line Wall
TPSS	Single-line Wall
Stairs and Halls	Single-line Wall
Area of Rescue Assistance Rooms	Single-line Wall & Emergency Telephone

\*Note: Wiring/termination is indicated for areas where inside plant cable and a modular telephone jack shall be furnished and installed by the Contractor for future telephone connection.

**TABLE 3.05-3**

**PASSENGER STATION  
TELEPHONE SYSTEM LINE ASSIGNMENTS**

LINE NUMBER	ASSIGNMENT
[ ]	ETS Telephones at [ ]
[ ]	ETS Telephones at [ ]
[ ]	ETS Telephones at [ ]
[ ]	ETS Telephones at [ ]
[ ]	ETS Telephones at [ ]
[ ]	ETS Telephones at [ ]
[ ]	ETS Telephones at [ ]
[ ]	ETS Telephones at [ ]
[ ]	Kiosk
[ ]	Communications Equipment Room, Train Control Room
[ ]	Operations Room
[ ]	Cleaners & Water Service Room/Maintenance Room
[ ]	Elevator Machine Room/Escalator Pits
[ ]	Areas Of Rescue Assistance/Stair(s)
[ ]	Terminal Supervisor Room/Trainperson's Room (End-of Line only)
[ ]	Traction Power Substation Room/Tie Breaker Station Room/Tie Breaker Station-Train Control Room
[ ]	AC Switchboard Room/Electrical Room
[ ]	Mechanical Equipment Room
[ ]	Communications Equipment Room
[ ]	Parking Booths (Stations with parking garages or lots)

**END OF SECTION**

## SECTION 16723

### COMMUNICATIONS - GARAGE EMERGENCY TELEPHONE SYSTEM

#### PART 1 - GENERAL

##### 1.01 SECTION DESCRIPTION AND BASIC REQUIREMENTS

- A. This Section describes the basic requirements for the installation of the Garage Emergency Telephone System (GETS). The GETS consists of emergency telephones installed in the public area of parking garages and linked to WMATA Metro Transit Police Department (MTPD) located in the Jackson Graham Building.
- B. The GETS provides WMATA customers with the capability of reporting emergency situations from the passenger station parking garages to WMATA Metro Transit Police Department (MTPD) located in the Jackson Graham Building.
- C. Emergency telephones shall be located at the entrance to the stairs and at designated locations on each level in the parking garage. The telephones shall be ADA compliant and shall be housed in rugged weatherproof enclosures. Approximately five GETS telephones are installed at each level of each garage.
- D. Each telephone shall have a blue indicator light mounted above the telephone. The blue light shall be constantly illuminated as an indicator of the telephone location. Within the same blue light housing shall be a strobe light, which will activate when a call is initiated to the MTPD office.
- E. Each MTPD console is pre-equipped with two telephone lines dedicated to GETS. Whenever an emergency call is initiated at one of the garages, the call will be indicated on the console's Rolm RP400HR telephone if one of the two numbers is not occupied. WMATA's PABX is programmed to display on the Rolm RP400HR telephones on the MTPD consoles the name of the parking garage and garage level where the call was originated.
- F. When the telephone is answered, the emergency telephone in the garage will send a pre-recorded audio announcement stating the location of the emergency telephone. If MTPD requires the audio message to be repeated, a pre-determined key on the Rolm RP400HR telephone touch-tone pad is pressed. All voice conversations will be recorded at the JGB.
- G. The GETS system shall contain a maintenance personal computer (PC) located in the Communications Equipment Room of the Jackson Graham Building. The computer will be equipped with software to interrogate the emergency telephones and telephone lines to assure reliable emergency communications. The PC software shall also provide remote programming of the emergency telephones in the parking garages.
- H. Through the PC computer the GETS system will be provided with end-to-end supervision, testing and logging of supervision and maintenance functions. This computer will be capable of dialing a specific telephone and performing diagnostics at the request of the Systems Maintenance (SMNT) attendant. The computer must also be capable of automatically dialing and checking all of the telephones in accordance with a number of pre-programmed schedules selectable from the computer by the SMNT attendant.
- I. The GETS system shall include the following equipment:
  - 1. Emergency telephones located at the entrance to the stairs in the parking garages and at other designated locations on each garage parking level.
  - 2. Strobe/blue lights located above the emergency telephones.

3. Power distribution modules located in the garage communication equipment room.
  4. Telephone line consolidators located in the garage communication equipment room.
  5. Personal computer and software located in the Jackson Graham Building.
- J. The GETS emergency telephones shall provide man/machine interface points between WMATA customers and GETS. The emergency telephone shall provide controls, indications, input/output devices, and instructions that are necessary for the customers to operate the GETS.
1. Depressing the momentary contact pushbutton switch on the emergency telephone shall illuminate the red indicator marked "CALLING" and start the strobe light. When the call is answered by MTPD the green indicator marked "RECEIVED" shall illuminate and the pre-recorded message shall play for both the caller and MTPD. If the pre-programmed telephone number is busy or not answered after 30 seconds, the emergency telephone shall hang up and dial the number again. This process shall continue until the call is answered.
  2. When the call is completed and the MTPD hangs up or after a remotely programmable period of time, whichever comes first the emergency telephone shall hang up.
- K. The strobe/blue light shall provide a means of locating an emergency telephone in the parking garage and indicate when it is in use. When the call button is pressed on the emergency telephone, it shall cause the strobe to flash until the telephone call is completed.
- L. The power distribution module shall provide a convenient method of supplying power from 120-Vac to the emergency telephone that requires 24-Vdc.
- M. The telephone line consolidator shall be used to reduce the number of dedicated PABX extensions required for each level of the parking garage. The telephone line consolidator shall provide up to eight line outputs per one line input while still maintaining the ability to remotely program each emergency telephone.
- N. If more than one emergency telephone on a level is activated all units above and beyond the first emergency telephone on that level shall receive a busy signal requiring the units to redial until the outgoing line becomes available.
- O. The personal computer and software shall provide automatic diagnostic test of all emergency telephones. Tests shall be performed on command or at regular prescheduled times. The results shall be saved for subsequent print out.
- P. The software shall test, as a minimum, whether the telephone is receiving power, the integrity of the telephone line, the emergency telephone circuitry, and the emergency telephone microprocessor for proper operation.
- Q. To initiate an emergency call, a WMATA customer will depress the "PUSH FOR HELP" pushbutton on the emergency telephone which shall cause:
1. The emergency telephone to dial the pre-programmed telephone number, the red LED light labeled "CALLING" to be illuminated, and the strobe light to be activated. If busy, the emergency telephone to redial the pre-programmed telephone number until the call is answered.
  2. When the call is answered by MTPD the LED light labeled "RECEIVED" to be illuminated and a pre-recorded message will play for both the WMATA patron and MTPD.
- R. An emergency telephone call shall be terminated by MTPD hanging up, which shall cause the emergency telephone to hang up, or after the emergency telephone's pre-programmed time out has expired, whichever comes first. When the call is terminated the strobe light shall extinguish.

## **1.02 SECTION INCLUDES**

- A. Emergency telephones located at the entrance to the stairs in the parking garages and at other designated points on each parking garage level.
- B. Strobe/blue lights, one for each emergency telephone.
- C. Power distribution module located in the parking garage communication equipment room.
- D. Telephone line consolidator located in the parking garage communication equipment room.

## **1.03 UNIT PRICES [THESE ARTICLES MAY NOT BE APPLICABLE UNDER CURRENT CONTRACT PACKAGING.]**

- A. Unit Prices include all equipment racks, terminals, hardware, protector blocks, enclosures, connecting blocks, wiring and cabling, conduits and fittings, all the connections and cross-connections required for a complete operational installation of the GETS and incidental items, not specifically mentioned, but required for complete and proper system operation.

## **1.04 RELATED SECTIONS**

- A. Section 16705 - Communications Standard Specifications - Equipment & Material.
- B. Section 16706 - Communications System Submittals & Services.
- C. Section 16707 - Communications Systems Quality Assurance & Testing
- D. Section 16710 - Communications Grounding.
- E. Section 16715 – Communication Electrical Power Distribution.
- F. Section 16771 – Communications Carrier Transmission System.

## **1.05 REFERENCES**

- A. National Electrical Manufacturers Association (NEMA) Standard Publication 250-1997, Enclosures for Electrical Equipment (1000 Volts Maximum).
- B. Code of Federal Regulations, Title 7, Agriculture, Subtitle B, Regulations of the Department of Agriculture, Chapter XVII - Rural Utilities Service, Department of Agriculture, Part 1755 - Telecommunications Standards and Specifications for Materials, Equipment and Construction, Section 1755.390, RUS Specification for Filled Telephone Cables.
- C. National Electric Code. (NEC).
- D. Americans with Disabilities Act Accessibility Guidelines (ADAAG) 4.10.14, Emergency Communications.
- E. American Society of Mechanical Engineers (ASME) A17.1, Safety Code for Elevators and Escalators.
- F. American National Standards Institute (ANSI)/Insulated Cable Engineers Association (ICEA) S-84-608-1994, Telecommunications Cable, Filled Polyolefin Insulated Copper Conductor

## **1.06 SYSTEM DESCRIPTION**

- A. Description: The GETS provides WMATA patrons with the capability of reporting emergency situations from the passenger station parking garages to WMATA MTPD located in the Jackson Graham Building.
- B. Capacity:
  - 1. The Contractor shall provide an emergency telephone for each entrance to each stairway and at other designated locations on every level of a garage.
  - 2. The Contractor shall provide a strobe/blue light to accompany each emergency telephone in the garage.
  - 3. The Contractor shall provide Power Distribution Modules, or other dc power equipment suitable to provide dependable, separately-fused 24 Vdc circuits to the emergency telephones.
  - 4. The Contractor shall provide Telephone Line Consolidators in quantities based on the number of emergency telephones required in the garage.
- C. The GETS provides a means of reporting emergency situations from the passenger station parking garages to MTPD in the Jackson Graham Building. Emergency telephones located at the entrance to the stairs and at designated locations on each level in the parking garages, when activated, automatically call telephones located in the MTPD office in the Jackson Graham Building.
- D. Each of the MTPD consoles has an existing Rolm RP400HR telephone dedicated to GETS. Two telephone numbers, for receiving incoming GETS calls, have been assigned and distributed to each of these telephone instruments. These telephones are also connected to the MTPD voice recorder and record all conversation on the two assigned telephone numbers. Whenever an emergency call is initiated at a GETS telephone, the call is answered on the MTPD console's Rolm RP400HR telephone if one of the two numbers is not occupied. WMATA's PABX is programmed to display the name of the parking garage and garage level that originated the call on the Rolm RP400HR telephones. When the telephone is answered, the emergency telephone in the garage sends a prerecorded audio announcement stating the location of the emergency telephone. If MTPD requires the audio message to be repeated, a pre-determined key on the Rolm RP400HR telephone touch-tone pad is pressed.
- E. The GETS system includes an existing personal computer (PC) (located in the Jackson Graham Building) equipped with software to interrogate the emergency telephones and telephone circuits to assure reliable emergency communications. The PC software also provides for remote programming of the emergency telephones in the parking garages.

## **1.07 SYSTEM PERFORMANCE REQUIREMENTS**

- A. The following overall system performance objectives are applicable to WMATA's existing telephone system, and shall be maintained when performing the work in this Contract:
  - 1. Emergency telephone input sensitivity: The emergency telephone microphone shall be sensitive to (accept) any normal speaking voice from a distance of 20-inches or less from in front of the microphone, while moving to positions up to 30-degrees off center in any gradient.
  - 2. Emergency Telephone Sound Pressure Level: The emergency telephone shall produce clear and continuous speech (to persons who are not significantly hearing impaired within the 300 to 3,600 Hz audio range) to a distance of up to 36-inches or less, while moving to positions 40-degrees off-center in any quadrant. Interfering signals, hum, or objectionable noise shall not be discernible to listeners during or between speech messages.

3. System Noise: Noise from the emergency telephone speaker shall not exceed -45 dB below a 1-kHz test tone level when all system and equipment controls are operated to any possible combination of positions. Momentary switching transients may peak to -30 dB below a 1-kHz test tone level for a duration not to exceed 10-milliseconds.
4. Note: Persons not significantly hearing impaired within the 300 to 3,600 Hz audio range are defined for the purpose of these performance specifications as males or females with hearing capabilities that are normal, or slightly impaired to the extent that their response to audio tones in the 300 to 3,600 Hz frequency range is within -15 dB at all test frequencies, and averages within -10 dB of "NORMAL" standard values for their classification (sex, age, etc.) as defined in ANSI Standards

#### **1.08 SUBMITTALS**

- A. Submit under provisions of Section 16706.
- B. Shop Drawings: Indicate electrical characteristics and connection requirements, including system wiring diagram.
- C. Product Data: Provide showing electrical characteristics and connection requirements for each component.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

#### **1.09 QUALIFICATIONS**

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Supplier: Authorized distributor of specified manufacturer with minimum three years documented experience.
- C. Installer: Service facilities within 50 miles of Project.

#### **1.10 MAINTENANCE SERVICE**

- A. Furnish service and maintenance of Garage Emergency Telephone System until Final Completion.

### **PART 2 - PRODUCTS**

#### **2.01 EMERGENCY TELEPHONE**

- A. Manufacturers:
  1. Vandal-Proof Products, Inc. Model No. T1240 (or approved equal).
- B. Fully ADA compliant as specified in ADAAG 4.10.14 and ASME A17.1.
- C. Surface Mount Enclosure: Stainless Steel 16-GA. Vandal-Proof Products, Inc Model No. AE740 vandal resistant hooded enclosure.
- D. Features:

1. 3/4-inch "PUSH FOR HELP" call button.
2. Red LED for "CALLING" light.
3. Green LED for "RECEIVING" light.
4. Grade-2 Braille and raised lettering to aid sight-impaired persons in identifying the emergency telephone.
5. Full duplex speakerphone.
6. Ability to record two different voice messages.
7. Programmable from any touch-tone telephone (password protected).
8. Equipped with four number autodial capability, and monitor the progress of incoming and outgoing calls.
9. Hang up after called party hangs up or after a remotely programmable period of time, whichever comes first.
10. Face Plate: 304 brushed stainless steel.
11. Auxiliary Output Contacts: Two normal open contacts.

E. Ratings:

1. Power Input: 5 to 25-Vdc.

## 2.02 STROBE/BLUE LIGHT

A. Manufacturers:

1. Vandal-Proof Products, Inc. Model No. A703 with stainless steel mounting bracket (or approved equal).

B. Description: Strobe/blue light normally illuminated (steady on). When the call button is pressed on the emergency telephone, it shall cause the blue light to strobe flash until the telephone call is completed.

C. Ratings:

1. Flash Rate: 80 flashes per minute.
2. Strobe Peak Candlepower: 750,000.
3. Power Requirements: 120-Vac, 5-Amps.
4. Blue light remains lit at all times.

## 2.03 POWER DISTRIBUTION MODULE

A. Manufacturers:

1. Vandal-Proof Products, Inc. Model No. A705 (or approved equal).

B. Ratings:

1. Input Voltage: 120-Vac.
2. Telephone Line inputs: RJ11.
3. Telephone Line/24-Vdc outputs: Quick Release type for Tip-Ring and Plus-Minus 24-Vdc.

## 2.04 TELEPHONE LINE CONSOLIDATOR

A. Ratings:

1. Telephone Line Inputs: One.
2. Telephone Line Outputs: Eight.
3. Power requirements: 120-Vac.
4. Provide busy signal tone to seven telephones when one is off hook.
5. Provide selective routing from one input telephone line to one of eight output lines.

## **2.05 FOUR PAIR 22-AWG CABLE**

- A. Manufacturers:
  - 1. Champlain Cable Part Number Plus-22-4UTP (or approved equal).
- B. Ratings:
  - 1. Four-Pair, 22-AWG, Unshielded Twisted Pair (UTP).
  - 2. Conforms to NEC CMP Category five.
  - 3. NEC Plenum Rated.
  - 4. Insulation (non-PVC) FEP Teflon (or approved equal).
  - 5. Jacket, (non-PVC), Halar® (or approved equal).

## **2.06 25-PAIR CABLE TERMINAL HOUSING**

- A. Manufacturers:
  - 1. Reltec, Model No. 36526VSR2 (or approved equal).
- B. Ratings:
  - 1. Protector Modules: Three-element gas tube.
  - 2. Termination: 25-pair.
  - 3. Clips: 66-type.

## **2.07 12-PAIR CABLE TERMINAL HOUSING**

- A. Manufacturers:
  - 1. Reltec, Model No. 3636VSR2 (or approved equal).
- B. Ratings:
  - 1. Protector Modules: Three-element gas tube.
  - 2. Termination: 25-pair.
  - 3. Clips: 66-type.

## **2.08 12-PAIR, 19-AWG TIE CABLE**

- A. Manufacturers:
  - 1. Superior Model TEL G 194 (or approved equal).
- B. Ratings:
  - 1. 12-pair, 19-AWG, single jacketed, shielded telephone cable.
  - 2. Solid, bare copper conductors, solid high-density polyethylene insulation with standard telephone color code, twisted into pairs.
  - 3. Core filling: ETPR compound.
  - 4. Core covering: Non-hygroscopic dielectric tape.
  - 5. Shield: .008 inch corrugated, copolymer coated aluminum.
  - 6. Armor: Corrugated bare 6 or 7-mil copper alloy 194 tape (TEL G194) applied longitudinally over the core.
  - 7. Jacket: Black polyethylene.
  - 8. Conforms to and meets the requirements of ANSI/ICEA S-84-608-1994 and Code of Federal Regulations, Title 7, Subtitle B, Chapter XVII, Part 1755, Section 1755.390.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. Emergency telephone instrument installation
  - 1. Install the emergency telephones and strobe/blue lights in the locations shown on the Contract drawings.
  - 2. Install the required conduit and connect the strobe/blue lights to the nearest emergency 277-Vac source using a 277 to 120-Vac transformer. The transformer shall be installed in the appropriate sized stainless steel box and mount under the strobe/blue lights.
  - 3. Install the required conduit and connect the strobe/blue lights to the emergency telephone's auxiliary contacts
  - 4. Install a 19-inch equipment rack in the garage Communications Equipment Room. Install the power distribution modules and telephone line consolidators (one set for each level of the garage) on the 19-inch equipment rack.
  - 5. Install conduit and a dedicated 4-pair cable from each emergency telephone on each level to the garage Communications Equipment Room (no bridge cable taps shall be permitted).
  - 6. Connect two of the four cable pairs from each of the emergency telephone locations to protector blocks in the garage Communications Equipment Room. The other two pairs in each cable shall be terminated and marked as spares.
  - 7. From the protector blocks, connect one cable pair for each emergency telephone to the associated tip and ring terminals on the power distribution module. Connect the second cable pair on the protector blocks from the emergency telephones to the associated plus and minus terminals on the power distribution module.
  - 8. From the power distribution modules connect the tip and ring line outputs to the telephone line consolidators.
  - 9. Cross-connect the inputs of the telephone line consolidators to the cables, from the passenger station Communications Equipment Room, in the cable entrance box of the garage Communications Equipment Room.
  - 10. Install a 12-pair, 19-AWG cable from the garage Communications Equipment Room to the passenger station Communications Equipment Room MD
  - 11. From the protector blocks in the cable entrance box of the garage Communications Equipment Room connect the cables from the passenger station Communications Equipment Room.
  - 12. Program the emergency telephone to dial 40000 when the "PUSH FOR HELP" button is pressed.
  - 13. Record a voice message on each emergency telephone to identify its location (i.e. "Phone number 6, north side stairwell, level number 4).
- B. Passenger station installation
  - 1. Cross-connect the GETS emergency telephone lines, in the cable entrance box of the passenger station Communication Equipment Room, to the Carrier Transmission System channels.
- C. Jackson Graham Building installation
  - 1. Connect the appropriate assigned telephone extensions of the existing Rolm CBX to the appropriate channels of the Carrier Transmission System terminal assemblies in the Jackson Graham Building. Refer to the Carrier Transmission System Article for channel assignments.

### **3.02 MANUFACTURER'S FIELD SERVICES**

- A. Prepare and start systems under provisions of Section 16707.
- B. Supervise final wiring connections and system adjustments.

**3.03 ADJUSTING**

- A. Adjust operating Products and equipment to ensure smooth and unhindered operation.

**3.04 DEMONSTRATION**

- A. Demonstrate operation and maintenance of Products to Owner's personnel two weeks prior to date of Substantial Completion.
- B. Demonstrate Project equipment by a qualified person who is knowledgeable about the Project.
- C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with WMATA personnel in detail to explain all aspects of operation and maintenance.
- D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at equipment location.
- E. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.
- F. Demonstrate system operation.
- G. Conduct walking tour of Project and briefly describe function, operation, and maintenance of each component.

**3.05 TABLES**

**Table 3.05-1**  
EMERGENCY TELEPHONE NUMBER ASSIGNMENTS FOR  
[ ]

LOCATION	TELEPHONE NUMBER	CONSOLIDATOR NUMBER
Level 1	[ ]	1 THROUGH [ ]
Level 2	[ ]	1 THROUGH [ ]
Level 3	[ ]	1 THROUGH [ ]
Level 4	[ ]	1 THROUGH [ ]
Level 5	[ ]	1 THROUGH [ ]

**END OF SECTION**

## SECTION 16727

### COMMUNICATIONS - PASSENGER EMERGENCY REPORTING SYSTEM

#### PART 1 - GENERAL

##### 1.01 SECTION DESCRIPTION AND BASIC REQUIREMENTS

- A. The Passenger Emergency Reporting System (PERS) shall provide a means of reporting emergency situations from the passenger station platforms to the station manager(s). Intercom facilities between call-station panels mounted on pylons (approximately 200 feet from the end of each platform) and the kiosk telephone(s) shall permit easy verbal communications between the station manager and customers. The Operations Control Center (OCC) will be rung if the kiosk(s) do not answer.
- B. The PERS shall include the following equipment, which shall be located in the passenger station Communications Equipment Room, except as noted:
1. Power distribution Module.
  2. Line Sharing Switch.
  3. Call Process Tone Detector.
  4. Double pull double throw relay to activate the strobe light.
  5. Emergency phones, complete with mounting brackets located at designated positions on the station platform.
  6. Yellow strobe light in the kiosk, which will activate when a call is initiated. These lights are provided in the kiosks as part of the elevator phone system. They are Amesco No. 05733, UL listed, 24 V Strobe lights with orange lenses, Model SL-1, 150 ma.
  7. Personal computer and software located in the Jackson Graham Building, provided by and shared with the Garage Emergency Telephone System (GETS) system.
- C. The kiosk telephones shall provide the interface point between the station manager and the Passenger Emergency Reporting System. Answering the phone when a call station is activated shall result in the following actions:
1. The full-duplex audio path between the answerer and the emergency phone, shall be connected.
  2. When the telephone is answered, the emergency phone will send a pre-recorded audio announcement stating its location. If the answerer requires the audio message to be repeated, a pre-determined key on the answering telephone touch tone pad is pressed.
- D. The equipment shall provide the required interfaces between the kiosk telephone(s) and the emergency phones. The equipment shall accommodate eight emergency phones and shall be able to:
1. Establish and control the audio paths between the emergency phones, the kiosk and the OCC.
  2. Provide the appropriate dc power, ground and audio paths to the emergency phones.
  3. Automatically terminate an unanswered call, after the preset time period.
- E. The PERS system shall share the GETS maintenance personal computer (PC) located in the Communications Equipment Room of the Jackson Graham Building. The computer will be equipped with software to interrogate the emergency telephones and telephone lines to assure reliable emergency communications. The PC software shall also provide remote programming of the emergency phones, such as changing the autodial numbers.
- F. Through the PC, the PERS system will be provided with end-to-end supervision, testing and logging of supervision and maintenance functions. This computer will be capable of

automatically dialing and checking all of the telephones in accordance with a number of pre-programmed schedules selectable from the computer by the Systems Maintenance (SMNT) attendant.

- G. The PERS emergency phones shall provide human/machine interface points between WMATA customers and PERS. The emergency phone shall provide controls, indicators, input/output devices, and instructions that are necessary for the customers to operate the PERS.
  - 1. Pressing the "PUSH FOR HELP" button on the emergency phone shall illuminate the red indicator marked "CALLING," and start the strobe light in the nearest kiosk. It will also ring the first number programmed. When the call is answered, the green indicator marked "RECEIVED" shall illuminate and the prerecorded message shall play so that it can be heard by both the caller and the answerer. If the pre-programmed telephone number is busy or not answered after 30 seconds, the emergency phone shall hang up and dial the other programmed numbers. The process shall continue until the call is answered, or each number has been called three times.
  - 2. When the call is completed and the answerer hangs up, or after a remotely programmable period of time, whichever comes first, the emergency telephone shall hang up and the strobe shall revert to elevator use.
- H. The line sharing switch shall be used to reduce the number of dedicated PABX extensions required for each rail station. The line sharing switch shall provide up to eight line outputs per one line input while still maintaining the ability to remotely program each emergency phone. The strobe light shall provide a means of notifying the station manager that a call has been placed. When the call button is pressed on the emergency phone, it shall cause the strobe on the nearest kiosk to flash until the telephone call is terminated.
- I. When one emergency phones in a station is in use, if any other emergency phones in the station is activated, it shall receive a busy signal. It will redial until the outgoing line becomes available, or it times out.
- J. The PC and software shall provide automatic diagnostic testing of all emergency phones. Tests shall be performed on command or at regular, prescheduled times. The results shall be saved for subsequent printing.
- K. The software shall test, as a minimum, whether the telephone is receiving power, the integrity of the telephone line, the emergency phone circuitry, and the emergency phone microprocessor for proper operation.
- L. An emergency telephone call shall be terminated by the answerer hanging up, which shall cause the emergency phone to hang up, or after the emergency phone's pre-programmed time out has expired, whichever comes first.
- M. Hanging up shall:
  - 1. Cause the lights at the associated emergency phone to be extinguished.
  - 2. Cause the call from that emergency phone to be terminated.
  - 3. Cause the strobe light to revert to elevator use.
- N. When a call is initiated from an emergency phone, and it is not answered by a station manager or the OCC, the call shall be automatically terminated after a preset time period adjustable from one to four minutes.
- O. The dc voltage for the emergency phone shall be backed up by a NiCd battery with a four hour capacity.

## **1.02 SECTION INCLUDES**

- A. Emergency Phones.
- B. Power Distribution Module.
- C. Line Sharing Switch.
- D. Call Progress Monitoring Tone Detector.

## **1.03 UNIT PRICES**

- A. Unit Prices include incidental items, not specifically mentioned, but required for complete and proper system operation.

## **1.04 RELATED SECTIONS**

- A. Section 14200 - Hydraulic Elevators
- B. Section 16705 - Communications Standard Specifications - Equipment & Material.
- C. Section 16706 - Communications System Submittals & Services
- D. Section 16707 - Communications Systems Quality Assurance and Testing.
- E. Section 16710 - Communications Grounding.
- F. Section 16715 - Communications Electrical Power Distribution.
- G. Section 16733 - Communications - Kiosk Systems.
- H. Section 16771 - Communications - Carrier Transmission System

## **1.05 REFERENCES**

- A. National Electrical Manufacturers Association (NEMA) Standard Publication 250-1997, Enclosures for Electrical Equipment (1000 Volts Maximum).
- B. Latest National Electric Code (NEC).
- C. Americans with Disabilities Act Accessibility Guidelines (ADAAG) 4.10.14, Emergency Communications.

## **1.06 SYSTEM DESCRIPTION**

- A. Description: The Passenger Emergency Reporting System (PERS) provides WMATA Rail System customers with the capability of reporting emergency situations from the passenger station platforms to WMATA personnel.
- B. Capacity:
  - 1. The Contractor shall provide and install all emergency phones.
  - 2. The Contractor shall provide and install a Line Sharing Switch.
  - 3. The Contractor shall provide and install a Power Distribution Module.
  - 4. The Contractor shall provide and install a Call Progress Monitoring Tone Detector.

5. The Contractor shall provide a double pull double throw relay to transfer the strobe light from elevator control to PERS control. It will be connected to the phones and the power supply so that when a call is placed, the light is activated. It shall remain on and under the control of the PERS system until the call is terminated.
6. The PERS system shall be interfaced to an existing PC, located in the Jackson Graham Building, equipped with software to interrogate the emergency phones and telephone circuits to assure reliable emergency communications. The PC software also provides for remote programming of the emergency telephones.

#### **1.07 SYSTEM PERFORMANCE REQUIREMENTS**

- A. The Contractor shall be responsible for the overall performance of the Passenger Emergency Reporting System. The following overall System performance requirements are designed to ensure that the PERS, delivered under these Specifications, meets the performance requirements of the Authority.
  1. Emergency Phone Sound Pressure Level: The emergency phones shall produce clear and continuous speech and call waiting tones (to persons who are not significantly hearing impaired within the 300-Hz to 3,600-Hz audio range) to a distance of up to 36-inches or less, while moving to positions 40-degrees off-center in any quadrant. Interfering signals, hum, or objectionable noise shall not be discernible to listeners during or between speech messages or tone generations.
  2. Emergency Phone Input Sensitivity: The emergency phone microphone shall be sensitive to (accept) any normal speaking voice from a distance of up to 20-inches or less from the front of the speaker, while moving to positions up to 30-degrees off center in any quadrant.
  3. System Noise: Shall not exceed -45 dB below a 1-kHz test tone level when all system and equipment controls are operated to any possible combination of positions. Momentary switching transients may peak to -30dB below a 1-kHz test tone level for a duration that does not exceed 10-milliseconds.
  4. Note: Persons not significantly hearing impaired within the 300-Hz to 3,600-Hz audio range are defined for the purpose of these performance specifications as males or females with hearing capabilities that are normal, or slightly impaired to the extent that their response to audio tones in the 300-Hz to 3,600-Hz frequency range is within -15 dB at all test frequencies, and averages within -10 dB of "NORMAL" standard values for their classification (sex, age, etc.) as defined in ANSI Standards.

#### **1.08 SUBMITTALS**

- A. Submit under provisions of Section 16706.
- B. Shop Drawings: Indicate electrical characteristics and connection requirements, including system wiring diagram.
- C. Product Data: Provide data showing electrical characteristics and connection requirements for each component.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

#### **1.09 QUALIFICATIONS**

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Supplier: Authorized distributor of specified manufacturer with minimum three years documented experience.

- C. Installer: Authorized installer of specified manufacturer with service facilities within 50 miles of Project.

## **1.10 MAINTENANCE SERVICE**

- A. Furnish service and maintenance of the PERS until Final Completion.

## **PART 2 PRODUCTS**

### **2.01 EMERGENCY PHONE**

- A. Manufacturers:
  - 1. Vandal-Proof Products, Inc. Model No. 2100 (or approved equal).
- B. Fully ADA compliant as specified in ADAAG 4.10.14 and ASME A17.1.
- C. Surface Mount Enclosure: Stainless Steel 16-GA. Vandal-Proof Products, Inc. Model No. AE740 vandal resistant hooded enclosure.
  - 1. Features:
    - a. 3/4-inch "PUSH FOR HELP" call button.
    - b. Red LED for "CALLING" light.
    - c. Green LED for "RECEIVING" light.
    - d. Grade-2 Braille and raised lettering to aid sight-impaired persons in identifying the emergency phone.
    - e. Full duplex speakerphone.
    - f. Ability to record two different voice messages.
    - g. Programmable from any touch-tone telephone (password protected).
    - h. Equipped with four number autodial capability, and to monitor the progress of incoming and outgoing calls.
    - i. Hang up after called party hangs up or after a remotely programmable period of time, whichever comes first.
    - j. Face Plate: 304 brushed stainless steel.
    - k. Auxiliary Output Contacts: Two normally open contacts.
- D. Ratings:
  - 1. Power Input: 5 to 25-Vdc.

### **2.02 POWER DISTRIBUTION MODULE**

- A. Manufacturers:
  - 1. Vandal-Proof Products, Inc. Model No. A705 (or approved equal).
- B. Ratings:
  - 1. Input Voltage: 120-Vdc.
  - 2. Telephone Line Inputs: RJ11.
  - 3. Telephone Line/24-Vdc outputs: Quick Release type for Tip-Ring and Plus-Minus 24-Vdc.

### **2.03 LINE SHARING SWITCH**

- A. Ratings:
  - 1. Telephone Line Inputs: One.
  - 2. Telephone Line Outputs: Eight.
  - 3. Power requirements: 120-Vac.
  - 4. Provide busy signal tone to seven telephones when one is off hook.

5. Provide selective routing from one input telephone line to one of the eight output lines.

#### 2.04 PROGRESS MONITORING TONE DETECTOR

- A. Manufacturers:
- B. Vandal-Proof Products, Inc. Model A782-1 (or approved equal).

#### 2.05 FOUR PAIR 22-AWG CABLE

- A. Manufacturers:
  1. Champlain Cable Part Number Plus-22-4UTP (or approved equal).
- B. Ratings:
  1. Four-Pair, 22-AWG, Unshielded Twisted Pair (UTP).
  2. Conforms to NEC CMP Category five.
  3. NEC Plenum Rated.
  4. Insulated (non-PVC) FEP Teflon (or approved equal).
  5. Jacket, (non-PVC), Halar (c) (or approved equal).

#### 2.06 DOUBLE PULL, DOUBLE THROW RELAY

- A. Ratings:
  1. 24 V dc.
  2. At least 150 ma contacts.

### PART 3 EXECUTION

#### 3.01 INSTALLATION

- A. Emergency phone panel locations
  1. Install two emergency phones on each platform of the passenger stations. The emergency phones shall be surface mounted on selected pylons along the platform areas via mounting brackets.
  2. At passenger stations where the three-inch diameter circular opening exists in the designated panel of the selected pylons, the Contractor shall utilize these openings in his installation. These openings will have a four-inch diameter circular cover plate installed to conceal the opening. Remove the cover plate and deliver it to the Engineer.
  3. When required, provide the appropriate modifications to, or relocations of, the panel support bars of the pylon steel structure and the panel metal clips, which secure the panel to the pylon steel structure, so that the opening in the designated panel can be accomplished. All modifications and/or relocations, including the methods of accomplishing the changes, shall be approved by the Engineer.
  4. Install an appropriately sized rigid steel conduit passage from the interior of the pylon steel structure of each selected pylon to the nearest cable vault, environmental air plenum, cable trough, or area under the platform which has been assigned for the installation of cables through the platform area. There shall be no exposed conduit from the pylons to the nearest cable installation area of the platform. Restore all items removed, changed, modified, or damaged (such as platform tiles, granite apron around pylon base, parapets, floors, structures and finishes) due to installation of these conduit passages, to their original condition. Install an appropriately-sized junction box, and conduit fittings, and make the necessary connections to terminate each conduit passage from the selected pylon in the cable installation area of the

platform. Each conduit passage shall stub-up approximately six-inches into the steel pylon structure and shall be threaded at the end.

5. Install the emergency phones on the pylons via the mounting brackets. Verify, at each designated pylon, that the installation of the emergency phone does not interfere with pylon graphics before cutting the opening. Remove the handicapped decal and cleanse the panel surface if the installation will partially obscure the symbol. All other existing graphics shall not be tampered with. Conflicts between existing pylon graphics, other than the handicapped decal, and the installation of the emergency phone shall be referred to the Engineer for resolution.
6. To prevent tampering with the emergency phone, removal of the phone from the associated mounting bracket shall require special tools.
7. Install a 4-pair cable from each emergency phone to the MDF/Protector Cabinet in each station Communications Equipment Room. The one pair will attach to the tip and ring contacts, one pair to the plus and minus and one pair to the auxiliary contacts. The other pair in each cable shall be terminated and marked as spare.
8. Install a 4-pair cable from the strobe light in the kiosk to the Communications Equipment Room.

B. Kiosk

1. Cut the two wires to the strobe light from the elevator machine room. Secure the four ends to the terminal strip. Connect two of the four cable pairs from the Communications Equipment Room to the wires to the strobe light, one pair to each wire. The other two pairs in each cable shall be terminated and marked as spares

C. Communications Equipment Room

1. Install the power distribution module, line sharing switch, progress monitoring tone detector and relay on the 19-inch equipment rack.
2. Install the required cabling, connectors and plugs, and make the necessary connections and cross-connections to provide 120-Vdc, 60-Hz power to the various equipment from an ac power receptacle strip on uninterruptible power.
3. Install conduit and a dedicated 4-pair cable from each emergency phone to the Communications Equipment Room (no bridge cable taps shall be permitted).
4. Connect three of the four cable pairs from each of the emergency phone locations to protector blocks in the Communications Equipment Room. The other pair in each cable shall be terminated and marked as spare.
5. From the protector blocks, connect one cable pair for each emergency telephone to the associated tip and ring terminals on the power distribution module. Connect the second cable pair on the protector blocks from the emergency telephones to the associated plus and minus terminals on the power distribution module. Connect the third to the Auxiliary Output 1 terminals. These will be connected in parallel with each other and in series with the relay coil and a 24 V dc power supply from the Power distribution module, to activate the strobe light.
6. From the power distribution modules connect the tip and ring line outputs to the line sharing switch.
7. Program the emergency telephone to dial a) the nearest kiosk, b) the second number at that kiosk, other station kiosk(s), if any, and c) the OCC, when the "PUSH FOR HELP: button is pressed.
8. Record a voice message on each emergency telephone to identify its location (i.e. "North side of platform, Summerfield Station. To repeat this, press 5")
9. Cross-connect the PERS emergency telephone lines from the line sharing switch through the progress monitoring tone detector to the Carrier Transmission System channels, in the cable entrance box.

D. Jackson Graham Building installation

1. Connect the appropriate assigned telephone extensions of the existing Rolm PABX to the appropriate channels of the Carrier Transmission System terminal assemblies in the Jackson Graham Building. Refer to the Carrier Transmission System Article for channel assignments.

**3.02 MANUFACTURER'S FIELD SERVICES**

- A. Prepare and start systems under provisions of Section 16707.
- B. Supervise final wiring connections and system adjustments.

**3.03 ADJUSTING**

- A. Adjust operating Products and equipment to ensure smooth and unhindered operation.

**3.04 DEMONSTRATION**

- A. Demonstrate operation and maintenance of Products to WMATA personnel two weeks prior to date of Substantial Completion.
- B. Demonstrate Project equipment by a qualified person who is knowledgeable about the Project.
- C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with Authority personnel in detail to explain all aspects of operation and maintenance.
- D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at equipment location.
- E. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.
- F. Demonstrate system operation.
- G. Conduct walking tour of Project and briefly describe function, operation, and maintenance of each component.

**3.05 TABLES**

**Table 3.05-1**

EMERGENCY TELEPHONE NUMBER ASSIGNMENTS FOR  
 [ ]

TELEPHONE NUMBER	SWITCH NUMBER
[ ]	1 THROUGH [ ]

**END OF SECTION**

**SECTION 16728  
CALL FOR AID**

**PART 1: GENERAL**

**1.01 SUMMARY**

- A. Call-for-Aid consists of a communications system that integrates the Passenger Emergency Reporting System, the Kiosk Attendant/Passenger Intercoms and the Elevator Intercoms with the centralized state-of-the-art, Voice over Internet Protocol (VoIP) system. The Call-for-Aid shall provide a means of establishing clear and easy to use voice communications between passengers and the Station Manager(s)/Kiosk Attendant(s) for the following purposes:
1. Reporting emergency situations from the passenger station platforms using intercom call-station panels mounted on columns at the station platforms. The Emergency Call Stations on the platform no more than 200 feet apart and shall be clearly visible to the general public.
  2. Providing Passenger/Kiosk Attendant intercom facilities using call-station panels mounted on both the "paid" and "unpaid" areas of each station Kiosk.
  3. Providing intercom facilities between Kiosk attendants in stations with multiple Kiosks.
  4. Providing elevator intercom facilities from inside station elevators using the call-station panel mounted inside the elevator cab.
  5. Providing intercom facilities from all elevator machine rooms and elevator landings within each passenger station.
  6. Providing elevator intercom facilities within elevator cars and at elevator landings within the passenger stations.
  7. Providing intercom reporting emergency situations in the Areas Refuge and Dispersal Areas
  8. Providing intercom facilities from all main entrances into the station.
  9. Providing a means of connecting a portable Master Station intercom unit to a jack mounted on the top of each elevator car for maintenance communications between the top-of-car (TOC) and the Elevator Machine Room (EMR).
  10. Providing call transfer, or roll-over, capability to the Operations Control Center (OCC) through 5 digit DTMF dialing over local stations assigned to the VoIP telephone system in the event a Kiosk station manager does not answer or acknowledge within a predetermined time a call from any of the call stations.
  11. Providing a Call-for-Aid Call Station at each entrance pavilion and pedestrian bridge gated entry point.
- B. The communication Subcontractor will provide a Master Station for the Kiosk, and remote stations in each elevator, and on each elevator landing. All other components for the Call-for-Aid shall be designed, furnished, and installed under this specification. Design, coordination, integration, and documentation of the Call-for-Aid system shall be accomplished under this specification.

- C. The Call-for-Aid shall be a state-of-the-art VoIP system which shall be software-programmable, and shall be supplied with all software, programming devices and training needed for programming or reprogramming.
- D. The Call-for-Aid Intercom System shall be easily configurable to meet the varied requirements of the existing Metrorail system and future Metrorail extensions. For example, calls initiated from remote call-stations, within elevator cars, platforms and passenger walkway entrances, areas refuge, dispersal areas and/or from elevator landings could be directed to:
1. Specific Kiosk within a station location.
  2. All Kiosks within a station location simultaneously.
  3. Kiosk and then to remote-monitoring facilities based on a preprogrammed roll-over sequence through the VoIP telephone system.
  4. Remote monitoring facilities immediately, if so desired, through the VoIP telephone system.
  5. Call-for-Aid equipment gives the station location to both Rail Operation Control Centers when reporting emergency.
- E. The Call-for-Aid shall be capable of handling calls from multiple call stations. The Intercom Master Station at each Station Kiosk shall display the identification code of the originating instrument of each connected incoming emergency call, shall allow scrolling of identification codes of subsequently received emergency calls waiting to be connected, and shall provide a means to switch from one call to another without disconnecting either call, until a call-disconnect button is pushed.
- F. The Call-for-Aid system shall be scalable, so that additional remote call stations are easily added into the Call-for-Aid system, and supported by programming the VoIP call manager server and the Kiosk Master Station.
- G. The Call-for-Aid System shall meet all technical requirements for accessibility by individuals with disability under the Americans with Disability Act (ADA). These technical requirements are to be applied during the design and installation of the system. The Call-for-Aid shall fully comply with the following requirements:
1. ADA requirement 4.10.14 for providing emergency two-way communications between an elevator and a point outside the hoist way (the Kiosk).
  2. ASME A17.1-2007. The highest operable part of the two-way communication system shall be a maximum of 48 inches from the floor.
  3. ADA Standards 4.30. Raised symbol and lettering (Signage) located adjacent to the device.
- H. The Call-for-Aid shall be equipped with a programmable autodial capability, allowing the system to dial up to two additional phone numbers if the primary number or Kiosk intercom station is busy, and/or a call is not answered by the Kiosk Station Manager. This roll-over capability is especially important, to make certain that no call originated by a patron goes unanswered.

- I. The Call-for-Aid shall be provided with a full duplex speaker and microphone system to assure clear and continuous communication between the passenger and Kiosk (or remote telephone if rolled-over by the auto-dialer). It is essential that all information and instructions are transmitted and received by both parties of the conversation, including during the presence of high noise levels. The Call Stations shall be equipped with devices that shall allow adjustment of speaker volume and microphone sensitivity to overcome any background noise.
  
- J. The Call-for-Aid shall include the following equipment, which shall be located in the passenger station Kiosk, except as noted:
  - 1. Emergency Call-Stations complete with mounting plates and graphic panels located at designated locations.
  - 2. Yellow strobe light and horn mounted on top of the Kiosk, and a networked relay module which will activate the strobe light and horn when a call is initiated from an Call-for-Aid call station on the platform, at the entrances and/or in an elevator. The strobe light and horn should not be activated when a Kiosk Attendant/Passenger intercom call is initiated.
  - 3. Kiosk Master Station for communication with, and identification of, a calling station. The Kiosk Master Station shall provide the interface point between the Station Manager and the Integrated Intercommunication System. When a call station is activated, it shall result in the following actions at the Kiosk master station:
    - a. Provide a digital display identifying the calling station, together with a call tone that is repeated until the call is acknowledged or cancelled.
    - b. Once the call is answered by depressing the assigned button at the Kiosk master station, an audio path between the answerer and calling station shall be established.
    - c. For programmable Call-for-Aid units provide on answer, at Kiosk, OCC roll, and/or EOC over, call identify of itself by using a prerecorded audio message.
  
- K. The Master Station to be installed in the Kiosk shall operate much as a telephone so that it could be used to initiate calls, as well as receive and answer calls. The Master Station shall be programmed so that the Kiosk operator (manager) can identify the origination of the calling party.
  
- L. The Call-stations shall be equipped with two visual indicators allowing hearing-impaired individuals to follow the progress of the emergency call. One indicator shall show that the call has been placed, and the other indicator shall show that the call has been answered. These LED indicators shall be large and bright (high intensity/wide angle type) so that a patron can see and identify the progress of the call during bright daylight.
  
- M. The Call Stations shall be equipped with large red protruding Call Buttons (Approximately 1 1/4 inches in diameter) to allow easy patron identification and use.

Depending upon space availability, brail labels shall be installed either to the left, or below, the button.

- N. Activation of an intercom call station shall function in the following sequence:
  - 1. Pressing the "PUSH TO TALK" button on the call-station shall illuminate the red "call initiated" LED indicator and activate the strobe light in the nearest Kiosk. The strobe light should not be activated if the call-station located in the "paid" and/or "unpaid" areas of the Kiosk is used. When the call is answered, a green, "call acknowledged" LED indicator shall illuminate, and a full-duplex audio path shall be established with the master station. If the master station doesn't answer within a preset time, the call shall be automatically routed either to the secondary Kiosk or to a pre-assigned OCC telephone number within the WMATA PBX system. If there is no answer at OCC, the call shall terminate after a preset time period adjustable from one to four minutes. If no answer at OCC, then the call should roll over to MOC, if no answer, then the call should roll over to a third party that WMATA will specify.
  - 2. When the call is completed, and the answerer hangs up, or after a remotely-programmable period of time, whichever comes first, the emergency call station shall hang up, and the strobe shall be deactivated.
- O. The Subcontractor shall be responsible for design of the interface of the Call-for-Aid and/or the VoIP telephone system. The Call-for-Aid system shall utilize and be supported by the VoIP call manager server of the VoIP telephone system. Call-for-Aid equipment shall be connected through the VoIP telephone system and the Ethernet LAN/WAN network.

## **1.02 RELATED DOCUMENTS**

- A. Section 27 065 10 – Communication Standard Specifications Equipment and Materials.
- B. Section 27 05 26 – Grounding and Bonding for Communications Grounding Systems.
- C. Section 27 05 14 – Communication Electrical Power Distribution.
- D. Section 27 20 00 – Local Area Network / Wide Area Network (LAN/WAN)
- E. Section 27 31 23 – Communications – VoIP Telephone System
- F. Section 27 02 10 – Communications – KIOSK Systems

## **1.03 REFERENCES**

- A. The equipment shall meet ADA (Americans with Disability Act) requirements 4.10.14, when applicable, and installation shall comply with the current provisions of the following (applicable) standards and codes:

1. Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG).
  2. National Electrical Code (NEC).
  3. ASME A17.1 and A17.2.
  4. Elevator Code of the local jurisdictions hereinafter referred to as the Code.
  5. National Electrical Manufacturers' Association (NEMA).
  6. Federal Transit Administration (FTA).
  7. Underwriters' Laboratories, Inc. (UL).
- B. These specifications are not to be construed as supplanting any code requirements.
- C. In the event of a conflict between codes, regulations, these specifications or standards, the most stringent requirements as determined by the Contractor shall take precedence unless specifically addressed herein.

#### **1.04 SUBMITTALS**

- A. See the Division 1 specifications of the Contract Documents for this section.

#### **1.05 SUBCONTRACTOR'S TOTAL SYSTEM RESPONSIBILITY**

- A. The Subcontractor shall bear total system responsibility for all specified work, including specified or otherwise required additions and modifications to existing WMATA systems of any type. The Subcontractor's responsibility includes engineering services, design, fabrication, installation, testing, cut-over, commissioning, documentation, training and warranty. The Subcontractor has the responsibility to integrate the various necessary elements of work so that overall specification performance goals are met.
- B. All Subcontractor-provided systems, equipment and services shall perform and be suitable for their intended purpose, in accordance with best commercial practices (as a minimum), and in compliance with all applicable specification requirements.
- C. Subcontractor shall provide a complete and operable Integrated Intercom System meeting all performance specification requirements, notwithstanding any errors or omissions in Technical Specifications or Contract Drawings that would otherwise prevent such delivery shall be delivered. Clarification shall be requested from the Contractor if conflicts or errors are suspected.
- D. The Subcontractor shall assume total responsibility for configuration of equipment, parts, interconnecting wiring, powering and surge protection devices, software, and other materials and services furnished. Systems provided by the Subcontractor that do not meet performance levels required by these Specifications shall be modified, at the Subcontractor's expense, until the performance levels specified in this Subcontract are achieved. Any modifications to approved system design shall be subject to prior approval.

- E. The Subcontractor shall assume total responsibility for the correction of any degradation of the performance of existing systems or equipment, which results from the installation of any system or equipment interface required by these Specifications.
- F. Although the Contractor retains rights to review the Subcontractor's system and component configuration compliance or noncompliance; the Subcontractor retains sufficient latitude to ensure compliance with all specified performance and availability requirements. The Subcontractor shall, therefore, present engineering data, technical documentation, test program and quality assurance program data, and product selections that will ensure compliance with the system technical specifications. In the event these submissions are not accepted, the Subcontractor shall resubmit with corrections, or resubmit completely revised documentation. The Subcontractor shall remain responsible for bearing any additional cost associated with charges necessary to affect compliance with all specified performance and availability standards, and all other specifications.
- G. Contractor support will be limited to those items of work that are expressly stated to be "Contractor-Furnished" or "Contractor-Provided" in these Specifications or on the Contract Drawings. Certain other items of work may be performed by others. Such work is identified as "Work by others" or "Not in Contract (NIC)" means it is not part of this section, but may be part of the overall Subcontract. When (NIC) items are encountered, it is the Subcontractor's responsibility to coordinate with the Contractor to assure the system is fully integrated. All other items of work specified are the responsibility of the Subcontractor.
- H. The Subcontract price shall provide full compensation for complete operational system, and all items and work furnished in compliance with these provisions. The Subcontractor shall remove rubbish and debris resulting from his work on a daily basis. Removal of debris and rubbish from the premises shall be coordinated with the WMATA Representative and/or the Station Manager when working in active passenger stations.
- I. Quantities of equipment, material, and services specified in any of the following locations shall be furnished:
  - 1. Section entitled "...Equipment, Material, Spares..."
  - 2. Contract Drawings.
  - 3. Quantities determined from Contractor-approved final designs.
  - 4. This specification
- J. Participate in Contractor Pre-final Inspections, Substantial Completion and Final Acceptance activities.
- K. Clean the equipment and work site, secure the equipment, and remain responsible for prompt repair or replacement in case of loss or damage until acceptance by the Contractor is received. Furnish inventory services and demonstrate system or equipment operation in support of requests by the Contractor. Provide support and access so that

the Contractor Technicians, Mechanics and Inspectors can inspect and test any portion of the work during normal work hours.

- L. New record As-Built/In-Service drawings (hard copies, and electronic media) to reflect the systems installed and/or modified under this Contract shall be furnished to the Contractor.

## **1.06 SYSTEM PERFORMANCE REQUIREMENTS**

- A. The following overall System performance requirements are designed to ensure that the system delivered under these Specifications, meets the performance requirements of WMATA.
  - 1. Emergency call station Sound Pressure Level: The emergency call stations shall produce clear and continuous speech and call-waiting tones (to persons who are not significantly hearing impaired within the 300-Hz to 8,200-Hz audio range) to a distance of up to 36-inches or less, while moving to positions 40-degrees off-center in any quadrant. Interfering signals hum, or objectionable noise shall not be discernible to listeners during, or between, speech messages or tone generations.
  - 2. Emergency Call Station Input Sensitivity: The emergency call station microphones shall be sensitive to (accept) any normal speaking voice from a distance of up to 20-inches, or less, from the front of the speaker, while moving to positions up to 30- degrees off center in any quadrant.
  - 3. System Noise: Shall not exceed -45 dB below a 1-kHz test tone level when all system and equipment controls are operated to any possible combination of positions. Momentary switching transients may peak to -30dB below a 1-kHz test tone level for a duration that does not exceed 10-milliseconds. Note: Persons not significantly hearing-impaired within the 300-Hz to 3,600-Hz audio range are defined for the purpose of these performance specifications as males or females with hearing capabilities that are normal, or slightly impaired to the extent that their response to audio tones in the 300-Hz to 3,600-Hz frequency range is within -15 dB at all test frequencies, and averages within - 10 dB of "NORMAL" standard values for their classification (sex, age, etc.) as defined in ANSI Standards.

## **1.07 PRODUCT APPROVALS**

- A. Equipment to be installed under these Specifications (except for "Contractor-Furnished" items and miscellaneous hardware), shall be approved prior to purchase and installation. Exception: Product approval shall not be required prior to purchase and installation when the "Brand Name" or "Trade Name" products, as specified herein (without substitutions, option changes, deviations from specifications, etc.) are furnished. Record copies of such product data shall be furnished in lieu of product approval submitted (same schedule requirements, but not later than 30 days prior to installation or delivery to the Contractor, in any event).

- B. Data for product approval shall be submitted with complete descriptions of the item, intended locations and functions, catalog cut-sheets, and technical literature and supporting data required to ascertain compliance with these Specifications. Approval or rejection shall not relieve the Subcontractor of any contractual responsibility.
- C. Substitutions of items specified will only be acceptable if a Variance Request submitted by the Subcontractor has been approved.

#### **1.08 QUALITY ASSURANCE**

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Codes and regulations of the Authority Having Jurisdictions.
  - 2. 47 CFR 15, Subparts A and B.
  - 3. UL 50.
  - 4. NEMA AB 1 and NEMA KS 1.
  - 5. ITU-T
  - 6. ASME 17.1-2007 ADAAG
  - 7. NFPA 130.5, 2010
- B. Design and production tests: Perform the test and submit, certified test results, or provide certified test results on identical units. Furnish certified test reports showing test data and results as well as manufacturer's comments on tests.
- C. Interchangeability: Refer to the Contract Documents. Furnish products of a manufacturer regularly engaged in the manufacture of applicable systems. In addition:
  - 1. Standard commercial products shall be furnished whenever such equipment and materials will satisfy the stated specifications. Suitable modified standard commercial devices shall be furnished when required to satisfy specification requirements. Custom developed and fabricated equipment units and devices shall be confined to those items for which suitable commercial off-the-shelf (COTS) products are not available to guarantee compliance with the Specifications. When custom design, fabrication, or assembly is required, every effort shall be made to minimize the number of different modules, solid-state devices used.
  - 2. With each system, subsystem and facility, two or more like functions shall be performed by identical units. In no case shall the equipment or hardware used in one portion of a system, subsystem or facility be different from that used in another portion to perform the same function under similar operating and environmental conditions (outdoor systems are distinct from indoor systems).
  - 3. Equipment shall be physically and plug compatible with recent versions of existing WMATA equipment performing similar functions and used for comparable applications elsewhere in similar WMATA's facilities, insofar as possible. The use of adapter plugs, interface boxes, and replacement mounting brackets or enclosures that fit available space and mounting holes may be allowed by the Airports Authority to maintain interchangeability when competitive

products that do not require such devices are determined to be unavailable (applicable to COTS major equipment items only). Custom designed and fabricated equipment must be fully interchangeable without requiring the use of such devices. If a determination is made to allow use of such devices, all necessary adapters and interface devices shall be provided with each item of equipment furnished, at no additional cost to the Airports Authority.

4. Equipment shall be software compatible with recent versions of existing WMATA equipment performing similar functions and used for comparable applications elsewhere in similar WMATA facilities.
5. Major items of equipment furnished shall be within the physical size and configuration limitations specified in provisions of this Subcontract. If such specifications are not included in the provisions, major items of equipment shall be of a physical size and configuration closely comparable to equipment currently in use of comparable applications elsewhere in similar WMATA facilities.
6. Exception: Lighter weight and smaller sized more modern versions of equipment are sought by the Airports Authority where their use presents significant advantages. The use of new generations of equipment that differ in size and are not fully interchangeable will be considered for approval by the Airports Authority, in order to take advantage of significant technological improvements developed by industry.

D. Qualifications of Instructor for Operation and Maintenance Training:

1. Instructor has in-depth knowledge of the design, packaging, operations, maintenance and trouble-shooting of the systems to be taught.
2. Instructor has been trained in teaching methods or has previous satisfactory experience in teaching with emphasis on the subject matter to be covered in the course of instruction.

#### **1.09 SUBCONTRACTOR COORDINATION**

- A. Accomplishment of the work included in these Specifications may require the Subcontractor to coordinate with the Contractor representing the operating elements of WMATA and other subcontractors, to develop work schedules, to determine assignment of space and the availability of equipment, and to ascertain means of access to work areas.
- B. Work schedules shall be coordinated with operating elements of WMATA through the Contractor, for assignments of space and access to operating facilities and for assignments of space and access to areas and rooms within the passenger stations, and the OCC, if applicable. All work performed at in-service Metrorail passenger stations shall be in accordance with WMATA Operating procedures, and at the discretion of the Contractor, and may require WMATA Escorts.

- C. The Subcontractor shall coordinate with the Contractor to determine the availability and quantity of telephone lines roll-over or direct dial telephone numbers and call time-out details.
- D. The Subcontractor shall (if applicable) coordinate with local fire authorities to ensure compliance with local fire codes, and to obtain all required permits and inspections. (Copies of all related documentation shall be furnished to the Contractor within 3 working days of receipt.)
- E. The Subcontractor shall make every reasonable effort to resolve conflicts with other subcontractors and agencies. Those conflicts that cannot be resolved to the satisfaction of all parties concerned shall be referred to the Contractor for resolution.
- F. Specific coordination with the elevator subcontractor will be required for the elevator intercom for elevator construction and certification. The Subcontractor shall coordinate design of wire and conduit plant, and connection of call stations, with the elevator subcontractor(s).

#### **1.10 INITIAL SPARES**

- A. The Subcontractor shall develop a Recommended Spare Parts list for the system being provided in this contract and shall furnish the items in the quantities indicated in the Recommended Spare Parts list, subject to the agreement and approval of selected by the Authority.
- B. All spare equipment and material shall be packed for warehouse storage. Like items (only) shall be grouped together and boxed as lots, as designated by the Contractor. Lots shall be marked as to item nomenclature, WMATA part number, contact number, specification reference, and end use (WMATA project identification data), as directed by the Contractor. Each individual item shall also be tagged with a WMATA part number, if a number is assigned by WMATA.
- C. Spare equipment and materials shall be delivered for the newly-installed Intercom System to any of the various locations designated by the Contractor.

#### **1.11 WARRANTY**

- A. Furnish a one (1) year service and maintenance program on Intercom equipment after final completion.

### **PART 2: PRODUCTS**

#### **2.01 CENTRAL EXCHANGE UNIT - EQUIPPED FOR 100 PLUS STATIONS**

- A. Manufacturer: Commend Model GE800 or approved equal
- B. IP Intercom Server (Central Exchange Unit)

1. Central Exchange Unit (CEU) shall be installed in the passenger station Communications Room for control of the Integrated Intercommunications System equipment. Connect unit's power supply to an Uninterrupted Power Supply (UPS) backed source.
2. Configure the complete Central Exchange Unit so that it is capable of supporting up to 100 subscribers and include all subscriber cards required.
3. Install an analog telephone auto-dialer card to provide roll-over of calls to the WMATA Operations Control Center (OCC), Elevator Control Center (EOC), or other continuously staffed WMATA designated Control Center, when a call goes unanswered at the Kiosk. Connect this card to an analog telephone line.
4. Power supply: 24 VAC/40VA/16 subscribers or 24-35 VDC/40W/16 subscribers.
5. Relay outputs: maximum switching capacity 60W / 125VA, maximum switching current: 2 A, maximum switching voltage: 60 VDC/40 VAC.

## **2.02 MASTER STATION FOR KIOSK**

- A. Manufacturer: Commend Model EE320AS or approved equal
- B. Kiosk - Master Station:
  1. Integrated electret microphone and speaker for high fidelity audio.
  2. Wall-mounted master station can be used as a handset or hands- free unit.
  3. Telephone handset, with coiled cord.
  4. Equipped with multifunction LED to indicate incoming calls.
  5. Equipped with 6-character, alphanumeric (16-segment) display for identification of calling party.
  6. Equipped with reinforced silicon keypad with additional function keys.
  7. Modern DSP technology.
  8. Frequency Range: 200-7000 Hz.
  9. Color: Light grey

## **2.03 ELEVATOR MACHINE ROOM INTERCOM CALL STATION**

- A. Manufacturer: Command Model WS800FI or approved equal
- B. Master Station for Elevator Machine Room:
  1. Integrated microphone and speaker for high fidelity audio.
  2. Surfaced mounted.
  3. One-touch access to key Avaya features.
  4. Equipped with red light indicating the station is in use.
  5. Equipped with alphanumeric high-resolution backlit display for identification of calling party.
  6. Includes a membrane keypad designed for harsh/or industrial environment.

7. VoIP Technology: IETF RFC 3261 (Session Initiation Protocol – SIP).
8. Power over LAN: IEEE802.3af.
9. Frequency Range: 200-16000 Hz.
10. Color: Light grey.

#### **2.04 CALL STATIONS FOR ELEVATOR CARS/LANDINGS, KIOSKS AND PLATFORMS**

- A. Manufacturer: Commend Model ET508-DC Rev. B or approved equal
- B. Elevator Cars/Landings, Kiosk and Platform Call Station:
  1. Consists of a vandal resistant 11 AWG steel panel, custom painted to the Contractor required color.
  2. Speaker, microphone and associated electronic circuitry are mounted behind the panel.
  3. Includes a red mushroom-type call button.
  4. Unit will include LED indications, one for call made, (red), and one for call answered, (green).
  5. Relay contact.
  6. VoIP Technology: IETF RFC 3261 (Session Initiation Protocol – SIP).
  7. Power over LAN: IEEE 802.3af.

#### **2.05 KIOSK PAID/UNPAID AND STATION GATED ENTRY- CALL STATIONS**

- A. Manufacturer: Commend Model ES931 A or approved equal
- B. Kiosk Paid/Unpaid and Station Gated Entry - Call Stations:
  1. Integrated weather resistant, vandal proof electret microphone and speaker for high fidelity audio.
  2. Tamper and weather resistant construction.
  3. Rugged, tamper resistant call button.
  4. Faceplate Dimensions: 6-9/16" wide x 4-15/16" high.
  5. Wiring: 4 twisted pair (Category 5 or higher).
  6. Interface: RJ 45 (Static IP).
  7. Power Requirement: 12-24VAC or 15-35VDC, 500mA or PoE (with PoE switch).
  8. Frequency Range: 50-16,000 Hz.
  9. Mounting: Standard 3-gang backbox. Backbox painted Benjamin Moore (Color 2) HC-170 Stonington Gray or other approved color.
  10. LED for indication of conversations.
  11. Protocol: IP-Protocol based on UDP/IP.

#### **2.06 KIOSK CALL-ALERT STROBE LIGHT AND SONALERT UNIT**

- A. Manufacturers: Custom-built Kiosk Strobe and Sonalert Unit.

- B. Strobe light and son-alert unit for Kiosk:
1. Unit is comprised of a weather resistant amber colored strobe light mounted to a short length of pipe for better visibility and a weather resistant outdoor speaker horn. Both the strobe light and speaker are mounted to a heavy duty box for installation on the roof of the Kiosk.
  2. Power Requirements: .75 Amps @ 24VDC. (Power supply included).
  3. Strobe Luminosity & Life: 1800 mcd @ 30MilliAmperes 100,000+ Hours.
  4. Lens & Material: 5-3/4" diam., diffused lens optimum visibility and reliability for effective visual signaling.
  5. Speaker: 15 Watt, 8 Ohm nominal.
  6. Tone Frequency: Solid state generated square wave at approx. 800 Hz.
  7. Tone Level Settings: Volume control, screw driver type located at rear of unit.
  8. Functionality: Configured and installed as an integral unit of the Washington DC Metrorail System to provide features and functions per CALL-FOR-AID design in existing stations.
  9. Two-piece screw terminal wiring means for ease of installation and maintenance.
  10. Connect unit to ET901-D Ethernet IP converter & EB2E2A Option board in the Kiosk for activation control

## **2.07 PORTABLE MASTER STATION (MAINTENANCE-INTERCOM UNIT)**

- A. Manufacturer: Commend Model EE311AS or approved equal
- B. Portable Master Station:
1. Integrated electret microphone and speaker for high fidelity audio.
  2. Telephone handset with line cord for connection to elevator top-of-car jack.
  3. Equipped with multifunction LED.
  4. Equipped with 6-character, alphanumeric (16-segment) display for identification of calling party.
  5. Equipped with reinforced silicon keypad with additional function keys.
  6. Modern DSP technology.
  7. Frequency Range: IP-Protocol based on UDP/IP
  8. Color: Light grey.

## **2.08 IP-INTERCOM INTERFACE UNIT**

- A. Manufacturer: Commend Models ET901-A & ET901-D or approved equal
- B. IP-Intercom Interface Unit:

1. Establishes the bridge between an Ethernet network with IP- protocol and any 2-wire digital or 4-wire analog intercom terminal.
2. utilizes the latest DSP technology which enables features such as Loudspeaker-/Microphone Surveillance and Audio Monitoring for any terminal connected.
3. Unit can be upgraded to handle additional inputs and outputs with an EB2E2A Option board.
4. Available as an open PC board unit; with a standard housing; or with a weatherproof housing.
5. Power: 24VAC +/- 5% or 28-35 VDC or PoE.
- 6 PoE (Power over Ethernet): IEEE 802.3af standard. Power connection of terminal device: Class 0 (0.44 W to 12.95 W).
7. Protocol: IP-Protocol based on UDP/IP.
8. Data Rate: 2 x 10/100 MBit/s (full/half duplex).

## **2.09 OPTION BOARD - (FOR KIOSK STROBE AND SONALERT UNIT ACTIVATION**

- A. Manufacturer: Commend Model EB2E2A or approved equal
- B. Option Board:
  1. Provides Intercom terminals with an expansion plug to be upgraded to handle additional inputs and outputs.
  2. Unit can be integrated in the housing of the IP-Intercom Box ET 901.
  3. Inputs: 2 inputs for floating contacts, max. 1 kOhm.
  4. Outputs: 2 relay outputs (changeover contacts) rated 30V.

## **2.10 ELEVATOR MACHINE ROOM - IP CONVERTER ENCLOSURE**

- A. Manufacturer: Hoffman A30H20BLP or approved equal.
- B. Interface Enclosure:
  1. NEMA 4 enclosure for housing the IP converters associated with the elevator car units, elevator landing units and top-of-car jacks.
  2. Provide backplate inside enclosure for mounting purposes.
  3. The size of this enclosure may be adjusted to meet the needs of the devices being housed within it for each Elevator Machine Room but it shall be a NEMA 4 rated enclosure.

## **2.11 ELEVATOR MACHINE ROOM - PORTABLE MASTER STATION STORAGE ENCLOSURE**

- A. Manufacturer: Hoffman AHE12X8X4 w/T-Handle Latch or approved equal.

B. Interface Enclosure:

1. NEMA 1 enclosure to be installed in the Elevator Machine Room for housing the portable master station when not in use.

**2.12 ELEVATOR TOP-OF-CAR JACK/MODULE**

A. Manufacturer: Ortronics - OR-404IP22 Two-port industrial grade surface box, cover plate and watertight cable gaskets & plugs. Ortronics - OR-IPJ6 Category 6 industrial jack with protective cover cap or approved equals

B. Elevator Top-of-Car (TOC) jacks:

1. Provides a connection jack on top of each elevator car for the Portable Master Station Maintenance-Intercom Unit.
2. Assembly consists of a Category 6 telephone jack mounted in a weatherproof box with a weatherproof cover.

**2.13 PLATFORM-EMERGENCY CALL STATION**

A. Manufacturer: Commend Model EF963AM or approved equal

B. Platform-Emergency Call Station:

1. Provides a means for rail passengers located along the station platform to report emergencies to the Station Manager in the Kiosk.
2. The Emergency Call Station shall be located within signage, provided by others, that identifies the Call Station as an emergency reporting communications device.
3. Vandal-proof Stainless steel faceplate.
4. Integrated omnidirectional electret microphone and special membrane type loudspeaker for optimal sound quality.
5. Integrated amplifier class "D" 1.5 W.
6. Input: 3 inputs for floating contacts max. 1kOhm.
7. Output: 2 relay outputs.
8. Display: red operation LED.
9. Call button: red mushroom.
10. Frequency range: 200-7,000 Hz.
11. Power: external power supply 12-24 VAC or 15-35 VDC, 500mA, or PoE.
12. PoE: IEEE 802.3af standard. Power consumption of terminal device: Class 0 (0.44 W to 12.95 W).
13. Protocol: IP-Protocol based on UDP/IP.
14. Data rate: Autosense (10/100 MBit/s, full/half Duplex).
15. Cabling: Category 5 (minimum) required.
16. Surface mount using GUEF 63 backbox inside an EF 63G hood.

## **2.14 IP SUBSCRIBER CARD**

- A. Manufacturer: Commend Model G3-IP-4B or approved equal
- B. IP Subscriber Card:
  - 1. Cards install in Intercom Server for the connection of up to 8 Intercom terminals via Ethernet networks with IP-protocol.
  - 2. Cards connect directly to a LAN/WAN without the need of media converters or multiplexers.
  - 3. Available with 4 or 8 subscribers per card.
  - 4. Provide with license upgrades L3-IP-8D and L3-IP-8B to allow connection of up to 8 subscribers per card.
  - 5. Install proper number of cards with upgrade licenses to accommodate at least 100 subscribers (intercom units) per station.

## **2.15 MULTI-FUNCTION TELEPHONE INTERFACE CARD**

- A. Manufacturer: Commend Model G8-TEL4 or approved equal
- B. Telephone Interface Card:
  - 1. Integrated auto-dialer and telephone interface.
  - 2. Powered from intercom server.
  - 3. Telephone connection: RJ11.

## **2.16 CATEGORY-6 UNSHIELDED TWISTED PAIR (UTP) CABLE**

- A. Manufacturer: Berk-Tek LANMARK-1000 100 ohm, Category 6, 23 AWG, 4-pair shielded twisted pair (UTP) (or equal).
- B. Cable to provide signal and power (POE) for ISS call stations and Master Stations:
  - 1. 4-pair, unshielded twisted pair (UTP).
  - 2. Meet TIA and ISO Category-6.
  - 3. 23-AWG solid bare copper.
  - 4. Insertion loss: 32.9 dB/100 meters at 250MHz.
  - 5. Cable outside diameter: 0.220 inches.
  - 6. Color: Blue (other color may be submitted for approval).
  - 7. Primary insulation: FEP.
  - 8. Jacket: Low-smoke PVC rated CMP (plenum).

## **2.17 TEST AND PROGRAMMING EQUIPMENT**

- A. Provide a minimum of one set of all equipment, adapters, software, manuals and external processors required to program, or reprogram, any portion or subsystem of the system.

## **PART 3 : EXECUTION**

### **3.01 INSTALLATION**

- A. The new Call-for-Aid shall be installed and configured to provide the following Communications capabilities:
1. From the Kiosk Master Station to the "Paid" and "Unpaid" sides of the Kiosk.
  2. From Elevator Car and Elevator Landing call stations to the Kiosk Master Stations.
  3. From the passenger emergency Call Stations on the station platform(s) to the Kiosk Master Stations.
  4. From the station entrance emergency Call Station to the Kiosk Master Stations.
  5. From inside the gated entry points to the Entrance Pavilions or Pedestrian Bridges that end at a gated entry
  6. The Area Refuge and Dispersal Areas.
  6. From top of elevator cars utilizing a waterproof jack as a connection means for a portable master stations maintenance intercom unit
  7. Roll-over capabilities to other Kiosk Call-Stations or to external facilities as pre-programmed into the system, if a Kiosk Master Station doesn't respond to the incoming call.
  8. The Subcontractor shall coordinate and work with the Contractor and WMATA to develop a call routing plan designating numbers to be dialed and roll-over functions in the event that calls are unanswered at specific locations.
- B. **KIOSK**
1. Install a dedicated AC circuit for the Intercom System, originating from the Communications Room Power Distribution Panel supplied by the station UPS (Uninterrupted Power Source).
  2. Install the Passenger/Kiosk Attendant call-stations in the "paid" and "unpaid" areas of the Kiosk(s), and wire to the 24-Port Category-6 Patch Panel for connection to the Kiosk Data Switch.
  3. Install the Intercom Master Station in the Kiosk(s) and wire to the 24-Port Category-6 Patch Panel for connection to the Kiosk Data Switch.
  4. Install the Kiosk-mounted strobe light in view of one of the Kiosk windows, and wire to the Networked Relay Module for connection to the Kiosk Data Switch.
  5. The Call-for-Aid equipment and the VoIP call manager server shall be programmed to provide the necessary features and functions for all Call Stations (Elevator Car(s), Elevator Landings, Kiosk Intercom Call Stations and Master Station, and the Platform Stations). The Call-for-Aid equipment and the VoIP call manager server shall be completely programmed for all the correct Call- Station addresses and user-defined message, and roll-over functions where applicable.

### **C. Platform Call-Stations**

1. Install two Emergency Call Stations on each platform of the passenger stations. The Emergency Call Stations shall be surface-mounted on selected columns along the platform areas via mounting brackets or back-plates. The call station shall be clearly visible to the general public.
2. Install the Emergency Call Stations on the columns via the mounting brackets or back-plates. Verify, at each designated column, that the installation of the Emergency Call Station does not interfere with signage graphics. Conflicts between column graphics and the installation of the Emergency Call Station shall be referred to the Contractor for resolution.
3. To prevent tampering with the Emergency Call Station, removal of the phone from the associated mounting bracket shall require special tools.
4. Install two Category-6 cables from each Emergency Call Station to the nearest Category-6 Patch Panel in the Kiosk or in the Communications Equipment Room. One cable will be connected to the Data Switch. The other cable shall be terminated and marked as spare.

### **D. Elevator Call-Stations**

1. Install an Emergency Call Station in each elevator car and elevator landing location. The Subcontractor shall interface with the elevator subcontractor concerning the mounting method, and location of the call station inside the elevator car, and its' wiring connection to the Kiosk via the LAN/WAN outlet in the associated Elevator Machine Room. The Subcontractor shall submit drawing details of the proposed mounting method and location for approval prior to installation.
2. Install a Master Call-Station in each Elevator Machine Room and provide Category-6 wiring connection to the nearest Data Switch in the Kiosk or in the Communications Equipment Room.
3. Provide one portable Master Station for maintenance purposes locate in the storage enclosure of each Elevator Machine Room. The portable Master Station will be provided with a line cord for connection to the top-of-car jack for use during elevator maintenance

### **E. Communications Equipment Room**

1. Install a Call-for-Aid Central Exchange Unit (CEU GE 800) in the Communications Equipment Room at each passenger station and connect it to the Comm. Room LAN Data Switch for function control of all associated Call-for-Aid call stations.
2. Program the CEU and LAN Data Switches to provide all the system functions required by this specification.

3. Install and properly program a telephone auto-dialer card within the CEU in the Communications Equipment Room to allow calls that go unanswered by the Kiosk Call-for-Aid Master Station to be routed to WMATA Operations Control Center (OCC) or other continuously manned Control Center as designated by WMATA for handling of these calls. Connect the telephone auto-dialer to an analog phone line via the G450 unit in the Comm. Room.

#### **F. Entrance Pavilions and Pedestrian Bridges Gated Entry Points**

1. Install Call-for-Aid Call Station on the interior side of each Entrance Pavilion or Pedestrian Bridge gated entry point to provide emergency communications for persons that may become trapped at these gated entry points during hours when the passenger station is closed.
2. Provide Category-6 wiring from the Call-for-Aid Call Station to the nearest designated Patch Panel and LAN Data Switch.
  - a. Install one Emergency Call Stations immediately next to each main entrance into the passenger stations. The Emergency Call Stations shall be surface-mounted via mounting brackets or back-plates.
  - b. Verify that the installation of the Emergency Call Station does not interfere with signage and does not impede passenger entrance.
  - c. To prevent tampering with the Emergency Call Station, removal of the phone from the associated mounting bracket shall require special tools.

#### **3.02 FIELD QUALITY CONTROL**

- A. The new Intercom System shall be installed and fully tested with current calibrated equipment, under the supervision of trained manufacturers' representative. The system shall be demonstrated to perform all functions as specified.

#### **3.03 SYSTEM TESTINGS**

1. The completely-installed Intercom System shall be fully tested (on a station-by-station basis) with the Contractor-Approved test procedures. The Contractor reserves the right to witness system acceptance testing of the supplied Call-for-Aid at each location.
2. All test equipment, instruments, tools and labor required to conduct the tests shall be made available by the installing Subcontractor. All test equipment shall have a current calibrated test data tag.

#### **3.04 CLOSEOUT ACTIVITIES**

- A. Demonstrate operation and maintenance of Products to WMATA's personnel two weeks prior to date of Substantial Completion.
- B. Demonstrate Project equipment by a qualified person who is knowledgeable about the Project.
- C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with WMATA's personnel in detail to explain all aspects of operation and maintenance.
- D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at equipment location.
- E. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.
- F. Demonstrate system operation.
- G. Conduct walking tour of Project and briefly describe function, operation, and maintenance of each component

**END OF SECTION**

## SECTION 16729

### PASSENGER INFORMATION DISPLAY SYSTEM

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION

- A. This Section describes the Passenger Information Display System (PIDS). The equipment consists of Variable Message Sign (VMS) displays and associated mounting equipment located throughout the station platform and entrance areas, one Station Control Unit (SCU) and modem located in the Station Communications Room, and one Kiosk Control Panel (KCP) located in the Station Manager's Kiosk. The related communications equipment shall be installed in the Station Communications Room. All software and hardware shall operate seamlessly with the existing PIDS.
- B. Related Work Specified Elsewhere:
- |  |                |
|--|----------------|
| 1. Grounding and bonding:                          | Section 16060. |
| 2. Wire, cable and busways:                        | Section 16120. |
| 3. Raceways, boxes and cabinets:                   | Section 16130. |
| 4. Uninterruptible power system:                   | Section 16260. |
| 5. Circuit breakers, panelboards and load centers: | Section 16440. |
- C. The following abbreviations apply to this Section:
- |   |
|---|
| 1. ADA: Americans with Disabilities Act |
| 2. CPU: Central Processing Unit         |
| 3. EMI: Electromagnetic Interference    |
| 4. KCP: Kiosk Control Panel             |
| 5. LED: Light Emitting Diode            |
| 6. SCU: Station Control Unit            |
| 7. VMS: Variable Message Sign           |
| 8. PA: Public Address                   |
| 9. RH: Relative Humidity                |
| 10. LAN: Local Area Network             |
| 11. JGB: Jackson Graham Building        |
| 12. CTS: Carrier Transmission System    |
| 13. CD: Compact Disk                    |
- D. Listing and labelling: Provide products specified in this Section that are UL listed and labelled.
- E. Coordinate features, accessories, and functions of each VMS with corresponding SCU and KCP.
- F. Coordinate features of distribution equipment and VMS components to form an integrated interconnection of compatible components. Match components and interconnections for optimum performance of specified functions.
- G. Coordinate with general construction work and arrange in building structure during progress of construction to facilitate the electrical installations that follow.
- H. Coordinate work in this Section with that in Sections specifying distribution components that are monitored or controlled by VMS equipment.

- I. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
  - 1. Operating Temperature: 0 to 50 degrees C.
  - 2. Storage Temperature: -20 to 70 degrees C.
  - 3. Humidity Range: 5% to 90% RH, non-condensing.

**1.02 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Codes and regulations of jurisdictional authorities.
  - 2. 47 CFR 15, Subparts A and B
  - 3. NFPA 130
  - 4. UL 50
  - 5. NEMA AB 1 and NEMA KS 1
  - 6. ITU-T
  - 7. ADA Sections 4.30.2 and 4.30.3
  - 8. MIL-I-46058C
- B. Design and production tests: Perform and submit, in accordance with the General Requirements certified test results on the PIDS or provide certified test results on an identical unit. Furnish certified test reports showing test data and results as well as manufacturer's comments on tests.
- C. Interchangeability: Furnish products of a manufacturer regularly engaged in the manufacture of display systems. In addition:
  - 1. Standard commercial products shall be furnished whenever such equipment and materials will satisfy the stated specifications. Suitable modified standard commercial devices shall be furnished when required to satisfy specification requirements. Custom developed and fabricated equipment units and devices shall be confined to those items for which suitable commercial off-the-shelf (COTS) products are not available to guarantee compliance with the Specifications. When custom design, fabrication, or assembly is required, every effort shall be made to minimize the number of different modules, solid-state devices used.
  - 2. With each system, subsystem and facility, two or more like functions shall be performed by identical units. In no case shall the equipment or hardware used in one portion of a system, subsystem or facility be different from that used in another portion to perform the same function under similar operating and environmental conditions (outdoor display systems are distinct from indoor display systems).
  - 3. Equipment shall be physically and plug compatible with recent versions of existing Authority equipment performing similar functions and used for comparable applications elsewhere in similar WMATA facilities insofar as possible. The use of adapter plugs, interface boxes, and replacement mounting brackets or enclosures that fit available space and mounting holes may be allowed by the Engineer to maintain interchangeability when competitive products that do not require such devices are determined to be unavailable (applicable to COTS major equipment items only). Custom designed and fabricated equipment must be fully interchangeable without requiring the use of such devices. If a determination is made to allow use of such devices, the Contractor shall provide all necessary adapters and interface devices with each item of equipment furnished, at no additional cost to the Authority.
  - 4. Equipment shall be software compatible with recent versions of existing Authority equipment performing similar functions and used for comparable applications elsewhere in similar WMATA facilities.

5. Major items of equipment furnished by the Contractor shall be within the physical size and configuration limitations specified in provisions of this contract. If such specifications are not included in the provisions of this contract, major items of equipment shall be of a physical size and configuration closely comparable to equipment currently in use of comparable applications elsewhere in similar WMATA facilities.
  6. Exception: Lighter weight and smaller sized more modern versions of equipment are sought by the Authority where their use presents significant advantages. The use of new generations of equipment that differ in size and are not fully interchangeable will be considered for approval by the Engineer, in order to take advantage of significant technological improvements developed by industry.
- D. Qualifications of Instructor for Operation and Maintenance Training: Perform operation and maintenance training in accordance with the General Requirements for development and performance of operation and maintenance training for PIDS. Qualifications will be considered adequate when the following is demonstrated:
1. Instructor has in-depth knowledge of the design, packaging, operations, maintenance and trouble-shooting of the systems to be taught.
  2. Instructor has been trained in teaching methods or has previous satisfactory experience in teaching with emphasis on the subject matter to be covered in the course of instruction.

### 1.03 SUBMITTALS:

- A. Product Data: For each type of VMS, SCU, KCP, and modem. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Product Data for each type of fixture below. Include data on features and accessories.
1. Cantilever single side, Inova sketch E2 C-Mount
  2. Cantilever double side, Inova sketch E2 C-Mount
  3. Wall mount single side, Inova sketch E2 W-Mount
  4. Wall mount double side, Inova sketch E2 W-Mount
  5. Cantilever "T" Inova sketch E2 T-Mount
  6. Ceiling mount, single side, Inova sketch E2 O-Mount
  7. Ceiling mount, double side, Inova sketch E2 O-Mount
- C. Shop Drawings: For each type of VMS, SCU, KCP and modem:
1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include: enclosure types and details, nameplate legends, short-circuit current rating of integrated unit.
  2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
- D. Certification, including:
- a. Dimensioned Outline Drawing of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - b. Detailed description of anchorage devices on which the certification is based and their installation requirements.
- E. Documentation:

1. Submit field-test plan and documentation within 60 days after award with accompanying documentation in the form of test-data recording sheets and list of proposed test equipment.
  2. Do not proceed with testing until plan and documentation are approved.
  3. Indicate in scope of test plan method of testing in order to ensure safe and orderly transition from installation, through initial energizing, to specified field testing.
  4. Accompanying documentation to include data-recording sheets as used by manufacturer for in-plant testing of equipment and devices.
  5. Submit certified copies of test data, dated and clearly identified within two weeks after completion of testing. Testing shall be witnessed by WMATA representatives.
  6. Instructor qualifications: Five copies of resume which outlines each instructor's qualifications and skills not later than 180 calendar days prior to commencement of training.
- F. Field Test Reports to include the following:
1. Test procedures used.
  2. Test results that comply with requirements.
  3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- G. Operations and maintenance training material:
1. Five copies in paper format and five copies in CD format not later than 30 calendar days prior to commencement of training.
- H. Operations and Maintenance Manuals:
1. Include in manuals general theory of operation of the PIDS including description, purpose and function of:
    - a. VMS.
    - b. SCU.
    - c. KCP.
    - d. Modem.
  2. Describe and include in manuals procedures for:
    - a. PIDS testing.
    - b. Operational checks of PIDS.
    - c. Troubleshooting to include test procedures and system logic in identifying malfunctions.
    - d. Preventive maintenance inspection.
    - e. Maintenance actions to be performed by the contractor.
    - f. Maintenance actions to be performed by the Authority.
  3. Include in manual the shop drawings listed in C above. Print shop drawings on folded pages in accordance with the General Requirements.
  4. Five complete sets of As Built Drawings in paper format and five complete sets of As Built Drawings in CD format
  5. Maintenance training certificates.
- I. Manufacturer's factory-authorized service representatives inspectors reports.

**1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.
- B. Temporary Bracing: Where necessary, brace each unit for hoisting, lowering and sliding into position. Temporary bracing of the equipment labeled as follows: TEMPORARY-REMOVE BEFORE OPERATION.

- C. Protection Against Concealed Damage: Include within shipping container mechanical impact recorder of rating recommended by manufacturer for shipment by railroad and submit in accordance with the General Requirements impact chart with manufacturer's recommendations for disposition of damaged materials.
- D. Store equipment in secure and dry storage facility.

## **PART 2 - PRODUCTS**

### **2.01 PRODUCTS AND MATERIALS**

- A. General:
  - 1. Interchangeability: Components of same type, size, rating, functional characteristics and make are to be interchangeable.
  - 2. Integration: Coordinate features to form an integrated system. Match components and interconnections for optimum performance of specified functions.
  - 3. Expansion Capability: Unless otherwise indicated, provide spare fibers and conductor pairs in cables, positions in patch panels, cross connects, terminal strips, and space in backbone cable trays and wireways to accommodate a 100% future increase in VMS number per Metrorail station.
  - 4. Enclosures: Comply with NEMA 250 and NEMA KS 1 to meet environmental conditions of installed location.
- B. VMS General Description: Four-line, tri-color (Red, Amber, Green) LED Dot Matrix Display, with full text, and graphics capability, outdoor enclosure. Manufacturer: INOVA or a manufacturer of buyer-approved equal. Models: NTDI (indoor, double-sided), NTDO (outdoor, double-sided), WSI (mezzanine, single-sided), or equivalents.
- C. SCU General Description: Station Control Unit, PC, Rack Mount. Manufacturer: Avnet or a manufacturer of buyer-approved equal. Model: #72209 or equivalent.
- D. KCP General Description: KCP is a keypad that allows the Station Manager to activate message(s) for a special condition or emergency situation. Manufacturer: Avnet or a manufacturer of buyer-approved equal. Model: refer to KCP drawing #690023.
- E. Modem General Description: Modem is a unit which provides synchronous and asynchronous data communication to meet networking requirements. Manufacturer: Motorola or a manufacturer of buyer-approved equal. Model: Fast'R 3460 or equivalent.
- F. Equipment: Modular type, using solid-state components, fully rated for continuous duty, unless otherwise indicated.
- G. Waterproof Equipment: Listed and labelled for duty outdoors or in damp locations.
- H. VMS Finishes:
  - 1. Paint Finish: VMS painted Metro Bronze, Dupont Imron, or stainless steel, as required.
  - 2. Metallic Finish: All metallic housing components and fasteners are corrosion-resistant.
- I. VMS Housing: Case material is Aluminum. The housing shall have the capability to swivel (rotate) 90 degrees to a position parallel to the track.

- J. VMS Service Access: All electronics are mounted to a single sheet metal plate (backplate) for easy removal. Backplate is accessed from a removable front per specification.
- K. VMS Service access: Each enclosure shall be equipped with a keyed power switch that is capable of rebooting power to the backplate(s). The switch shall be made accessible through the bottom of the enclosure.
- L. Each VMS shall have an electrical disconnect provided within line of sight of sign to allow isolation of each ungrounded conductor in accordance with National Electrical Code.
- M. LED: Minimum features include the following:
  - 1. Outdoor Displays LED Panel Display Unit (Panasonic LNP175031S) 16X32 interchangeable modules
  - 2. Indoor Displays LED Panel Display Unit (Panasonic LNP175011S) 16X32 interchangeable modules
- N. LED Dot Size and Pitch: Dot dimension 5.0mm, Pitch 6.0mm
- O. VMS Display Size: 64 LEDs high X 192 LEDs wide (15.1" X 45.3")
- P. LED Brightness:
  - 1. Red: Typ. 600 cd/sq.m
  - 2. Green: Typ. 450 cd/sq.m
- Q. LED Wavelength:
  - 1. Red: Typ. 630 nm
  - 2. Green: Typ. 565 nm
- R. VMS Minimum Viewing Angle:
  - 1. Indoor: >45 degrees from the center viewing axis
  - 2. Outdoor: >30 degrees from the center viewing axis
- S. Ambient Light Adjust: Automatic dimming of LED's in darkened ambient light to prevent eyestrain on outdoor models.
- T. Internal Processor: CPU utilizing the Motorola MPC860 PowerPC PowerQUICC processor.
- U. Internal Memory: 4 megabyte.
- V. Display Capability: Programmable alphanumeric and graphic.
- W. Clock: Built-in time and day.
- X. VMS Speaker: One Pioneer 6" speaker mounted in the bottom of the sign projecting sound downward. The speaker and associated audio components should be mounted on a hinged assembly that can be accessed through the bottom of the enclosure.
- Y. Message Storage: Greater than 100 50-character messages.
- Z. VMS Standard Font Heights:
  - 1. Note that the ADA standard is a minimum of 3" for any sign mounted over 80" high.
    - a. There should be no display of transit information of less than 3" at any time.
      - 1) 1.60" 7 LED's high
      - 2) 1.85" 8 LED's high

- 3) 3.27" 14 LED's high
- 4) 3.78" 16 LED's high

- AA. VMS Fonts: Narrow, Bold, Wide, ADA compliant aspect ratios. VMS Background: Matte black.
- BB. VMS Weight: Approximately 325 lbs for double-sided signs.
- CC. Case Size: Approximately 50" X 23" X maximum thickness of 22".
- DD. VMS Display Face Plate: Polycarbonate, Lexan MR5, clear, anti-glare, 0.236" or equivalent.
- EE. Communications Interface: RS-485, full duplex, 2400-9600 baud.
- FF. Conformal Coating: Circuit boards conformal coated to MIL-I-46058C.
- GG. Addressability: Individual two byte address allows 255 displays with zone assignment allowed.
- HH. VMS Temperature Monitoring and Cooling: Fan cooled. Airflow sensor monitors the airflow through filters on fan, and notifies operator in the event of reduced airflow through air filters. Temperature sensor monitors overall temperature in case, and each is equipped with a bypass switch to allow for troubleshooting of a faulty sensor. Automatic shutoff in the event of high temperature. Operator in JGB notified through a screen error message.
- II. SCU Base Unit: Industrial computer chassis, ruggedized, 19" rack mount, filtered air, passive backplate, 8 slot, 3 ISA, 4 PCI, 1 shared.
- JJ. SCU Processor: Pentium III 750/100 FC-PGA.
- KK. SCU Floppy Disk Drive: 1.44 MB, 3.5" floppy drive.
- LL. SCU Operating System: Microsoft NT 4.0 on CD, factory installed.
- MM. SCU Memory: 128 MB SDRAM, 100 MHz.
- NN. SCU CD ROM: 48X CD ROM drive.
- OO. SCU Hard Drives: 10.2 GB hard drive, quantity 1.
- PP. SCU Sound Card: Soundwave PRO PCI 32 bit PCI.
- QQ. SCU Monitor Shelf: Dalco Electronics / Hubbell center weight shelf.
- RR. Modem Synchronous data rates up to 33.6 KBPS and asynchronous data rates up to 230.4 KBPS.
- SS. PIDS Plug-In Accessories Power Requirements: Emergency power, 120 V, 1 KVA in the communications room and 100 W, 120 V in the kiosk.
- TT. Platform VMS Electrical Power Service Requirement: A 2-pole, 480 V, 20 A circuit shall be provided from the nearest AC Switchboard Room's Fused Switch Emergency Panel and terminated in a NEMA 4X rated disconnect (safety) switch near where the VMS will be

located. The disconnect (safety) switch shall provide input power to a 5 KVA, single-phase, 480/240-120V transformer which will supply the 120-volt power to the platform VMS.

UU. Mezzanine VMS Electrical Power Service Requirement: A 120 V, 20 A circuit shall be provided from the nearest Emergency Panel to where the mezzanine VMS is located.

VV. Modem Power Requirements:

1. AC Power Supply Module
  - a. Voltage: 100/120/220/240 VAC nominal (switch-selectable)
  - b. Frequency: 50/60 Hz
2. DC Power Supply Module
  - a. Voltage: -48 VDC nominal

WW. Performance Requirements: VMS is capable of the following functions:

1. Sunlight Readability Due to the inconsistent rating of LED brightness by manufacturers, no minimum candella rating is specified. The outdoor displays should be readable in direct sunlight. A demonstration to the Authority will be required before full manufacturing approval.
2. VMS Message Storage - Each VMS shall have the ability to store a minimum of one hundred 50-character messages. The user shall be able to retrieve any stored message for display from local VMS storage using the VMS Server control software. The VMS shall have the capability of displaying and broadcasting emergency messages.
3. Fonts - An extensive font set shall be included with the VMS. All VMS fonts shall meet ADA requirements for signage. ADA Section 4.30.2 and 4.30.3 describe requirements for width-to-height ratio, stroke width-to-height ratio, and character height. Fonts shall include a robust character set containing all characters required to express messages in standard Spanish and English languages. The character sets include upper case, lower case, numerical digits, non-alphabetic and non-numeric special characters
4. VMS Self Diagnostics - Each VMS display shall be capable of self diagnosis and communicating its operational status to the VMS operator workstations. The VMS Server shall automatically request status from individual VMS displays. In addition to identifying errors, the status reports shall also serve as an independent and redundant means of verifying the message content of each VMS, allowing the effects of any spontaneous communication errors to be corrected. The proper execution of commands sent from the Station Manager's Kiosk, or from any workstation shall be verifiable, with the capability of dispatching service calls in the event of error messages. The VMS Server shall maintain a database which contains a description of each message within every VMS display. Through the status reporting, the VMS Server shall be in a position to query the entire system, compare the message content of each VMS with the control database, and automatically take corrective action if necessary. In the event that the sign lose communication with the server at JGB, the sign shall reboot automatically; if the failure persists, the sign shall stop displaying information (all LED's off).
5. VMS Environmental Design - The proposed VMS equipment shall be designed and manufactured to withstand a harsh transit environment including the effects of weather conditions on outdoor deployed equipment. Operating temperatures will be from -20 C to +50 C (-4 F to 122 F). All electronic components will be sealed using conformal coating. The VMS shall be designed to resist electromagnetic interference (EMI). VMS outdoor units shall be waterproof and sealed against particulate matter invasion such as steel and other metallic particulate matter typically found in a transit environment. The hardware will be modular and designed for ease of service. All VMS outdoor units shall be equipped with sunlight readable

LED's, and shall automatically adjust brightness based upon ambient lighting so not to hurt the readers' eyes in darkened conditions.

6. The LED matrix shall be composed of an array of replaceable LED modules. The VMS Unit shall use tri-color (Red, Amber, Green) LED Dot Matrix Display, with full text, and graphics capability, and housed in outdoor enclosure.

XX. Performance Requirements: SCU is capable of the following functions:

1. The SCU shall provide for data acquisition and control of the display and speaker VMS subsystems.
2. Network audio messages shall be in a standard format and shall be loaded to and stored in the SCU over the LAN communications network and output from the sound card to the Audio Interface Board. The Station Control Unit shall provide positive announcement verification and/or announcement failure indication locally and to OCC.
3. The SCU shall control the Carrier Transmission System modem and communications interface.
4. The SCU shall receive inputs from the Kiosk Control Panel for display of messages at the local station.
5. The SCU shall distribute control commands from the VMS Server to the VMS displays, and route VMS responses back to the Server.
6. The SCU shall provide SCU status reports back to the VMS Server, which collate the VMS status reports for the station.
7. Because of its open architecture, the SCU shall be suitable for expansion to additional inputs, outputs and system functions. For example, it can easily be adapted to read or generate switch closures, or to read or issue serial data.
8. The SCU shall have automatic reboot capability in the event of PIDS failure.
9. The SCU shall be equipped with a filter that has the capacity to remove from the filtered air stream particulate matter such as steel and other particulate matter typically found in a transit environment.

YY. Performance Requirements: KCP is capable of the following functions:

1. The KCP shall have 15 buttons that can be assigned messages by OCC, plus 1 message activation button.
2. Messages shall be created, stored and assigned by the system operator at the Operations Control Center, and activated by the Station Manager.
3. A single pushbutton reset for all PIDS signs at a station shall be provided from each SCU at the station.
4. The Station Manager shall not have the capability to generate original messages.

ZZ. Performance Requirements: Modem is capable of the following functions:

1. Synchronous and asynchronous communication in one unit, with two preset configurations for typical applications.
2. Automode with telephone-number linking and auto-redial.
3. Industry-standard error detection and data compression.
4. Automated software download and flash memory for easy upgrades.
5. V.54 diagnostic test suite.
6. LED displays that indicate modem activity.
7. Light bar displays (stand-alone modem only) that indicates line, data, and link-utilization rates.
8. Support for the Motorola 9000 Open Management System (OMS) Network Management System.
9. Support for secondary-channel modem management.
10. Support for a four-wire leased-line configuration, using Authority's in-house wiring.

11. Restoral: automatic rerouting of data traffic to the Public Switched Telephone Network (PSTN), over a two-wire dial line, for backup of critical leased-line applications when a leased line fails or signal quality deteriorates.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. Installer Qualifications: An experienced installer who is an authorized representative of equipment manufacturer for both installation and maintenance of equipment required for this Section.
- B. The Contractor is to run the communications wiring and is also to install the associated modems from the server in the JGB B1 Computer Room through the CTS infrastructure to the Station COMM Room. The Contractor must provide connectivity from the sign back to the server. The Contractor must insure sufficient server capacity to handle the additional signs.
- C. Install transmission media where applicable without damaging conductors, shield, or jacket. Do not bend cable, in handling or installation, to smaller radii than minimum recommended by manufacturer.
- D. Pull cables without exceeding cable manufacturer's recommended pulling tensions.
  1. Use pulling compound or lubricant where necessary.
  2. Use pulling means that will not damage media or raceway.
- E. Install exposed cables parallel and perpendicular to surfaces or exposed structural members, and follow surface contours where possible.
- F. All below-ground conduits with communications cable installed should be checked for water infiltration. No cable shall be installed in conduits that are wet.
- G. Support cables according to Section 16130.
- H. All new conduits shall be properly tagged for power and communications. Power and communications cables should be in separate conduits.
- I. Make no splices except at indicated splice points. Use splice and tap connectors compatible with cable material.
- J. Seal around cables penetrating fire-rated elements according to Section 07841 "Firestopping".
- K. Bond shields and drain conductors to ground at only one point in each circuit.
- L. Connect components to wiring system and to ground.
- M. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.
- N. Line Matching Transformer Connections: Make initial connections using tap settings indicated on Drawings.
- O. Identify cables according to Section 16120.

- P. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide the maximum possible headroom. ADA requires a minimum mounting height of 80"; if less, barriers must be provided.
- Q. Equipment: Install to facilitate service, maintenance, and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other locations.
- R. Install equipment level and plumb and according to manufacturer's written instructions.
- S. Arrange equipment to provide adequate spacing for access and for circulation of cooling air.
- T. Weatherproof Equipment: Install units that are mounted in damp locations or are exposed to weather, consistent with requirements of weatherproof rating.

### **3.02 FIELD QUALITY CONTROL**

- A. Field Testing and Inspection:
  - 1. General:
    - a. Conduct field inspection and field testing at each station to ensure proper operation of PIDS equipment and devices provided.
    - b. Operation and protective-device setting: the Contractor is responsible for setting and calibration of protective devices for proper operation during field testing.
  - 2. Field inspection:
    - a. Prior to field testing, check equipment installation in accordance with manufacturer's recommendations.
  - 3. Field Testing:
    - a. Furnish equipment to perform tests.
    - b. Provide services of manufacturer's engineering representative and supporting field crew for a period not less than three man-days. Conduct tests in the presence of the Engineer. Perform tests in accordance with approved test procedure.
  - 4. All conductors (power and communication) shall be meggered and continuity-tested.
  - 5. Certify compliance with test parameters.
  - 6. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- B. Demonstration: Engage a factory-authorized service representative to train Owner's operations and maintenance personnel to adjust, operate, and maintain systems.
  - 1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
  - 2. Train designated personnel in management and messaging operations.
  - 3. Review data in maintenance manuals.
  - 4. Schedule training with Owner, through Authority's Training Office.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installations, including connections. Report results in writing.

- D. Field-Testing Personnel:
  - 1. When more than one representative is involved, Contractor to ensure proper coordination.
  - 2. Provide engineering, technicians and journeymen personnel as necessary to set-up and implement testing.
  
- E. Authority Tests:
  - 1. The Authority reserves the right to require the Contractor to conduct acceptance tests on each VMS at each passenger station within one-year after installation.
  - 2. In order to perform VMS tests, the Contractor may re-create test conditions of applicable standards to the extent possible without disturbing existing structure or installed equipment or materials.
  
- F. Submit certified test reports.

**END OF SECTION**

**SECTION 16729**  
**INFORMATION DISPLAY SYSTEM**

**PART 1 – GENERAL**

**1.01 SUMMARY**

- A. This section describes the Passenger Information Display System (PIDS) and the Kiosk Information Display System (KIDS). The equipment consists of Variable Message Sign (VMS) displays and associated mounting equipment located throughout the station platform and entrance areas, one Protocol Converter (PC) and one DB.25 Male Terminal Block Converter located in the Station Communications Room. All software and hardware shall operate seamlessly with the existing PIDS and KIDS.
- B. Related Sections:
  - 1. Section 16060 – Grounding and Bonding
  - 2. Section 16120 – Wire, Cable and Busways
  - 3. Section 16130 – Raceways, Boxes and Cabinets
  - 4. Section 16260 – Uninterruptible Power System
  - 5. Section 16440 – Circuit Breakers, Panelboards and Load Centers
- C. Listing and labeling: Provide products specified in this section that are UL or ETL listed and labeled.
- D. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
  - 1. Operating Temperature: 0 to 50 degrees Celsius.
  - 2. Storage Temperature: -20 to 70 degrees Celsius.
  - 3. Humidity Range: 5% to 90% RH, non-condensing.

**1.02 REFERENCES**

- A. Abbreviations and Acronyms:
  - 1. ADA: Americans with Disabilities Act.
  - 2. CPU: Central Processing Unit.
  - 3. EMI: Electromagnetic Interference.
  - 4. LAN: Local Area Network.
  - 5. LCD: Liquid Crystal Display
  - 6. LED: Light Emitting Diode.
  - 7. PA: Public Address.
  - 8. PC: Protocol Converter
  - 9. VMS: Variable Message Sign.

B. Reference Standards:

1. Codes and regulations of jurisdictional authorities.
2. Code of Federal Regulations, Title 47 Telecommunications, Part 15 – Radio Frequency Devices (47 CFR 15), Subparts A and B.
3. UL 50 – Enclosures for Electrical Equipment, Non-Environmental Considerations
4. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
5. NEMA KS 1 - Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum)
6. ITU-T and EIA/TIA. Recommendations
7. ADA Sections 4.30.2 and 4.30.3.
8. MIL-I-46058C, Insulating Compound, Electrical
9. Standard for Fixed Guideway Transit and Passenger Rail Systems (NFPA 130), 2014 Edition.

**1.03 QUALITY ASSURANCE**

A. Qualifications:

1. Manufacturers: Select a manufacturer who is engaged in production of similar Information Display products and accessories.
2. Suppliers: An authorized distributor of specified manufacturer with a minimum of three years documented experience.
3. Installers: A manufacturer authorized installer of specified products with service facilities within 100 miles of WMATA.
4. Testing Agencies:
5. Licensed Professionals:

B. Codes, Regulations, Reference Standards and Specifications, refer to Article 1.02 above.

C. Design and production tests: Perform and submit, in accordance with the General Requirements certified test results on the VMS or provide certified test results on an identical unit. Furnish certified test reports showing test data and results as well as manufacturer's comments on tests.

D. Interchangeability: Refer to Division 1 specifications of the Contract Documents. Furnish products of a manufacturer regularly engaged in the manufacture of display systems. In addition:

1. Standard commercial products shall be furnished whenever such equipment and materials will satisfy the stated specifications. Suitable modified standard commercial devices shall be furnished when required to satisfy specification requirements. Custom developed and fabricated equipment units and devices shall be confined to those items for which suitable commercial off-the-shelf (COTS) products are not available to guarantee compliance with the Specifications. When custom design, fabrication, or assembly is required, every effort shall be made to minimize the number of different modules, solid-state devices used.
2. With each system, subsystem and facility, two or more like functions shall be performed by identical units. In no case shall the equipment or hardware used in one portion of a system, subsystem or facility be different from that used in another portion to perform the same function under similar operating and environmental conditions (outdoor display systems are distinct from indoor display systems).

3. Equipment shall be physically and plug compatible with recent versions of existing WMATA equipment performing similar functions and used for comparable applications elsewhere in similar WMATA facilities insofar as possible. The use of adapter plugs, interface boxes, and replacement mounting brackets or enclosures that fit available space and mounting holes may be allowed by the subcontractor to maintain interchangeability when competitive products that do not require such devices are determined to be unavailable (applicable to COTS major equipment items only). Custom designed and fabricated equipment must be fully interchangeable without requiring the use of such devices. If a determination is made to allow use of such devices, all necessary adapters and interface devices shall be provided with each item of equipment furnished, at no additional cost.
  4. Equipment shall be software compatible with recent versions of existing WMATA equipment performing similar functions and used for comparable applications elsewhere in similar WMATA facilities.
  5. Major items of equipment furnished shall be within the physical size and configuration limitations specified in provisions of this Subcontract. If such specifications are not included in the provisions, major items of equipment shall be of a physical size and configuration closely comparable to equipment currently in use of comparable applications elsewhere in similar WMATA facilities.
  6. Exception: Lighter weight and smaller sized more modern versions of equipment are sought by the Contractor where their use presents significant advantages. The use of new generations of equipment that differ in size and are not fully interchangeable will be considered for approval, in order to take advantage of significant technological improvements developed by industry.
- E. Qualifications of Instructor for Operation and Maintenance Training: Perform operation and maintenance training in accordance with the Division1 specifications of the Contract Documents for development and performance of operation and maintenance training for PIDS. Qualifications will be considered adequate when the following is demonstrated:
1. Instructor has in-depth knowledge of the design, packaging, operations, maintenance and trouble-shooting of the systems to be taught.
  2. Instructor has been trained in teaching methods or has previous satisfactory experience in teaching with emphasis on the subject matter to be covered in the course of instruction.

#### **1.04 SUBMITTALS**

A. Product Data:

1. For each type of VMS. Include dimensions and manufacturers technical data on features, performance, electrical characteristics, ratings and finishes.
2. For each type of VMS. Include data on features and accessories for mounting VMS.

B. Shop Drawings:

1. Dimensioned plans, elevations, sections and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features and ratings. Include enclosure type and detail, nameplate legend; short-circuit current rating of integrated unit.
2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer installed and field installed wiring.

C. Certificates:

1. Dimensioned outline drawing of equipment unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  2. Detailed description of anchorage devices on which the certification is based and their installation requirements.
- D. Documentation:
1. Submit field test plan and documentation within 90 days prior to testing with accompanying documentation in the form of test-data recording sheets and list of proposed test equipment.
  2. Do not proceed with testing until plan and documentation are approved.
  3. Indicate in scope of test plan method of testing in order to ensure safe and orderly transition from installation, through initial energizing, to specified field testing.
  4. Accompanying documentation to include data-recording sheets as used by manufacturer for in-plant testing of equipment and devices.
  5. Submit certified copies of test data, dated and clearly identified within two (2) weeks after completion of testing. Testing shall be witnessed by owner representatives.
- E. Field Test Reports:
1. Test procedures used
  2. Test results that comply with requirements.
  3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- F. Operations and Maintenance (O&M) Manuals:
1. Include in manuals general theory of operation of the PIDS including description, purpose and function of VMS.
  2. Describe and include in manuals procedures for:
    - a. PIDS testing
    - b. Operational checks for PIDS
    - c. Troubleshooting to include test procedures and system logic in identifying malfunctions.\
    - d. Preventive maintenance inspection
    - e. Maintenance actions to be performed by the Subcontractor
    - f. Maintenance actions to be performed by OWNER
  3. Include in manual the Shop Drawings listed in B above. Print shop drawings on folded pages in accordance with the General Requirements.
  4. As-Built Drawings in CD format; refer to General Requirements 01331.
  5. Maintenance training certificates.
- G. Manufacturer's factory-authorized service representatives' inspectors reports.

## **1.05 DELIVERY, STORAGE, AND HANDLING**

- A. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.
- B. Temporary Bracing: Where necessary, brace each unit for hoisting, lowering and sliding into position. Temporary bracing of the equipment labeled as follows: TEMPORARY – REMOVE BEFORE OPERATION.
- C. Protection against Concealed Damage: Include within shipping container; mechanical impact recorder of rating recommended by the manufacturer for shipment by railroad and submit in accordance with the General Requirements impact chart with manufacturer's recommendations for disposition of damaged materials.
- D. Store equipment in secure and dry storage facility

## **PART 2 – PRODUCTS**

### **2.01 PASSENGER INFORMATION DISPLAYS (PIDS)**

- A. New Products: GDS Model No. G4600106
- B. VMS General Description: Four-line, tri-color (Red, Green, Blue) Display, with full text, and graphics capability, outdoor enclosure.
- C. Equipment: Modular type, using solid-state components, fully rated for continuous duty, unless otherwise indicated.
- D. Waterproof Equipment: Listed and labeled for duty outdoors or in damp locations.
- E. VMS Finishes:
  - 1. Paint Finish: VMS painted Metro Benjamin Moore, Stonington Gray, #Hc-170, as required.
  - 2. Metallic Finish: All metallic housing components and fasteners shall be corrosion resistant.
- F. LCD Display Specifications
  - 1. Product: GDS Model No. G4600106
  - 2. Display Colors: 16.7 Million Colors (Maximum)
  - 3. Viewing Angle: 176° (H) 178° (V) with CR ≥ 10
  - 4. Active Display Area: 46"
  - 5. Resolution: 1920 x 1080
  - 6. Pixel Pitch:
  - 7. Contrast Ratio: 4000:1
  - 8. Brightness: 1500 cd/m<sup>2</sup>
  - 9. Backlight: LED
  - 10. Video: VGA, DVI-D, HDMI
  - 11. Power Consumption: 300W
  - 12. Electrical: 85 to 264 VAC, 47-63 Hz

13. Luminance (nits typ): 850 nits
  14. Operating Temperature:
    - a. Maximum: +50°C (+122°F)
    - b. Minimum: -30°C (-22°F)
  15. Life Expectancy: 87,600 hours
  16. Lines of text (Maximum): 4
  17. Character Height: 3.3 inches
  18. Characters per line:
    - a. 20-24 single high characters
    - b. 17 double high characters
  19. Enclosure Dimensions: 27.83"H X 46.85" W X 8.66"D (Single-sided)
  20. Weight: 110lbs
- G. VMS Housing: Case material shall be Aluminum.
- H. VMS Service Access: Each PIDS shall be mounted far enough from the platform edge so as not to foul train movement when being serviced. All internal electronics and components shall be accessible through bottom.
- I. Each enclosure shall be equipped with a keyed power switch that is capable of rebooting power to the backplate(s). The switch shall be made accessible through the bottom of the enclosure.
- J. Each VMS shall have an electrical disconnect provided within line of sight of sign to allow isolation of each ungrounded conductor in accordance with National Electrical Code.
- K. Display Capability: Programmable alphanumeric and graphic.
- L. Clock: Built-in time and day
- M. Message Storage: Greater than 100 50-character messages
- N. Message Storage: VMS Standard Font Heights:
  1. Note that the ADA standard is a minimum of 3" for any sign mounted over 80-inch high. All transit information displayed shall be a minimum of 3 inches.
- O. VMS Fonts: Narrow, Bold, Wide, ADA compliant aspect ratios. VMS Background: Matte black.
- P. Conformal Coating: Circuit boards conformal coated to MIL-I-46058C.
- Q. Addressability: Individual two-byte address allows 255 displays with zone assignment allowed.
- R. VMS Temperature Monitoring and Cooling Temperature sensor will read internal temperature and report the temperature to the server when polled. Over temp thermostat will disable power to the sign should the temperature go past a pre-set limit of about 140 degrees F. When power is cut off, the sign will appear to the server as being disabled since all communications will be severed with power loss to the display.
- S. Integrated 10/100 BaseT TCP/IP Ethernet Communications support.

- T. PIDS Plug-In Accessories Power Requirements: Emergency power, 120 V, 1 KVA in the communications room.
- U. Platform VMS Electrical Power Service Requirement: A 1-pole, 120 V, 20 A circuit shall be provided from the Communications Room and terminated in a NEMA 4X rated disconnect (safety) switch near where the VMS will be located. The disconnect (safety) switch shall provide input power to the platform VMS.
- V. Mezzanine VMS Electrical Power Service Requirement: A 120 V, 20 A circuit shall be provided from the nearest Emergency Panel to where the mezzanine VMS is located.
- W. Performance Requirements: VMS shall be capable of the following functions:
  1. VMS Message Storage - Each VMS shall have the ability to store a minimum of one hundred 50-character messages. The user shall be able to retrieve any stored message for display from local VMS storage using the VMS Server control software. The VMS shall have the capability of displaying and broadcasting emergency messages.
  2. Fonts - An extensive font set shall be included with the VMS. All VMS fonts shall meet ADA requirements for signage. ADA Section 4.30.2 and 4.30.3 describe requirements for width-to-height ratio, stroke width-to-height ratio, and character height. Fonts shall include a robust character set containing all characters required to express messages in standard Spanish and English languages. The character sets include upper case, lower case, numerical digits, non-alphabetic and non-numeric special characters
  3. VMS Self Diagnostics - Each display may be polled by the server to retrieve the status of each sign. See Appendix A at the end of this document to review the information sent to the server when the display is polled. When messages are sent to the display an 'ACK' is sent back acknowledging the received message was valid and complete. If a message was corrupted or fragmented, the display will send back a 'NAK' for message not received. This will also serve as verification to the overall health of the display. A timer can be set in the sign so that after a pre-determined period of time, if the display does not receive ANY message or command, the display will then reset itself, or go 'blank' until it receives a new message or command. VMS Environmental Design - The proposed VMS equipment shall be designed and manufactured to withstand a harsh transit environment including the effects of weather conditions on outdoor deployed equipment. Operating temperatures will be from -20 degrees Celsius to +50 degrees Celsius (-4 degrees Fahrenheit to 122 degrees Fahrenheit). All electronic components will be sealed using conformal coating. The VMS shall be designed to resist electromagnetic interference (EMI). VMS outdoor units shall be waterproof and sealed against particulate matter invasion such as steel and other metallic particulate matter typically found in a transit environment. The hardware will be modular and designed for ease of service.

## **2.02 KIOSK INFORMATION DISPLAY SYSTEM (KIDS)**

- A. New Products: Ciil Model No. CL-47PLC68
- B. VMS General Description: Four-line, tri-color (Red, Green, Blue) Display, with full text, and graphics capability.
- C. Equipment: Modular type, using solid-state components, fully rated for continuous duty, unless otherwise indicated.
- D. Waterproof Equipment: Listed and labeled for duty outdoors or in damp locations.
- E. VMS Finishes:
  1. Paint Finish: VMS painted Metro Benjamin Moore, Stonington Gray, #Hc-170, as required.
  2. Metallic Finish: All metallic housing components and fasteners shall be corrosion resistant.

F. LCD Display Specifications

1. Product: Ciil Model No. CL-47PLC68
2. Display Colors: 16.7 Million Colors (Maximum)
3. Viewing Angle: 178° vertical/horizontal
4. Active Display Area: 47"
5. Resolution: 1920 x 1080
6. Contrast Ratio: 1000:1
7. Aspect Ratio: 16:9
8. Brightness: 700 cd/m<sup>2</sup>
9. Backlight: LED
10. Video: VGA, DVI-D, HDMI, S-Video, RCA
11. Power Consumption: 235W
12. Safety: UL/FCC Class B
13. Operating Temperature:
  - a. Maximum: +60°C (+140°F)
  - b. Minimum: -40°C (-40°F)
14. Life Expectancy: 87,600 hours
15. Lines of text (Maximum): 4
16. Character Height: 3.3 inches
17. Characters per line:
  - a. 20-24 single high characters
  - b. 17 double high characters
18. Weight: 110lbs

G. Display Capability: Programmable alphanumeric and graphic.

H. Clock: Built-in time and day

I. Message Storage: Greater than 100 50-character messages

J. Message Storage: VMS Standard Font Heights:

1. Note that the ADA standard is a minimum of 3" for any sign mounted over 80-inch high. All transit information displayed shall be a minimum of 3 inches.

K. VMS Fonts: Narrow, Bold, Wide, ADA compliant aspect ratios. VMS Background: Matte black.

L. Conformal Coating: Circuit boards conformal coated to MIL-I-46058C.

M. Addressability: Individual two-byte address allows 255 displays with zone assignment allowed.

- N. Integrated 10/100 BaseT TCP/IP Ethernet Communications support.
- O. KIDS Plug-In Accessories Power Requirements: Emergency power, 120 V, 1 KVA in the Kiosk.
- P. Kiosk Electrical Power Service Requirement: A 120 V, 20 A circuit shall be provided from the Kiosk or nearest Emergency Panel.
- Q. Performance Requirements: VMS shall be capable of the following functions:
  1. VMS Message Storage - Each VMS shall have the ability to store a minimum of one hundred 50-character messages. The user shall be able to retrieve any stored message for display from local VMS storage using the VMS Server control software. The VMS shall have the capability of displaying and broadcasting emergency messages.
  2. Fonts - An extensive font set shall be included with the VMS. All VMS fonts shall meet ADA requirements for signage. ADA Section 4.30.2 and 4.30.3 describe requirements for width-to-height ratio, stroke width-to-height ratio, and character height. Fonts shall include a robust character set containing all characters required to express messages in standard Spanish and English languages. The character sets include upper case, lower case, numerical digits, non-alphabetic and non-numeric special characters

VMS Self Diagnostics - Each display may be polled by the server to retrieve the status of each sign. See Appendix A at the end of this document to review the information sent to the server when the display is polled. When messages are sent to the display an 'ACK' is sent back acknowledging the received message was valid and complete. If a message was corrupted or fragmented, the display will send back a 'NAK' for message not received. This will also serve as verification to the overall health of the display. A timer can be set in the sign so that after a pre-determined period of time, if the display does not receive ANY message or command, the display will then reset itself, or go 'blank' until it receives a new message or command. VMS Environmental Design - The proposed VMS equipment shall be designed and manufactured to withstand a harsh transit environment including the effects of weather conditions on outdoor deployed equipment. Operating temperatures will be from -20 degrees Celsius to +50 degrees Celsius (-4 degrees Fahrenheit to 122 degrees Fahrenheit). All electronic components will be sealed using conformal coating. The VMS shall be designed to resist electromagnetic interference (EMI). VMS outdoor units shall be waterproof and sealed against particulate matter invasion such as steel and other metallic particulate matter typically found in a transit environment. The hardware will be modular and designed for ease of service.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. Installer Qualifications: An experienced installer who is an authorized representative of equipment manufacturer for both installation and maintenance of equipment required for this section.
- B. The Contractor is to run the communications wiring and conduit in accordance with the WMATA Design Criteria.
- C. Install transmission media where applicable without damaging conductors, shield, or jacket. Do not bend cable, in handling or installation, to smaller radii than minimum recommended by manufacturer.
- D. Identify cables according to Section 16120.
- E. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide the maximum possible headroom. ADA requires a minimum mounting height of 80"; if less, barriers must be provided.
- F. Equipment: Install to facilitate service, maintenance, and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other locations.

- G. Install equipment level and plumb and according to manufacturer's written instructions.
- H. Arrange equipment to provide adequate spacing for access and for circulation of cooling air.

### **3.02 FIELD QUALITY CONTROL**

#### **A. Field Testing and Inspection:**

##### **1. General:**

- a. Conduct field inspection and field testing at each station to ensure proper operation of PIDS equipment and devices provided.
- b. Operation and protective-device setting: the Contractor is responsible for setting and calibration of protective devices for proper operation during field testing.

##### **2. Field Inspection:**

- a. Prior to field testing, check equipment installation in accordance with manufacturer's recommendations.

##### **3. Field Testing:**

- a. Furnish equipment to perform test.
- b. Provide services of manufacturer's engineering representative and supporting field crew for a period not less than three man-days. Conduct tests in the presence of the Engineer. Perform tests in accordance with approved test procedure.

##### **4. All conductors (power and communication) shall be meggered and continuity tested.**

##### **5. Certify compliance with test parameters.**

##### **6. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.**

#### **B. Demonstration: Engage a factory-authorized service representative to train Owner's operations and maintenance personnel to adjust, operate, and maintain systems.**

- 1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
- 2. Train designated personnel in management and messaging operations.
- 3. Review data in maintenance manuals.
- 4. Schedule training with Owner, through Authority's Training Office.

#### **C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installations, including connections. Report results in writing.**

#### **D. Field-Testing Personnel:**

- 1. When more than one representative is involved, the Contractor shall ensure proper coordination.
- 2. Provide engineering, technicians and journeymen personnel as necessary to set-up and implement testing.

E. Authority Tests:

1. The Authority reserves the right to require the Contractor to conduct acceptance tests on each VMS at each passenger station within one-year after installation.
  2. In order to perform VMS tests, the Contractor may re-create test conditions of applicable standards to the extent possible without disturbing existing structure or installed equipment or materials.
- F. Submit certified test reports.

**END OF SECTION**

## SECTION 16731

### COMMUNICATIONS - FIRE AND INTRUSION ALARM SYSTEM

#### PART 1 -GENERAL

##### 1.01 SECTION DESCRIPTION AND BASIC REQUIREMENTS

- A. The purpose of the Fire and Intrusion Alarm (FIA) System is to provide alarm warnings to assist Washington Metropolitan Area Transit Authority (WMATA) employees in protecting the public, employees, and property. Fire Detectors and Intrusion Detectors are located in passenger stations and associated ancillary buildings. The FIA System is monitored at each passenger station by the station manager. Fire and Intrusion Alarms report to monitoring equipment located in the WMATA Rail Operations Control Center (OCC) via the Data Transmission System (DTS). The Fire and Intrusion Alarm System described herein includes, but is not limited to, the following components:]
1. Common Control Unit.
  2. Kiosk FIA Liquid Crystal Display (LCD) Annunciator Panel
  3. Fire Detection System.
  4. Intrusion Detection System.
- B. The Common Control Unit located in the station Communications Equipment Room contains all the logic and circuitry required to supervise and control the Fire and Intrusion Detectors. Fire Detectors and Intrusion Detectors are grouped into zones. Fire Zones and Intrusion Zones are independent of each other. Fire Zones and Intrusion Zones are connected to the Common Control Unit. The Common Control Unit contains trouble circuitry powered from a dedicated power source that electrically supervises all zone circuit wiring for a "Short" or an "Open." The Common Control Unit performs the following functions:
1. Provides Alarm detection of each zone.
  2. Provides Trouble detection of each zone
  3. Provides audible and visual "Trouble" and "Alarm" indications at the kiosk FIA LCD Annunciator Panel.
  4. Provides common system controls to the kiosk FIA LCD Annunciator Panel.
  5. Provides contact closures to the Data Transmission System (DTS) to indicate "Alarm" conditions.
  6. Provide contact closures to indicate "Trouble" conditions.
  7. Provide special interfacing between the FIA System and the following systems and equipment:
    - a. Automatic Fare Collection (AFC) System.
    - b. Automatic Public Address Announcement System (APAAS).
    - c. Escalators and elevators.
    - d. Fan shut-down controls to selected rooms/areas within the passenger station.
    - e. Audible/visual fire alarms.
  8. Provides electrical power for the Fire and Intrusion Zone circuits.
- C. The Common Control Unit is modular in construction to provide for ease of maintenance and expansion. The following types of modules are used in a typical passenger station FIA System:
1. Zone Modules - Contain circuitry to recognize and accept alarms, and to provide supervision of detector circuits. Zone Module outputs shall be sent to the Control Module(s) or used directly.

2. Control Modules - Contain the circuitry and logic to generate all necessary interface signals, accept and generate kiosk FIA LCD Annunciator signals, and send Zone Module outputs to their proper destinations.
  3. Power Supply Modules - Provide primary and backup power, and supervision for the Fire and Intrusion Alarm System.
- D. The Common Control Unit shall be designed to operate with "smart sensors" (sensors which transmit a digital data message to the Common Control Unit when triggered).
- E. A kiosk FIA LCD Annunciator Panel shall be located in each passenger station kiosk, and shall contain a multi-line LCD display capable of displaying text messages. The FIA annunciator panel must be mountable "horizontally" in the standard 5" x 19" space provided in the kiosk cabinetry. The LCD Annunciator Panel shall provide the following features:
1. Alarm, Supervisory, and Trouble conditions shall be indicated on the multi-line display and by a tone-alert.
  2. Each reported condition shall allow a push-button to silence the tone-alert, but retain the display text until the reported condition is returned to normal.
  3. System display shall indicate alarm status, identification of "smart" alarm, type of alarm, number of alarms, supervisory conditions, and system troubles.
- F. Fire Detectors are located in the passenger stations, in ancillary buildings located within the passenger station limits, and in ancillary buildings located along the right-of-way. Limited use of Ionization Detectors are permitted in the arrangement. All Fire Detectors shall contain "smart" circuitry that transmits a programmable data message to the Common Control Unit when alarmed. All fire detector Zone Alarms and Trouble Indications report directly to the Common Control Unit, which displays the alarms on the kiosk FIA LCD Annunciator Panel. The Fire Detection System provides controls to and/or interfaces with the following systems and equipment:
1. Ventilation Fans.
  2. Wet Fire Suppression System.
  3. Fare Gates.
  4. Elevators and Escalators.
  5. Manual Pull Stations.
  6. Data Transmission System (DTS).
  7. Automatic Public Address Announcement System (APAAS).
  8. Automatic Fare Collection (AFC).
- G. Combination Detectors (Rate-of-Rise and Fixed Temperature) shall be used to monitor room and area ambient temperature and temperature change to include elevator hoistways. Fixed Temperature Detectors shall be used to monitor room and area temperature. Combustion Product (Ionization) Detectors shall be used to detect the presence of smoke. Duct Detectors shall be used to detect the presence of smoke in ventilation duct work. Both Combination Detectors and Fixed Temperature Detectors shall be used in AC Switchboard Rooms.
- H. The Fire Detection System shall provide for ventilation fan shutdown when triggered by a Fire Alarm. Selected ventilation fans within the passenger station are remotely controlled by the Common Control Unit. Upon receipt of a Fire Alarm associated with an area being serviced by a ventilation fan, the Common Control Unit shall provide an "open" in the control circuit to a relay located in the Fire Alarm/Fan Interface Box (FA/FIB) of that particular area, thereby disabling the fan. Solid-state control relays are provided for each fan motor control circuit in the FA/FIB. A separate control relay circuit is provided from the Common Control Unit to each solid-state control relay in the FA/FIB.

- I. There are two basic configurations employed for local fan shutdown; One for control by Combination Detectors and one for control by Ionization Detectors:
  - 1. Combination Detectors - When the detector triggers an alarm, its ancillary contacts close. The contacts are wired to the associated normally de-energized control relay(s) in the FA/FIB. The contact closure from the detector(s) energizes the control relay(s), thereby opening the fan motor control circuit(s).
  - 2. Ionization Detectors - When the detector triggers an alarm, its ancillary contacts open. The contacts are wired to the associated normally-energized control relay(s) in the FA/FIB. The "open" contacts from the detector(s) de-energize the control relay(s), thereby opening the fan motor control circuits.
  
- J. The Wet Fire Suppression (Sprinkler) System is monitored by the Common Control Unit and displayed on the kiosk FIA LCD Annunciator Panel. Tamper switches detect any movement of the fire main manual shut-off valves and provide a "Trouble" condition in the Fire Zone associated with that Sprinkler System. Upon activation of the sprinkler system, a flow valve detector provides a contact closure, thereby creating an "Alarm" condition in the Fire Zone associated with that sprinkler system.
  
- K. A Fire Alarm associated with a passenger station room or an ancillary building within the passenger station limits (except Tie Breaker Stations and Traction Power Substations) shall cause an output from the Common Control Unit to open the Fare Gates. After a preset period of time, the Common Control Unit shall stop the entering escalators in the passenger station. Alarms from remote ancillary buildings along the right-of-way shall not affect the fare collection equipment or escalators in the passenger station.
  
- L. Upon detection of smoke within an Elevator Machine Room, all elevators associated with the Elevator Machine Room shall immediately return to a designated level. The elevator(s) shall remain at this designated level and elevator cab controls (except for emergency controls) are rendered inoperative as long as smoke is detected within the associated Elevator Machine Room.
  
- M. Manual Pull Stations with local audible/ visual alarms (typically a horn/strobe-light) shall be located in hallways connecting passenger station service rooms to the public areas. Activation of a Manual Pull Station shall cause a Fire Alarm in the Fire Zone associated with the hallway and energize the local audible/visual alarm. The audible/visual alarm is energized only by activation of a Manual Pull Station.
  
- N. A contact closure in the Common Control Unit shall provide a single alarm output (contact closure) to the DTS for the following Fire Alarms:
  - 1. Each Ancillary Structure.
  - 2. A Station Fire Alarm.
  - 3. Each Tie Breaker Station.
  - 4. Each Traction Power Substation.
  - 5. Each Elevator Machine Room.
  
- O. The Fire and Intrusion Alarm System/Automatic Public Address Announcement System (FIA/APAAS) interface shall be accomplished as follows:
  - 1. Upon detection of a Fire Alarm within the passenger station limits (except Tie Breaker Stations and Traction Power Substations), the Automatic Public Address Announcement System shall be activated after a predetermined time delay during which a "Reset" circuit shall attempt (3 times) to reset. . A "Reset" circuit shall be provided that will permit the Automatic Public Address Announcement System to reset the FIA Common Control Unit. Alarms from remote ancillary buildings along

the right-of-way shall not activate the Automatic Public Address Announcement System.

- P. Fire Zones are assigned in accordance with the following criteria:
1. No Fire Zone shall contain more than 10,000 square feet. The 10,000 square feet zone shall be contiguous.
  2. No Fire Zone shall contain more than four rooms plus a connecting passageway.
  3. No Fire Zone shall contain more than ten Ionization Detectors.
  4. A separate Fire Zone shall be assigned to each remote ancillary building along the main line, unless otherwise specified.
  5. The maximum distance between any two points of a Fire Zone shall not exceed 300 feet.
  6. Each Tie Breaker Station shall be assigned a separate Fire Zone.
  7. Each Traction Power Substation shall be assigned a separate Fire Zone.
  8. Each Elevator Machine Room shall be assigned a separate Fire Zone.
- Q. Intrusion Detectors shall be located in the passenger station rooms and equipment areas, ancillary buildings within the passenger station limits and ancillary buildings or outside areas located along the right-of-way that are accessible to the public. All Intrusion Detectors shall contain "smart" circuitry that transmits a programmable data message to the Common Control Unit when alarmed. Intrusion Detectors shall provide alarms upon unauthorized entry for each of the following conditions:
1. A broken or opened window connected to a public or outside area.
  2. A broken or opened air duct cover, louver or grating connected to a public or outside area, if the shortest side is greater than six inches.
  3. A protected door when opened.
- R. The following types of Intrusion Detectors are used:
1. Trip Wire - Provided across louver openings. When the wire is broken or disturbed, a relay associated with the wire shall place +24 Vdc on the "Alarm" lead.
  2. Magnetic Switch - Used on grates and doors to detect when they are opened. Each magnetic switch shall be weather tight or installed in a weather tight enclosure.
- S. Doors leading from an outside or public area into a protected zone, including roll-up doors, are furnished with additional features. At these locations, a key-operated access control switch, a non-locking pushbutton switch, and a magnetic switch are provided. Roll-up doors are equipped with only a key-operated access control switch and a magnetic switch.
- T. The Fare Collection System, furnished, installed and wired to the Kiosk by others, will be equipped with Intrusion Detectors. These Intrusion Detectors shall be combined so that there is one Fare Collection Intrusion Zone for the Kiosk. The Contractor shall interface the Intrusion Detection System with the Fare Collection Intrusion Detector circuit at the Kiosk.
- U. Intrusion Detectors will be provided by others in entrance elevators. One Intrusion Zone shall be allocated for each entrance elevator. The Contractor shall interface with the Intrusion Detectors via the junction box provided by others in the Elevator Machine Room(s).
- V. A contact closure in the Common Control Unit provides a single alarm output (contact closure) to the DTS for the following intrusion alarms
1. Automatic Fare Collection Equipment and Revenue Cart Storage Areas.
  2. Each Ancillary Structure.
  3. A Station Intrusion Alarm.
  4. Each Tie Breaker Station.

5. Each Traction Power Substation.
- W. The "tamper proof" intrusion detectors to be furnished are arranged so that a single alarm indication is given for each zone encompassing a number of rooms directly accessible to each other and, as a group, accessible from a public or outside area. A single alarm is given for a single room only if it is directly accessible from a public or outside area and is not directly connected to other rooms. Although the Intrusion Zones need not match the coverage of the Fire Protection Zones in detail (due to criteria differences), the general areas of coverage are matched where practical. The number of Intrusion Zones for each FIA System varies with the passenger station configuration and number of ancillary buildings. Intrusion Zones are assigned in accordance with the following criteria:
1. A separate zone to be assigned to each street-level entrance elevator doors.
  2. A separate zone to be assigned to the fare collection equipment for each station.
  3. A separate zone to be assigned for protected doors to areas containing multiple rooms.
  4. A separate zone to be assigned to each remote ancillary building along the right-of-way.
  5. A separate zone to be assigned for each Tie Breaker Station.
  6. A separate zone to be assigned for each Traction Power Substation.
  7. No zone may contain more than 10,000 square feet. Zone areas are contiguous.
- X. The Fire and Intrusion Alarm (FIA) System is to provide an immediate alarm indication on the kiosk FIA LCD Annunciator Panel upon the activation of any Fire and/or Intrusion Detector, flow valves and tamper switches.
- Y. The audible alarm signal and an LED are activated upon receipt of a Detector Alarm. Depressing the "Alarm Acknowledge" pushbutton shall silence the audible signal. The LED light shall extinguish after the Fire Detector initiating the alarm has been attended, repaired or replaced, or the Intrusion Detector initiating the alarm has been returned to its original state. Depressing the "Alarm Acknowledge" pushbutton in response to an alarm in any zone shall not inhibit the audible alarm signal from being activated upon receipt of a detector alarm in subsequent zones.
- Z. A Manual Fire Alarm Pushbutton and the Manual Intrusion Alarm Pushbutton shall be installed in the Kiosk to provide the Station Manager with the means to manually activate either a Fire Alarm or an Intrusion Alarm in the FIA zones associated with the Kiosk.
- AA. A wiring fault (trouble condition) affecting circuit operation shall cause an audible and visual trouble indication at the Kiosk FIA LCD Annunciator Panel and shall cause a "Trouble" signal (contact closure) to be activated. A trouble condition shall not activate FIA System zone alarms. Additionally, the FIA System shall provide some alarm information (specified herein) to the Rail Operations Control Center (OCC) via the existing Data Transmission System (DTS). The operation of a pushbutton to acknowledge a trouble alarm shall silence the audible trouble signal, but the associated LED indicator shall remain on until the fault is corrected. Correcting the fault shall extinguish the associated LED.
- BB. Activation of a Manual Pull Station to be installed in a passenger station equipment room hallway shall cause an audible and visual indication at the Kiosk FIA LCD Annunciator Panel and shall also energize an audible/visual alarm to be installed in the hallway. The audible and visual indications on the Kiosk FIA LCD Annunciator Panel shall be similar to any other detected Fire Alarm.
- CC. Doors leading from a non-protected zone, within a station, to a protected zone shall operate as follows:

1. The magnetic switch shall detect the door opening.
  2. An authorized key-operated access control switch shall have two positions: "Secure" and "Access." Opening the door from an unprotected area with the switch in the "Secure" position shall cause an alarm. When the door is opened with the switch in the "Access" position, no alarm shall be given.
- DD. The key, which operates the key-operated switch, shall be removable after the door has been opened, but not with the switch remaining in the "Access" position. Removal of the key with the door open shall not cause an alarm nor shall any device have to be operated to prevent an alarm. The keys for all access control switches shall be master keys, which shall work in all existing Authority access control switches. When the authorized access control key switch is within the view of the general public, it shall be mounted and installed with all connecting conduit and wiring entering from the back concealed from view.
- EE. The non-locking pushbutton shall be located on the protected area side of the door and shall serve the same function from that side as the "Access" position of the access control switch. Releasing the pushbutton once the door is open shall not cause an alarm nor shall any device have to be operated to prevent an alarm. Closing of the door with the key-operated switch in the "Secure" position and the pushbutton not depressed shall automatically re-arm the alarm. Releasing the pushbutton when the door is closed and the key-operated switch is in the "Secure" position shall automatically re-arm the alarm. Securing the key-operated switch when the door is closed and the pushbutton is not depressed shall automatically re-arm the alarm.

#### **1.02 SECTION INCLUDES**

- A. Fire and Intrusion Alarm common control panel.
- B. Manual fire alarm stations.
- C. Smoke and heat detectors.
- D. Signaling devices.
- E. Kiosk Fire and Intrusion Alarm LCD Annunciator panel.

#### **1.03 RELATED SECTIONS**

- A. Section 08331 - Overhead Coiling Doors.
- B. Section 08710 - Finish Hardware.
- C. Section 13905 - Fire Protection, Suppression and Alarm.
- D. Section 14200 - Hydraulic Elevators.
- E. Section 14240 - Traction Elevators..
- F. Section 14300 - Heavy-Duty Escalator.
- G. Section 16120 - Wire, Cable and Busways.
- H. Section 16705 - Communications Standard Specifications - Equipment & Material.

- I. Section 16706 - Communications System Submittals & Services.
- J. Section 16707 - Communications Systems Quality Assurance & Testing.
- K. Section 16710 - Communications Grounding.
- L. Section 16715 - Communications Electrical Power Distribution.
- M. Section 16733 - Communications - Kiosk Systems.
- N. Section 16821 - Communications - Automatic Public Address Announcement System.
- O. Section 16925 - ATC - Data Transmission System

#### **1.04 REFERENCES**

- A. NFPA 130 - Standard for Fixed Guideway Transit Systems.
- B. UL 1076 - Proprietary Burglar Alarm Units and Systems

#### **1.05 SYSTEM DESCRIPTION**

- A. Fire and Intrusion Alarm System: A state-of-the-art “smart, addressable, software-programmable” Fire and Intrusion Alarm System shall be designed, installed, tested, and documented. The “smart addressable, software-programmable” system shall be designed to report detected events using data messages to the LCD Annunciator Panel via the Common Control Unit. Fire Detectors and Intrusion Detectors are to be installed in passenger stations and associated ancillary facilities. The FIA System shall be designed to be monitored at each passenger station by the station manager. Summary Fire and Intrusion Alarms shall also report to monitoring equipment located in the OCC via the DTS.
- B. Capacity:
  1. The Common Control Unit shall be equipped to supervise the number of alarm points needed to meet Specification coverage requirements and to allow the addition of at least 25% additional sensors without the addition of modules or other modifications.
  2. The kiosk LCD Annunciator Panel shall be equipped to allow the supervision of at least 25% additional alarm points without panel hardware modifications.
  3. The number of Fixed-Temperature Detectors shall be determined by the contractor using the coverage requirements detailed in this specification.
  4. The number of Combination Rate-of-Rise and Fixed-Temperature Detectors (Single-Pole) shall be determined by the contractor using the coverage requirements detailed in this specification.
  5. The number of Combination Rate-of-Rise and Fixed-Temperature Detectors (Double-Pole) shall be determined by the contractor using the coverage requirements detailed in this specification.
  6. The number of Ionization Detectors shall be determined by the contractor using the coverage requirements detailed in this specification.
  7. The number of Photoelectric Detectors shall be determined by the contractor using the coverage requirements detailed in this specification.
  8. The number of Duct Detectors shall be determined by the contractor using the coverage requirements detailed in this specification.

9. The number of Manual Pull Stations shall be determined by the contractor using the coverage requirements detailed in this specification.
10. The number of Audible/Visible Notification Appliances shall be determined by the contractor using the coverage requirements detailed in this specification.
11. The number of Fan Relays (Normally-closed Contracts) shall be determined by the contractor using the coverage requirements detailed in this specification.
12. The number of Magnetic Switches shall be determined by the contractor using the coverage requirements detailed in this specification.
13. The number of Limit Switches shall be determined by the contractor using the coverage requirements detailed in this specification.
14. The number of Pushbutton Switches shall be determined by the contractor using the coverage requirements detailed in this specification.
15. The number of Keyswitches (Access Control) shall be determined by the contractor using the coverage requirements detailed in this specification.
16. The FIA Distribution Frame shall be sized by the contractor using the coverage requirements detailed in this specification.
17. The number of Ancillary facility Protector/Terminal Enclosures shall be determined by the contractor using the coverage requirements detailed in this specification.

#### **1.06 SUBMITTALS**

- A. Submit under provisions of Section 16706.
- B. Shop Drawings: Provide LCD Annunciator layout and system wiring diagram showing each device and wiring connection required.
- C. Product Data: Provide electrical characteristics and connection requirements.
- D. Test Reports: Indicate satisfactory completion of required tests and inspections.
- E. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of products.

#### **1.07 QUALIFICATIONS**

- A. Manufacturer: Company specializing in manufacturing the products specified in this section with minimum three years documented experience, and with service facilities within 100 miles of Project.
- B. Installer: Company specializing in installing the products specified in this section with minimum three years documented experience, and certified as fire alarm installer in the State, or District of Columbia, where the equipment is being installed.

#### **1.08 REGULATORY REQUIREMENTS**

- A. Conform to requirements of NFPA 130
- B. Furnish products listed and classified by UL as suitable for purpose specified and indicated.

#### **1.09 MAINTENANCE SERVICE**

- A. Furnish service and maintenance of fire alarm system until Final Completion.

## **1.10 EXTRA MATERIALS**

- A. Provide a spare manual station break-glass rod for each manual station being installed.
- B. Provide a spare key of each lock being installed.
- C. Provide one, or 20% (whichever is greater), additional (spare) detectors of each type of automatic smoke detector [without base].

## **PART 2 - PRODUCTS**

### **2.01 FIRE AND INTRUSION ALARM COMMON CONTROL PANEL**

- A. Manufacturer
  - 1. Simplex Model 4100(or approved equal).
- B. Control Panel: Modular construction with surface wall-mounted enclosure.
- C. Zone Capacity: 128 Zones minimum.
- D. Power supply: Adequate to serve control panel modules, remote detectors, remote LCD Annunciators, relays, and alarm signaling devices. Include battery-operated emergency power supply with capacity for operating system in standby mode for 12 hours followed by alarm mode for 10 minutes.
- E. System Supervision: Component or power supply failure places system in trouble mode.
- F. Initiating Device Circuits: Supervised zone module with alarm and trouble indication; occurrence of single ground or open condition places circuit in trouble mode but does not disable that circuit from initiating an alarm.
- G. Indicating Appliance Circuits: Supervised signal module, sufficient for signal devices connected to system; occurrence of single ground or open condition places circuit in trouble mode but does not disable that circuit from signaling an alarm.

### **2.02 INITIATING DEVICES**

- A. Manufacturer
  - 1. Simplex (or approved equal).
- B. Manual Station: Surface mounted, non-coded type, dual action manual station. Provide manufacturer's standard backbox.
- C. Spot Heat Detector: Fixed temperature, 135 degrees F (57 degrees C).
- D. Spot Heat Detector: Combination rate-of-rise and fixed temperature, rated 135 degrees F (57 degrees C), and temperature rate of rise of 15 degrees F (8.3 degrees C).
- E. Spot Heat Detector: Combination rate-of-rise and fixed temperature, rated 135 degrees F (57 degrees C), and temperature rate of rise of 15 degrees F (8.3 degrees C) with ancillary normally-open contact which closes when the detector is triggered (used to control ventilation fans).

- F. Ceiling Mounted Smoke Detector: NFPA 72E, ionization type with adjustable sensitivity, plug-in base. Provide two-wire detector with common power supply and signal circuits.
- G. Ceiling Mounted Smoke Detector: NFPA 72E, ionization type with adjustable sensitivity, plug-in base. Provide four-wire detector with separate power supply and signal circuits.
- H. Ceiling Mounted Smoke Detector: NFPA 72E, photoelectric type with adjustable sensitivity, plug-in base. Provide two-wire detector with common power supply and signal circuits.
- I. Duct Mounted Smoke Detector: NFPA 72E photoelectric type with auxiliary SPDT relay contact.

### **2.03 SIGNALING APPLIANCES**

- A. Manufacturer
  - 1. Simplex (or approved equal).
- B. Alarm Horn: NFPA 72G, surface type fire alarm horn. Sound Rating: 87 dB at 10 feet (3M). Provide integral strobe lamp and flasher .
- C. Kiosk LCD Annunciator Panel: Provide remote LCD Annunciator including audible and visual indication of fire and intrusion alarm by zone, and audible and visual indication of system trouble. Install in kiosk cabinet in designated space. The annunciator panel shall be one that is designed to operate exclusively with the Common Control Unit.

### **2.04 SOLID-STATE FAN RELAYS (NORMALLY-OPEN CONTACTS)**

- A. Manufacturer
  - 1. Teledyne Part No. SSR1200480D25 (or approved equal).
- B. Contact Configuration: Normally open.
- C. Output current rating: 25-amps.

### **2.05 FAN RELAYS (NORMALLY-CLOSED CONTACTS)**

- A. Manufacturer
  - 1. Teledyne Part No. S2840B5SSR (or approved equal).
- B. Contact Configuration: Normally closed.
- C. Output current rating: 25-amps.

### **2.06 WINDOW FOIL AND VARNISH**

- A. Window Foil Manufacturer
  - 1. Ademco Part No. RR-1000 (or approved equal).
- B. Varnish Manufacturer
  - 1. Ademco Part No. AB-177 (or approved equal).

### **2.07 TRIP WIRE**

- A. Manufacturer

1. Ademco Part No. CL-171000608 (or approved equal)
2. Ratings:
3. Gauge: 22AWG.
4. Insulation: 300 Volts.

**2.08 WINDOW FOIL/TRIP WIRE RELAY**

- A. Manufacturer
1. Stancore RBM Part No. 84D903 (or approved equal).

**2.09 MAGNETIC SWITCH**

- A. Manufacturer
1. Ademco Part No. 40-2SP (or approved equal).

**2.10 WEATHER-TIGHT ENCLOSURE**

- A. Manufacturer
1. Ademco Part No. 42 (or approved equal).

**2.11 LIMIT SWITCH**

- A. Manufacturer
1. Cutler-Hammer Part No. 10316H187 (or approved equal).

**2.12 PUSHBUTTON SWITCH (ACCESS CONTROL)**

- A. Manufacturer
1. Cutler-Hammer Part No. 10250T23B (or approved equal).

**2.13 KEYSWITCH (ACCESS CONTROL)**

- A. Manufacturer
1. Chicago Lock Co. Part No. 3039 (or approved equal).
  2. Keyed to WMATA Key Switch currently in operation: Key No. AMP- 585

**2.14 FIA DISTRIBUTION FRAME**

- A. Manufacturer
1. Reltec cabinet model Series BEPNP (or approved equal).

**2.15 TERMINALS**

- A. Manufacturer
1. Weidmuller, Model No. SAKR (or approved equal).
- B. Disconnect feature: Knife switch design, remains attached to terminal block body.
- C. Complete with test sockets, labeling, and all required terminal block mounting hardware and accessories.

**2.16 ANCILLARY FACILITY PROTECTOR/TERMINAL ENCLOSURES**

- A. Manufacturer
1. Hoffman Model CHNF (or approved equal).

- B. NEMA 4 complete with required terminals and protector blocks.

## **2.17 INTRA-BUILDING CONDUIT WIRING**

- A. Manufacturer
  - 1. Remece, Part No. 760186 (or approved equal).
- B. Number of conductors shall be determined by the Contractor based on interface requirement.
- C. Ratings:
  - 1. Type: Plenum Fire Alarm Cable.
  - 2. Gauge: 18 AWG Solid
  - 3. Insulation (non-PVC), plenum Polymer Alloy (75°C).
  - 4. Jacket: Non-PVC, Fluoropolymer Resin - Allied Chemical's Halar® (or approved equal) or Dupont's FEP Telfon® (or approved equal).
  - 5. Conforms to UL/NEC FPLP Subject 1424, NEC Article 760, and CSA FT6.

## **PART 3 - EXECUTION**

### **3.01 TEMPORARY FIRE AND INTRUSION ALARM DETECTION SYSTEM INSTALLATION (OPTIONAL)**

- A. Install the Temporary Fire and Intrusion Alarm Detection equipment if needed to protect the buildings and equipment during construction.
- B. The need for and timing for the installation of the temporary fire and intrusion alarm equipment shall be determined by the Engineer.

### **3.02 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Install manual station with operating handle 4 feet 6 inches [1.4 M] above floor. Install audible and visual signal devices 7 feet 6 inches [2.3 M] above floor.
- C. Use 18 AWG minimum size conductors for fire alarm detection and signal circuit conductors. Install wiring in conduit.
- D. Mount end-of-line device box with last device or separate box adjacent to last device in circuit.
- E. Make conduit and wiring connections to door magnetic switches, keyswitches, and pushbutton switches.
- F. Make conduit and wiring connections to sprinkler flow switches, sprinkler valve tamper switches, duct smoke detectors and fan shutdown relays.
- G. Install conductors and appropriate zone wiring to interconnect the FIA System Common Control Unit to the intrusion circuit terminals for the Farecard Vending Machines on the Kiosk Cable Termination Rack.

- H. Provide and install the necessary wiring to interface the FIA Common Control Unit with the Fare Gate Control Panel. This interface shall cause the Fare Gates to be activated by the FIA System.
- I. Provide and install all necessary cables, wiring, relays, additional components, connections, and cross-connections needed to interface the FIA System to the Kiosk Escalator Control Panel. This interface shall allow the FIA System to control all escalators within the passenger station(s). Any relays installed to shut down escalators (in response to a Fire Alarm) shall be installed within the station Communications Equipment Room.
- J. Install conductors and appropriate zone wiring to interconnect the FIA System Common Control Unit to the terminal block in the Entrance Elevator Machine Room(s) where the Entrance Elevator Intrusion circuit is terminated. Provide and install all required junction boxes, terminal strips and cabling from the intrusion detector in the associated Elevator Machine Room(s) to the FIA Common Control Unit.
- K. Interface the ionization detector ancillary contacts to the elevator control equipment. This interface shall cause all elevators traveling more than 25 feet to return to a designated level upon activation of the ionization detector. This action shall override the elevator cab controls. (emergency controls shall not be effected.) Install within the Elevator Machine Room conduit, wires and cables, junction boxes, terminal strips, and any other mechanical and/or electronic equipment necessary to effect the interface described herein.

### **3.03 TEMPORARY FIRE AND INTRUSION ALARM DETECTION SYSTEM REMOVAL**

- A. If a Temporary Fire and Intrusion System is installed, the Contractor shall remove the Temporary System upon commissioning of the permanent system.

### **3.04 AUTOMATIC PUBLIC ADDRESS ANNOUNCEMENT SYSTEM INTERFACE**

- A. Provide and install all necessary cables, wiring, additional components, connections, and cross-connections needed to interface the FIA System to the Automatic Public Address Announcement System (APAAS), as described in Section 16821.

### **3.05 FIELD QUALITY CONTROL**

- A. Field inspection and testing will be performed under provisions of Section [16707.]
- B. Test in accordance with NFPA 72H and local fire department requirements.

### **3.06 MANUFACTURER'S FIELD SERVICES**

- A. Prepare and start systems under provisions of Section [16707.]
- B. Include services of certified technician to supervise installation, adjustments, final connections, and system testing.

### **3.07 FIRE ALARM WIRE AND CABLE COLOR CODE**

- A. Provide fire alarm circuit conductors with insulation color coded as follows, or using colored tape at each conductor termination and in each junction box.
- B. Power Branch Circuit Conductors: Black, red, white.

- C. Initiating Device Circuit: Black, red.
- D. Detector Power Supply: Violet, brown.
- E. Signal Device Circuit: Blue (positive), white (negative).

### **3.08 ADJUSTING**

- A. Adjust operating Products and equipment to ensure smooth and unhindered operation.

### **3.09 DEMONSTRATION**

- A. Demonstrate operation and maintenance of Products to WMATA personnel two weeks prior to date of Substantial Completion.
- B. Demonstrate Project equipment by a qualified person who is knowledgeable about the Project.
- C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with WMATA personnel in detail to explain all aspects of operation and maintenance.
- D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at equipment location.
- E. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.
- F. Demonstrate system operation.
- G. Conduct walking tour of Project and briefly describe function, operation, and maintenance of each component.

### **3.10 SCHEDULES AND TABLES**

- A. The Contractor shall provide schedules and tables at each Design Review depicting how the Installation of the Fire and Intrusion Alarm systems will be integrated into the overall project schedule.

**END OF SECTION**

**SECTION 16732**  
**FIRE ALARM, DETECTION AND NOTIFICATION SYSTEM**

**PART 1 – GENERAL**

**1.01 SUMMARY**

- A. The work covered by this Section of the Specification shall include all labor, equipment, materials and services to furnish and install a complete fire alarm system.
1. Fire Alarm Control Panel.
  2. Remote Annunciator.
  3. Manual pull stations.
  4. Smoke detectors.
  5. Heat detectors.
  6. Fire Alarm System Interface Controls- Proprietary supervising station, magnetic door/card access release override, and air handling system.
  7. Notification appliances.
  8. Air handling systems shutdown control.
  9. Magnetic door holder release.
  10. Fire Suppression Supervision- Wet pipe, dry pipe, deluge valve, pre-action System, kitchen hood, clean agent and Halon system monitoring.
- B. Related Sections:
1. Section 08331 – Overhead Coiling Doors.
  2. Section 08710 – Finish Hardware.
  3. Section 13905 – Fire Protection, Suppression and Alarm.
  4. Section 14200 – Hydraulic Elevators.
  5. Section 14240 – Traction Elevators.
  6. Section 14300 – Heavy-Duty Escalator.
  7. Section 16120 – Wire, Cable and Busways.
  8. Section 16130 – Raceways, Boxes and Cabinets.
  9. Section 16705 – Communications Standard Specifications – Equipment & Material.
  10. Section 16706 – Communications Systems Submittals & Services.
  11. Section 16707 – Communications Systems Quality Assurance & Testing.
  12. Section 16710 – Communications Grounding. Section 16715 – Communications Electrical Power Distribution.
  13. Section 16733 – Communications – Kiosk Systems.

14. Section 16925 – ATC – Data Transmission System.

1.02 REFERENCES

- A. The system and all components shall be approved by insurance provider for use in fire protection systems and compliant with all insurance provider guidelines. If insurance provider approval is not available, insurance representatives must be consulted to ensure system is acceptable and components must at least be listed by Underwriters Laboratories, Inc. for use in fire protective signaling systems.
- B. The installation shall comply with:
  - 1. State and Local Building and Fire Codes.
  - 2. Americans with Disabilities Act (ADA).
  - 3. NFPA 70 – National Electrical Code.
  - 4. NFPA 72 – National Fire Alarm and Signaling Code.
  - 5. Local and State Authorities Having Jurisdiction.
  - 6. NFPA 130 - Standard for Fixed Guideway Transit and Passenger Rail Systems
  - 7. NFPA 70 - National Electrical Code
  - 8. NFPA 101 - Life Safety Code

1.03 SUBMITTALS

- A. Provide a list of all types of equipment and components provided. This shall be incorporated as part of a Table of Contents, which shall also indicate the manufacturer's part number, the description of the part, and the part number of the manufacturer's product data sheet on which the information can be found. See Division 1 for specific details about submissions.
- B. Provide a Sequence of Operation matrix. The sequence of operation shall be building specific, and shall provide individual sequences for every type of alarm, supervisory or trouble condition which may occur as part of normal or off-normal system use.
- C. Provide manufacturer's original printed product data, catalog cuts and description of any special installation procedures. Photocopied and/or illegible product data sheets shall not be acceptable. All product datasheets shall be highlighted or stamped with arrows to indicate the specific components being submitted for approval.
- D. Provide manufacturer's installation instruction manual for specified system.
- E. Provide samples of various items when requested.
- F. Provide copy of state License to perform such work.
- G. Provide copies of NICET Level IV Fire Alarm certifications for a minimum of two (2) technicians assigned to this project also responsible for Fire Alarm Control Panel (FACP) programming.
- H. Provide shop drawings as follows:
  - 1. Coversheet with project name, address and drawing index.
  - 2. General notes drawing with peripheral device back-box size information, part numbers, device mounting height information, and the names, addresses, point of contact, and telephone numbers of all contact project team members.

3. Building specific device riser diagram, which individually depicts all control panels, annunciators, addressable devices, and notification appliances. Include a specific, proposed point descriptor above each addressable device. Include a specific discrete point address that shall correspond to address depicted on the device layout floor plans. Drawing shall provide wire specifications, and wire tags shown on all conductors depicted on the riser diagram. All circuits shall have designations that shall correspond with those required on the control panel and floor plan drawings. End-of-line resistors (and values) shall be depicted.
  4. Control panel termination drawing(s). Include internal component placement and all internal and field termination points. Drawing shall provide a detail indicating where conduit penetrations shall be made, so as to avoid conflicts with internally mounted batteries. For each additional data gathering panel, a separate control panel drawing shall be provided, which clearly indicates the designation, service and location of the control enclosure. End-of-line resistors (and values) shall be depicted.
  5. Building specific device wiring diagram drawing(s) shall be provided which depict all system components, and their respective field wiring termination points. Wire type, gauge, and jacket shall also be indicated. When an addressable module is used in multiple configurations for monitoring or controlling various types of equipment, different device typical diagrams shall be provided. End-of-line resistors (and values) shall be depicted.
  6. See section 3.05 CLOSEOUT ACTIVITIES for other documents relating to this section.
- I. Battery calculations shall be provided on a per power supply/charger basis. These calculations shall clearly indicate
    1. The quantity of devices
    2. The device part numbers
    3. The supervisory current draw
    4. The alarm current draw
    5. Totals for all categories, and the calculated battery requirements (which reflect a 20% DEGRADE, for 24 hour supervisory, 5 minute alarm operation).
    6. Battery calculations shall also reflect all control panel components, remote annunciator, and auxiliary relay current draws.
  - J. Scale drawing sets shall be submitted along with the submittal book. These drawings shall be 22" x 34" and of a sufficient resolution to be completely legible when reduced to 11" x 17" size.
  - K. Written proof of proper disposal by the installing contractor shall be required prior to release of outstanding retainage.
  - L. Turnover of all software database hard/soft copies to WMATA prior to the end of the one (1) year warranty period (or period as amended earlier in this specification). This shall include all possible programming software logs, exported project files, hard copies of all device maps, the revision number of the version of programming utility used, and all required passwords. This information shall be provided to WMATA on a flash drive.

#### 1.04 QUALITY ASSURANCE

- A. Qualifications: Company specializing in installation of work in this Section with minimum of three years documented experience, approved by manufacturer.
- B. System Standards:
  1. NFPA 72.

2. CEC, Article 760.

C. Design criteria:

1. Comply with all system standards.
2. Meet all requirements of fire authorities having jurisdictions.
3. The Building Electronics contractor shall provide complete fire detection and alarm system design, wiring diagrams, interphase wiring diagrams, and operational details.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Protect equipment delivered and placed in storage from the weather, humidity and temperature variation, dirt, dust and any other contaminants.
- B. Project staging may be provided at stakeholders' convenience. A staging area is not guaranteed.

1.06 RELATED WORK

- A. The fire alarm and detection system provides controls to and/or interfaces with the following systems and equipment:
  1. Ventilation fans.
  2. Fire suppression systems.
  3. Elevators and escalators.
  4. Data Transmission Systems (DTS).
  5. Automatic Fare Collection (AFC).
  6. Automatic public address.
  7. Fire standpipe systems.
  8. Clean agent systems.
  9. Combustible gas detection.
  10. Carbon monoxide detection.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Manufacturers capable of meeting the system requirements of Part 2 of this specification.
- B. New fire alarm equipment shall be compatible with the existing WMATA fire alarm equipment. New equipment shall be able to provide two-way command and control communication between an EST Fireworks® head end and all protected premise fire alarm control panels and field devices.

2.02 EQUIPMENT

- A. Fire Alarm Control Panel (FACP)
  1. The fire alarm control panel(s) shall be an Edwards EST-3 or equivalent. System devices (notification appliances, pull stations, smoke and heat detectors, etc.) shall be compatible with one another. All components will be labeled "FM approved" for the use of fire alarm systems in this area of the United States of America.

2. Fire alarm control panel cabinet shall be 3-CAB series or equivalent. Cabinet shall be manufactured from #14 AWG cold rolled steel with a gray baked enamel finish. Operating controls shall be located behind a locked door with a viewing window.
3. Fire alarm control panel enclosures shall have engraved labels indicating, "FIRE ALARM SYSTEM", and the areas of the building served by that panel.
4. All control modules shall be labeled, and all zone locations shall be identified.
5. Conventional fire alarm panel supporting 1/3/5/10 initiating device circuits and 1 through 4 notification appliance, Class B circuits as required in the space. If the panel is not a slave provide Digital Alarm Communicator Transmitter (DACT) for off premises communication.
6. The system shall store all basic system functionality and job specific data in non-volatile memory. All site specific and operating data shall survive a complete power failure intact. Passwords shall protect any changes to system operations.
7. The system shall have built-in automatic system programming to automatically address and map all system devices attached to the main controller. A minimum default single stage alarm system operation shall be supported with alarm silence, event silence, drill, lamp test, and reset common controls.
8. The system shall support distributed processor intelligent detectors with the following operational attributes: integral multiple differential sensors, automatic device mapping, electronic addressing, environmental compensation, pre-alarm, dirty detector identification, automatic day/night sensitivity adjustment, normal/alarm LEDs, relay bases, sounder bases and isolator bases.
9. The system shall use full digital communications to supervise all addressable loop devices for placement, *correct location*, and operation. It shall allow swapping of "same type" devices without the need of addressing and impose the "location" parameters on replacement device. It shall initiate and maintain a trouble if a device is added to a loop and clear the trouble when the new device is mapped and defined into the system.
10. The fire alarm panel shall provide integral security system interfaces.

#### B. User Interface

1. The display module shall be of membrane style construction with a 24 line by 40-character (960 total characters) Liquid Crystal Display (LCD). The LCD shall use super-twist technology and backlighting for high contrast visual clarity and a colored grey/black and white display.
  - 1.1 In the normal mode the LCD shall display the time, a customer facility name, and the number of history events.
  - 1.2 In the alarm mode the LCD shall display the total number of events and the type of event. The LCD shall display the first event of the highest priority as well as the previous seven (7) alarm events "hands free" in chronological order so that the arriving firefighter may track the fire progression. The LCD shall reserve 42 characters of display space for each user custom message by addressable device.
2. There shall be common control keys and visual indicators for reset, alarm silence, panel silence and drill.
  - 2.1 Provide four pairs of display control keys for selection of event display by type (alarm, supervisory, monitor and trouble) and forward/backward scrolling through event listings.

2.2 The operation of these keys shall be integrated with the related common control indicators to flash the indicators when un-displayed events are available for display and turn on steady when all events have been displayed.

3. Provide system function keys for status, reports, enable, disable, activate, restore, program and test. The module shall have a numeric keypad, zero through nine with delete and enter keys.
4. Provide field programmable 12 switch 12 LEDs control display module.

As an alternate if the above cannot be provided, provide UL 864, 9<sup>th</sup> edition PC graphics display.

#### C. Software

1. Windows-based System Utility with Program Version Reporting to document any and all changes made during system start-up or system commissioning shall be used to maintain site specific programming. Time and Date Stamps of all modifications made to the program must be included to allow full retention of all previous program version data. Software will be Edwards EST-3 or equivalent and capable of coordination with EST fireworks head end. It shall support programming of any input point to any output point. The system shall support the use of Bar Code readers to assist custom programming functions. It shall allow authorized customization of fundamental system operations using initiating events to start actions, timers, sequences and logical algorithms. The system program shall meet the requirements of this project, current codes and standards, and satisfy the local Authority Having Jurisdiction.

#### D. Digital Alarm Communicator Transmitter (DACT)

1. The FACP shall have a DACT module to transmit alarm, supervisory and trouble signals to a central monitoring or proprietary supervising station.
2. The DACT shall support dual telephone lines, Contact I.D. communications, and configured for dual tone multi-frequency (DTMF) or pulse modes.
3. It shall be possible to delay AC power failure reports, auto test call, and be site programmable.
4. The dialer shall be capable of transmitting every individual alarm condition to the central station or proprietary supervising station.

#### E. Network Communications Card

1. A network communication card shall be provided for each building to allow building to building, peer to peer networking.

#### F. Fiber Optics Communications Interface

1. Fiber optics communications interface shall be provided for buildings, where available, to allow building to building networking in a Class A configuration.

#### G. System Controllers

1. The main controller shall be supervised, site programmable, and of modular design supporting at least 125 detectors and 125 remote modules per addressable Signaling Line Circuit (SLC).
2. The controllers shall support up to 10 SLC's per panel for a total system capacity of 2,500 intelligent addressable points.
3. The system shall be designed with peer-to-peer networking capability for enhanced survivability, with support for up to 64 nodes, each with up to 2,500 points and an overall capacity of 160,000 points.

4. The cabinets shall be steel, with a red finish.
5. The main controller module shall control and monitor all local or remote peripherals. It shall support at least a large 960 character LCD, power supply, remote LCD and zone display annunciators, printers, and support standard communication interface protocol devices such as color computer annunciators and color graphic displays. If configured as a network, each system shall display every point in the system and shall support up to 64 remote LCD display annunciators. Remote LCD annunciators shall also display every point in the system and be sized with the same number of characters as in the main FACP display.
6. Each controller shall contain a communication card which contains two RS232 ports. A computer for programming locally and a printer shall be provided and connected to the RS232 ports, a RS232 printer/programming port for programming locally via PC. When operational, each controller shall support a printer through the RS232 port and be capable of message routing.
7. Single stage operations shall be provided.
8. The system shall have a listed Detector Sensitivity test feature, which will be a function of the smoke detectors and performed automatically every 4 hours.
9. The system shall support 100% of all remote devices in alarm and provide support for a 100% compliment of detector isolator bases.

#### H. Power Supplies

1. Provide a power supply with power input of 120 VAC, 3.0A, 50/60 Hz and power output of Internal DC 24 Vdc @ 7.0A Max, Auxiliary DC Two 24 Vdc @ 3.5A Max. The battery charger shall be included in the power supply.
2. The power supply shall be a high efficiency switch mode type with line monitoring to automatically switch to batteries for power failure or brown out conditions. The automatic battery charger shall have low battery discharge protection.
3. The power supply shall provide internal power and 24VDC at 7.0A continuous for notification appliance circuits.
4. The power supply shall be capable of providing 7.0A to output circuits for a maximum period of 100 milliseconds. All outputs shall be power limited.
5. The battery shall be sized to support the system for 24 hours of supervisory and trouble signal current plus general alarm for 5 minutes.

#### I. Auxiliary Power Supplies

1. The power supply shall be a high efficiency switch mode type with line monitoring to automatically switch to batteries for power failure or brown out conditions. The automatic battery charger shall have low battery discharge protection.
2. The power supply shall provide internal power and 24VDC at 7.0A continuous for notification appliance circuits.
3. The power supply shall be capable of providing 7.0A to output circuits for a maximum period of 100 milliseconds. All outputs shall be power limited.
4. The battery shall be sized to support the system for 24 hours of supervisory and trouble signal current plus general alarm for 5 minutes.

#### J. Annunciators

1. The graphic remote annunciators shall be mounted in stand-alone enclosures or integrated into the network panels. The annunciator graphical diagram shall be 1/16 inch per foot scale minimum and operating on normal 24 Vdc. All annunciator switches shall be system input points and shall be capable of controlling any system output or function. The graphic annunciator shall be UL and ULC listed. The graphic shall be back-lit using high intensity LEDs. The unit shall be semi-flush or surface mounted. The main graphic door shall be tamper resistant and equipped with a key lock. It shall be possible to update the graphic image in the field without replacing the entire graphic.
2. Network alpha-numeric annunciators shall be located throughout the facility as indicated on the design drawings. The system shall have the capacity to support 64 network annunciators or network panel nodes. Each annunciator shall contain a supervised, back lit LCD with a minimum of 8 lines with 21 characters per line. Where required, the annunciator shall include additional zonal annunciation and manual control without additional enclosures.
3. The annunciator shall support full ability to serve as the operating interface to the system and shall include the following features:
  - a. Matched appearance with other system displays.
  - b. Each LCD on each node (cabinet) in the system shall be configurable to show the status of any or all of the following functions anywhere in the system: Alarm, Supervisory, Trouble and Monitor.
4. Each annunciator shall be capable of supporting custom messages as well as system event annunciation. It shall be possible to filter unwanted annunciation of trouble, alarm or supervisory functions by point or by geographic area.

#### K. Intelligent Devices

1. Each remote device shall have a microprocessor with non-volatile memory to support its functionality and serviceability. Each device shall store as required for its functionality the device serial number, device address, device type, personality code, date of manufacture, hours in use, time and date of last alarm, amount of environmental compensation left/used, last maintenance date, job/project number, current detector sensitivity values, diagnostic information (trouble codes) and algorithms required to process sensor data and perform communications with the loop controller. Each device shall be capable of electronic addressing, either automatically or application programmed assigned, to support physical/electrical mapping and supervision by location. Setting a device's address by physical means shall not be necessary.

#### L. Intelligent Detectors

1. The system intelligent detectors shall be capable of full digital communications using both broadcast and polling protocol. Each detector shall be capable of performing independent fire detection algorithms. The fire detection algorithm shall measure sensor signal dimensions, time patterns and combine different fire parameters to increase reliability and distinguish real fire conditions from unwanted deceptive nuisance alarms. Signal patterns that are not typical of fires shall be eliminated by digital filters. Devices not capable of combining different fire parameters or employing digital filters shall not be acceptable.
2. Each detector shall have an integral microprocessor capable of making alarm decisions based on fire parameter information stored in the detector head. Distributed intelligence shall improve response time by decreasing the data flow between detector and analog loop controller. Maximum total analog loop response time for detectors changing state shall be 0.5 seconds.

3. Each detector shall have a separate means of displaying communication and alarm status. A green LED shall flash to confirm communication with the analog loop controller. A red LED shall flash to display alarm status.
4. The detector shall be capable of identifying up to 32 diagnostic codes. This information shall be available for system maintenance. The diagnostic code shall be stored at the detector. Each smoke detector shall be capable of transmitting pre-alarm and alarm signals in addition to the normal, trouble and need cleaning information. It shall be possible to program control panel activity to each level.
5. Each smoke detector may be individually programmed to operate at any one of five (5) sensitivity settings. Each detector microprocessor shall contain an environmental compensation algorithm that identifies and sets ambient "Environmental Thresholds" approximately six times an hour. The microprocessor shall continually monitor the environmental impact of temperature, humidity, other contaminants as well as detector aging. The process shall employ digital compensation to adapt the detector to both 24-hour long term and 4-hour short-term environmental changes. The microprocessor shall monitor the environmental compensation value and alert the system operator when the detector approaches 80% and 100% of the allowable environmental compensation value. Differential sensing algorithms shall maintain a constant differential between selected detector sensitivity and the "learned" base line sensitivity. The base line sensitivity information shall be updated and permanently stored at the detector approximately once every hour.
6. The intelligent analog detectors shall be suitable for mounting on a variety of orientation/condition-specific detector mounting bases.

#### M. Fixed Temperature/Rate of Rise Detector

1. Heat detectors shall have a low mass thermistor heat sensor and operate at a fixed temperature and at a temperature rate-of-rise. It shall continually monitor the temperature of the air in its surroundings to minimize thermal lag to the time required to process an alarm. The integral microprocessor shall determine if an alarm condition exists and initiate an alarm based on the analysis of the data. The intelligent heat detector shall have a nominal fixed temperature alarm point rating of 135<sup>0</sup>F and a rate-of-rise alarm point of 15<sup>0</sup>F per minute. The heat detector shall be rated for ceiling installation at a minimum of 70 ft centers and be suitable for wall mount applications.

#### N. Photoelectric Smoke Detector

1. Analog photoelectric detectors shall utilize a light scattering type photoelectric smoke sensor to sense changes in air samples from its surroundings. The integral microprocessor shall dynamically examine values from the sensor and initiate an alarm based on the analysis of data. Systems using central intelligence for alarm decisions shall not be acceptable. The detector shall continually monitor any changes in sensitivity due to the environmental effects of dirt, smoke, temperature, aging and humidity. The information shall be stored in the integral processor and transferred to the analog loop controller for retrieval using a laptop PC or other equivalent program/service tool. The photo detector shall be rated for ceiling installation at a minimum of 30 ft centers and be suitable for wall mount applications. The photoelectric smoke detector shall be suitable for direct insertion into air ducts up to 3 ft high and 3 ft wide with air velocities up to 4,000 ft/min. without requiring specific duct detector housings or supply tubes. The percent smoke obscuration per foot alarm set point shall be field selectable to any of five sensitivity settings ranging from 1.0% to 3.5%. The photo detector shall be suitable for operation in the following environment: Temperature: 32<sup>0</sup>F to 120<sup>0</sup>F, Humidity: 0-93% RH, non-condensing, Elevation: no limit.

#### O. Multi-sensor Detector

1. Provide intelligent multi-sensor smoke detectors. The multi-sensor analog detector shall use a light scattering type photoelectric smoke sensor, a unipolar ionization smoke sensor and an

ambient temperature sensor to sense changes in air samples from its surroundings. The integral microprocessor shall employ time based algorithms to dynamically examine values from the three sensors simultaneously and initiate an alarm based on that data. The multi-sensor detector shall be capable of adapting to ambient environmental conditions. The temperature sensor shall self-adjust to the ambient temperature of the surrounding air and input an alarm when there is a change of 65°F in ambient temperature. Systems using central intelligence for alarm decisions shall not be acceptable. The detector shall continually monitor any changes in sensitivity due to the environmental effects of dirt, smoke, temperature, age and humidity. The information shall be stored in the integral processor and transferred to the analog loop controller for retrieval using a laptop PC. Separately mounted photoelectric detectors, ionization detectors and heat detectors in the same location are not acceptable alternatives. The multi-sensor smoke detector shall be rated for ceiling installation at a minimum of 30 ft centers and suitable for wall mount applications.

**P. Detector Mounting Base**

1. Detector mounting bases shall be suitable for mounting on North American 1-gang, 3½" or 4" octagon box and 4" square box. The base shall contain no electronics, support all detector types and have the following minimum requirements: Removal of the respective detector shall not affect communications with other detectors, Terminal connections shall be made on the room side of the base; bases that must be removed to gain access to the terminals shall not be acceptable. The base shall be capable of supporting one (1) remote alarm LED Indicator. Provide remote LED alarm indicators where shown on the plans.

**Q. Duct Detector Housing**

1. Provide low profile intelligent addressable duct smoke detector as indicated on the project plans. Provide for variations in duct air velocity between 100 and 4,000 feet per minute and include a wide sensitivity range of .79 to 2.46%/ft. Obscuration. Include one shut down relay rated 2.0 amps @ 30 Vdc and also include slave high contact relays if required. Provide an air exhaust tube and an air sampling inlet tube that extends into the duct air stream up to ten feet. The addressable duct housing shall be suitable for extreme environments, including a temperature range of -20 to 158 degrees F and offer a harsh environment gasket option. Provide remote alarm LED Indicators and/or remote test station as indicated on the project plans.

**R. Intelligent Modules**

1. It shall be possible to address each module without the use of DIP or rotary switches. Devices using DIP switches for addressing shall not be acceptable. The personality of multifunction modules shall be programmable at site to suit conditions and may be changed at any time using a code downloaded from the Analog Loop Controller. Modules requiring EPROM, PROM, ROM changes or DIP switch and/or jumper changes shall not be acceptable. The modules shall have a minimum of 2 diagnostic LEDs mounted behind a finished cover plate. A green LED shall flash to confirm communication with the loop controller. A red LED shall flash to display alarm status. The module shall be capable of storing up to 24 diagnostic codes which can be retrieved for troubleshooting assistance. Input and output circuit wiring shall be supervised for open and ground faults. The module shall be suitable for operation in the following environment: Temperature: 32°F to 120°F, Humidity: 0-93% RH, non- condensing.

**S. Single Input Module**

1. Provide intelligent single input modules. The Single Input Module shall provide one (1) supervised Class B input circuit capable of a minimum of 4 "personalities", each with a distinct operation. The module shall be suitable for mounting on North American 2 ½" deep 1-gang boxes and 1 ½" (38mm) deep 4" square boxes with 1-gang covers. The single input module shall support the following circuit types: Normally- Open Alarm Latching (Manual Stations, Heat Detectors, etc.), Normally-Open Alarm Delayed Latching (Waterflow Switches), Normally-

Open Active Non-Latching (Monitor, Fans, Dampers, Doors, etc.), Normally-Open Active Latching (Supervisory, Tamper Switches).

T. Dual Input Module

1. Provide intelligent dual input modules. The Dual Input Module shall provide two (2) supervised Class B input circuits each capable of a minimum of 4 "personalities", each with a distinct operation. The module shall be suitable for mounting on North American 2 ½" deep 1-gang boxes and 1 ½" deep 4" square boxes with 1-gang covers. The dual input module shall support the following circuit types: Normally-Open Alarm Latching (Manual Stations, Heat Detectors, etc.), Normally-Open Alarm Delayed Latching (Waterflow Switches), Normally-Open Active Non-Latching (Monitor, Fans, Dampers, Doors, etc.), Normally-Open Active Latching (Supervisory, Tamper Switches).

U. Monitor Module

1. Provide intelligent monitor modules. The Monitor Module shall be factory set to support one (1) supervised Class B Normally-Open Active Non-Latching Monitor circuit. The monitor module shall be suitable for mounting on North American 2 ½" deep 1-gang boxes and 1 ½" deep 4" square boxes with 1-gang covers.

V. Universal I/O

1. Provide motherboards that provide mounting and wire terminations for modules. The motherboard shall support up to six modules. Locations: Communication Equipment Room, and Ancillary locations.

W. Waterflow/Tamper Module

1. Provide intelligent waterflow/tamper modules. The Waterflow/Tamper Module shall be factory set to support two (2) supervised Class B input circuits. Channel A shall support a Normally-Open Alarm Delayed Latching Waterflow Switch circuit. Channel B shall support a Normally-Open Active Latching Tamper Switch. The waterflow/tamper module shall be suitable for mounting on North American 2 ½" deep 1-gang boxes and 1 ½" deep 4" square boxes with 1-gang covers.

X. Single Input Signal Module

1. Provide intelligent single input signal modules. The Single Input (Single Riser Select) Signal Module shall provide one (1) supervised Class B output circuit capable of a minimum of 2 "personalities", each with a distinct operation. When selected as a telephone power selector, the module shall be capable of generating its own "ring tone". The module shall be suitable for mounting on North American 2 ½" deep 2-gang boxes and 1 ½" deep 4" square boxes with 2-gang covers. The single input signal module shall support the following operations: Audible/Visible Signal Power Selector (Polarized 24 Vdc @ 2A).

Y. Control Relay Module

1. Provide intelligent control relay modules. The Control Relay Module shall provide one form "R" dry relay contact rated at 2 amps @ 24 Vdc to control external appliances or equipment shutdown. The control relay shall be rated for pilot duty and releasing systems. The position of the relay contact shall be confirmed by the system firmware. The control relay module shall be suitable for mounting on 2 ½" deep 1-gang boxes and 1 ½" deep 4" square boxes with 1-gang covers.

Z. Conventional Manual Pull Stations

1. It shall be double action model with single pole contact used for pre-signal or general alarm initiation. The model shall have terminals for field connection of wire. The manual stations

shall be provided with a key lock matching the FACP. The manual pull station shall not be provided with a glass break operation. Surface mount the manual pull station unless flush mount is possible. The fire alarm pull station shall be suitable for operation in the following environment: Temperature: 32°F to 120°F, Humidity: 0-93% RH, non- condensing. Provide accessories as required for the installation.

#### AA. Intelligent Manual Pull Stations

1. It shall be possible to address each fire alarm pull station without the use of DIP or rotary switches. Devices using DIP switches for addressing shall not be acceptable. The manual stations shall have a minimum of 2 diagnostic LEDs mounted on their integral, factory assembled single or two stage input module. A green LED shall flash to confirm communication with the loop controller. A red LED shall flash to display alarm status. The station shall be capable of storing up to 24 diagnostic codes that can be retrieved for troubleshooting assistance. Input circuit wiring shall be supervised for open and ground faults. The fire alarm pull station shall be suitable for operation in the following environment: Temperature: 32°F to 120°F, Humidity: 0-93% RH, non-condensing.

#### BB. Manual Pull Station

1. Provide intelligent double action, single stage fire alarm stations. The fire alarm station shall be of metal construction with an internal toggle switch. Provide a locked test feature. Finish the station in red with silver "PULL IN CASE OF FIRE" English lettering. The manual station shall be suitable for mounting on North American 2 ½" deep 1-gang boxes and 1½" deep 4" square boxes with 1-gang covers.

#### CC. Notification Appliances

1. All appliances shall be FM Approved for Fire Protective Service. All strobe appliances or combination appliances with strobes shall be capable of providing the "Equivalent Facilitation" which is allowed under the Americans with Disabilities Act accessibility guidelines (ADA (AG)), and shall be UL 1971. All appliances shall be of the same manufacturer as the Fire Alarm Control Panel (NO EXCEPTIONS) specified to insure absolute compatibility between the appliances and the control panels, and to insure that the application of the appliances are done in accordance with the single manufacturers' instructions. Any appliances that do not meet the above requirements, and are submitted for use must show written proof of their compatibility for the purpose intended. Such proof shall be in the form of documentation from THE CONTROL PANEL MANUFACTURER clearly stating that the control equipment (as submitted) is 100% compatible with the submitted Notification Appliances.

#### DD. Strobes

1. Provide low profile wall mounted strobes at the locations shown on the drawings. Strobes shall provide synchronized flash outputs. Strobe output shall be field selectable as indicated on the drawings in one of the following intensity levels; 15/75, 15cd, 30cd, 75cd or 110cd\*. Low profile strobes shall mount in a North American 1-gang box or surface mounted on a matching back box provided by the manufacturer, as directed in the field. Provide weatherproof type and associated components when strobe is located outside or in areas requiring weather proofing.

#### EE. Temporal Horn/Strobes

1. Provide low profile wall mount horn/strobes at the locations shown on the drawings. The horn/strobe shall provide an audible output of 84.4 dBA at 10 ft at the high setting and for smaller room size locations (as indicated on the plans) a low dB setting (field selectable) of 79.4 dB at 10 ft. when measured in reverberation room per UL-464. Strobes shall provide synchronized flash outputs. The strobe output shall be as indicated on the drawings in one of the following field selectable intensity levels\*; 15/75, 15cd, 30cd, 75cd & 110cd devices. The horn shall have a selectable steady or synchronized temporal 3-3-3 output. Low profile

horn/strobes shall mount in a North American 1-gang box or surface mounted on a matching back box provided by the manufacturer, as directed in the field.

#### FF. Temporal Horn

1. Provide low profile wall mount horn at the locations shown on the drawings. The horn shall provide an audible output of 84.4 dBA at 10 ft at the high setting and for smaller room size locations (as indicated on the plans) a low dB setting (field selectable) of 79.4 dB at 10 ft. when measured in reverberation room per UL-464. The horn shall have a selectable steady or synchronized temporal 3-3-3 output. Low profile horn shall mount in a North American 1-gang box or surface mounted on a matching back box provided by the manufacturer, as directed in the field.

#### GG. Speaker/Strobe

1. Provide low profile wall mount speaker/strobes at the locations shown on the drawings. The strobe output shall be as indicated on the drawings in one of the following field selectable intensity levels; 15cd, 30cd, 75cd & 110cd devices. Speakers shall operate between ¼ Watt and 2 Watts and shall provide an audible output between 80 dBA and 89 dBA.

#### HH. Speaker

1. Provide low profile wall mount speakers at the locations shown on the drawings. Speakers shall operate between ¼ Watt to 2 Watts and shall provide an audible output between 80 dBA and 89 dBA.

#### II. Multi-Voltage Control Relays

1. Provide remote control relays connected to supervised ancillary circuits for control of fans, dampers, door releases, etc. Relay contact ratings shall be DPDT and rated for 10 amperes at 115 Vac. A single relay may be energized from a voltage source of 24 Vdc, 24 Vac, 115 Vac, or 230 Vac. A red LED shall indicate the relay is energized. A metal enclosure shall be provided.

#### JJ. Electromagnetic Door Holders

1. Electromagnetic door holders submitted for use must have written proof of their compatibility for the purposes intended. Such proof shall be in the form of documentation from all manufacturers that clearly states that their equipment (as submitted) is 100% compatible with each other for the purposes intended.
2. Wall mounted, provide flush, semi-flush or surface wall mounted electromagnetic door holder/releases rated at 24 Vac/dc. Finish shall be brushed zinc.

#### KK. Surge Suppressor

1. Surge suppressors shall be multi-stage, hardwired base, field replaceable, with multiple voltage settings. 2 pairs shall be protected per module. UL497B listed with 10AWG max screw terminals. 0-75 service voltage, 6.6-108V list through voltage.

#### LL. Manual Pull Station Guards

1. Manual pull stations shall be provided with guards as required on the plans. They shall be surface or flush mounting, as required for each individual device.

#### MM. Voice Evacuation

1. The audio system must provide simultaneous page, alert, and evacuation signals. Systems that cause signaling devices to go silent while performing signaling functions will not be acceptable. The system must provide operation to 25Vrms or 70.7Vrms speakers. The system

must provide as a minimum the following paging common controls and indicators: Ready to page LED, VU display of paging output level, single switch function for paging to all — Alert zones, Evacuation zones, and areas not programmed for signaling. The system must provide high quality analog to digital conversion of paging sources. Digital transmission of paging must be provided between system nodes. The analog sources must be sampled and converted to digital with a sampling rate no less than 9600 samples per second. It must be possible to transmit signal sources (Alert, Alarm, Page, etc.) together over a single pair of wires between nodes. System amplifiers must be distributed zoned type. Centrally banked systems are not acceptable. An integral circuit for operating traditional Network Access Control (NAC) devices must be provided with each system amplifier. The circuit must carry a minimum rating of 3.5 Amps for operating 24 VDC signals. The system shall provide fully integrated fire fighters' telephone system that shall provide 2-way communication between the fire alarm control panel and any fire fighters' telephone station. The system shall include an alphanumeric user display and controls. When a telephone is activated, a call-in buzzer shall sound, and the location of the phone shall be shown on the alphanumeric display. The display shall be capable of bilingual operation, displaying English, Dutch, Finnish, French, German, Italian, Portuguese or Spanish messages. The incoming call shall be selected by activating a single button. All subsequent telephone call locations shall be displayed in full text. The system shall display all incoming calls, all connected phone(s) on the alphanumeric display. The system shall be configured so that page messages may be issued from any firefighter's telephone connected to the system, as directed by the emergency operator.

## PART 3 – EXECUTION

### 3.01 INSTALLATION

- A. Shop drawings must be submitted and approved prior to execution of any installation or demolition activity.
- B. Circuiting
  1. Addressable analog signaling line circuit, initiating device circuit and notification appliance circuit loops shall be Class B. Conventional signaling line circuit, initiating device circuit and notification appliance circuit loops shall be Class B. Network communication and annunciator communication loops shall be Class A. Tee tapping is not permitted for any circuit.
  2. Device loading shall not exceed 80% of loop capacity for each addressable or conventional analog loop to accommodate the installation of future devices.
  3. Provide intelligent input modules to supervise Class B zone wiring where required to interface conventional initiating devices.
  4. Sprinkler systems shall be supervised as follows:
    - a. Provide one (1) supervisory module for each sprinkler valve supervisory switch.
    - b. Provide one (1) dual input addressable module where water flow and tamper switches exist at the same location.
    - c. Provide one (1) additional single input addressable module where odd numbers of devices exist at a single location.
  5. Notification appliance circuits:
    - a. Audible Signals: Provide sufficient spare capacity to assure that an increase of 20% of the audible devices can be supported without the need for additional components (power supplies, signal circuit modules, batteries, etc.).

- b. Visual Signals: Provide sufficient spare capacity to assure that an increase of 20% of the visual devices can be supported without the need for additional components (power supplies, signal circuit modules, batteries, etc.).
6. Each of the following types of remote equipment associated with the fire alarm system shall be provided with a form 'C' control relay contact as follows, unless otherwise noted on the drawings:
  - a. HVAC Fan Systems: Provide one (1) shutdown control relay contact for each HVAC fan system.
  - b. HVAC Supply Fans: Provide one (1) shutdown control relay contact for each HVAC supply fan.
  - c. HVAC Return Fans: Provide one (1) shutdown control relay contact for each HVAC return fan.
7. Provide a dedicated 24VDC circuit to feed all auxiliary relays required for inductive loads. Circuits shall be supervised via an end-of-line relay and addressable input module. Auxiliary relays shall not derive their power from the starter or load being controlled.
8. Each control or data gathering panel shall have a dedicated 20 Amp, 120VAC feed. This feed shall come from an emergency circuit breaker panel where available, and shall have a locked circuit breaker. Earth grounds shall also terminate to the same circuit breaker panel from each respective control panel.
9. The system shall have a CPU "watchdog" circuit to initiate trouble should the CPU fail.
10. All low voltage wiring terminated to the fire alarm system shall be plenum rated with no exceptions and no less than No. 18 AWG in size, and solid copper.
11. All line voltage (120VAC) wiring shall be no less than No. 12 AWG in size, and solid copper. This shall include all system grounding. FACP must have a dedicated 20 Amp circuit marked back at the power panel no exceptions.
12. All wiring shall be color-coded throughout, to National Electrical Code standards.
13. Power-limited/non-power-limited NEC wiring standards shall be observed.
14. All junction box covers shall be painted federal safety red and labeled FIRE ALARM SYSTEM ONLY in black letters.
15. Fire alarm system wiring shall not co-mingle with any other system wiring in the facility. Conduits shall not be shared under any circumstance. Only when fire alarm wiring enters the enclosure of a monitored or controlled system will co-habitation be permitted (i.e. at fan starters or elevator controllers).
16. Auxiliary relays shall be appropriately labeled to indicate "FIRE ALARM SYSTEM" and their specific function (i.e. FAN S-1 SHUTDOWN).
17. All fire alarm wiring shall be continuous and without splices. Terminations shall only occur at fire alarm devices or control panel enclosures under terminal screws. All other splicing methods are specifically disallowed (i.e. plastic wire nuts).
18. All fire alarm wiring shall be installed in conduit. See Specification Section 16120.
19. All fire alarm wiring shall be sleeved when passing through any wall, using conduit sleeves (1"min.) with bushings, and fire stopped in accordance with Code.

20. The fire alarm system shall be arranged to receive power from one three wire 120 Vac, 20 A supply. All low voltage operation shall be provided from the fire alarm control panel.
21. End of Line Resistors shall be furnished as required for mounting as directed by the manufacturer. Devices containing end-of-line resistors shall be appropriately labeled. Devices should be labeled so removal of the device is not required to identify the EOL device.
22. New door holders shall derive their 24VAC/VDC power from a separate power supply housed in a dedicated, metal enclosure. The power supply shall have a 120VAC feed, and is to be centrally located to serve door holders on a per floor or area basis. All existing door holders shall be connected to new FACP. E.C. shall extend all existing wiring in order to make this work.
23. All WMATA protected premises report to two proprietary supervising station locations. The supervising station locations are located at the Jackson Graham Building and at the Carmen Turner Facility.

#### C. Fire Alarm System Sequence of Operation

1. The system shall identify any off normal condition and log each condition into the system database as an event.
  - a. The system shall automatically display on the control panel Liquid Crystal Display the first event of the highest priority by type. The priorities and types shall be alarm, supervisory, trouble and monitor.
  - b. The system shall have a Queue operation, and shall not require event acknowledgement by the system operator. The system shall have a labeled color coded indicator for each type of event; alarm shall be red, supervisory shall be yellow, trouble shall be yellow, monitor shall be yellow. When an unseen event exists for a given type, the indicator shall be lit.
  - c. For each event, the display shall include the current time, the total number of events, the type of event, the time the event occurred and up to a 42 character custom user description.
  - d. The user shall be able to review each event by scrolling keys (up-down) for each event type.
  - e. New alarm, supervisory or trouble events shall sound an audible signal at the control panel; the operator shall be able to silence this audible signal.
2. Operation of any alarm initiating device shall automatically:
  - a. Update the control/display as described in this Section.
  - b. Sound all audible appliances in a Temporal-3 pattern. All audible appliances shall be synchronized with each other when two or more horns can be heard. Audible devices shall have the ability to be silenced.
  - c. Activate all strobe appliances throughout the facility. All strobe appliances shall be synchronized with each other in any location with two or more devices in a common field of view. Visual devices shall be non-silenced unless the system is successfully reset.
  - d. Operate control relay contacts to shutdown HVAC units in accordance with IMC requirements.

- e. Operate control relay contacts to return all elevators that serve the floor of alarm initiation to the ground floor. If the alarm originates from the ground floor, operate control circuits contacts to return all elevators to the floor above or to a level as directed by the local fire department.
  - f. Operate control relay contacts to release all magnetically held smoke doors throughout the building.
  - g. Visually annunciate the individual point of alarm on all remote annunciator panels. The visual indication shall remain activated until the alarm condition is reset to normal.
  - h. Transmit an alarm condition to central station/local fire department and/or proprietary supervising station (as required by the AHJ/WMATA).
3. Elevator smoke and heat detector sequences shall comply with ANSI A17.1 Safety Code for Elevators and Escalators requirements and local code requirements for main/alternate floor recalls, and shunt trip activations.
  4. Activation of a sprinkler supervisory initiating device shall:
    - a. Update the control/display as described in this Section.
    - b. Transmit a supervisory condition to central station/local fire department and/or proprietary supervising station (as required by the AHJ/WMATA).
    - c. Visually annunciate the individual point of alarm on all remote annunciator panels. The visual indication shall remain on until the alarm condition is reset to normal.
  5. All fire alarm system wiring shall be electrically supervised to automatically detect and report trouble conditions to the fire alarm control panel. Any opens, grounds or disarrangement of system wiring and shorts across alarm signaling wiring shall automatically:
    - a. Update the control/display as described in this Section.
    - b. Transmit a trouble condition, via the integral central station communicator, to the central station/local fire department and proprietary supervising station (as required by the AHJ).
    - c. Visually and audibly annunciate a general trouble condition on the remote annunciator panels. The visual indication shall remain on until the trouble condition is repaired.
  6. Purge/Smoke Control
    - a. Smoke control panels shall be UUKL listed specifically for smoke control operation to allow the smoke purge control to be housed in the FACP cabinet. The smoke control switches shall be located behind a locked glass door.
    - b. Where required, each floor shall have a dedicated switch for fan shutdown via a listed addressable control module. Each damper shall also be monitored at the panel for open/close position via control module. This module shall illuminate the associated green LED when the damper is open and the red LED when the damper is closed. The dampers shall be interlocked with the fans to prevent the fan from activating while the damper is closed.
  7. All panel modules shall be supervised for placement and return trouble if damaged or removed.
  8. All WMATA protected premises report to two proprietary supervising station locations, and to the WMATA contracted third party monitoring location. The supervising station locations are located at the Jackson Graham Building and at the Carmen Turner Facility.

#### D. Device Mounting

1. The entire system shall be installed with aesthetics in mind as approved by WMATA. All control panels and remote annunciators installed in public spaces shall be semi-flush mounted with no exposed conduit or cable trays unless approved by WMATA.
2. All manual pull stations shall be mounted 48 inches above the finished floor, as measured to the handle.
3. Wall-mounted appliances shall be mounted such that the entire lens is not less than 80 in. and not greater than 96 in. above the finished floor. Where low ceiling heights do not permit mounting at a minimum of 80 in., appliances shall be mounted within 6 in. of the ceiling. All audiovisual devices shall have lexan covers in all areas.
4. No area smoke detectors shall be mounted within 36 inches of any HVAC supply, return air register or lighting fixture.
5. No area smoke or heat detector shall be mounted within 12 inches of any wall. All detectors shall be installed in strict accordance with NFPA 72 guidelines for such devices.
6. All addressable modules shall be mounted within 36 inches of the monitored or controlled point of termination. This shall include, but is not necessarily limited to, fan shutdown, elevator recall, shunt trip, sprinkler status points, or door release. Label all addressable modules as to their function.
7. All fire alarm devices shall be accessible for periodic maintenance. Should a device location indicated on the Contract Drawings not meet this requirement, it shall be the responsibility of the installing contractor to bring it, in writing, to the attention of WMATA. Failure to bring such issues to the attention of WMATA shall be the exclusive liability of the installing Contractor.

### 3.02 CONSTRUCTION

- A. System cable and devices shall be installed and inspected based on Fire Marshal approved drawings. Original contract drawings are for bidding purposes only. The entire system shall be installed in accordance with approved manufacturer's wiring diagram. The contractor shall furnish all conduit, wiring, outlet boxes, junction boxes, cabinets and similar devices necessary for the complete installation. All wiring shall be of the type recommended by the manufacturer, approved by the local Fire Department and specified herein.
- B. All penetration of floor slabs and firewalls shall be sleeved (1" conduit minimum) fire stopped in accordance with all local fire codes.
- C. The existing fire alarm system shall remain in operation until such time that approval has been granted for its removal.
- D. After acceptance of the new building fire alarm system, the installing Contractor shall be responsible for the removal of entire existing fire alarm system components and controls, upon approval of the AHJ and WMATA. WMATA reserves the right to retain any existing fire alarm system components, upon their request. All existing fire alarm system components requiring special handling for disposal (due to radioactivity) shall be the responsibility of the installing contractor.
- E. Prior to commencement and after completion of work notify Authorities Having Jurisdiction

### 3.03 FIELD/SITE QUALITY CONTROL

- A. The system shall be installed and fully tested under the supervision of a trained manufacturer's representative. The system shall be demonstrated to perform all of the function as specified.

- B. The installing contractor or fire alarm equipment vendor shall have no less than two (2) NICET Level III fire alarm technicians dedicated to this project.
- C. The Installing Contractor and the Fire Alarm System Vendor shall, upon the request of the Consulting Engineer or WMATA attend any and all project meetings for the purpose of accurately determining progress.
- D. It shall be the responsibility of the installing contractor to assure that construction debris does not adversely affect any sensing devices installed as part of this project. Should it be deemed necessary by the WMATA construction manager, the installing contractor shall be responsible for the cleaning of all smoke detectors prior to final acceptance.

### 3.04 SYSTEM STARTUP

#### A. Tests

1. The fire alarm system vendor shall test the system in accordance with the manufacturer's requirements and NFPA 72. The vendor shall provide final acceptance test reports to WMATA for review and approval prior to final acceptance.
2. Each individual system operation on a circuit by circuit basis shall be tested for its complete operation in accordance with NFPA 72 (2010ed.), Table 14.4.2.2 (see appropriate section from other editions). The procedure for testing the entire fire alarm system shall be set forth with the consent of the code enforcement official, the Engineer and the manufacturer.
3. Provide a NFPA 72 System Record of Completion Form for each part of the fire alarm system as required.

### 3.05 CLOSEOUT ACTIVITIES

#### A. Documentation and Training

1. The contractor shall compile and provide to WMATA a complete manual on the completed system to include site specific operating and maintenance instruction, catalog cuts of all equipment and components, as-built wiring diagrams and a manufacturer's suggested spare parts list. An operational Video, on DVD media, shall also be included.
2. The Contractor shall provide the onsite services of a manufacturer's trained representative for two (2) separate calendar days for a period of eight (8) hours per day to instruct the WMATA's designated personnel on the operation and maintenance of the entire system.
3. Submit letter of approval for installation before requesting acceptance of system.

#### B. As-built Drawings

1. Revise existing drawings to incorporate contract work.
2. Point-to-point depiction of all device wiring on the device layout floor plans.
3. Full size, as-built drawings.
4. All drawings should be readable and printable in 11 x 17.
5. Provide electronic copies in AutoCAD and PDF.
6. Provide one copy inside PVC pipe next to FACP.

### 3.06 MAINTENANCE

- A. Provide a coded one-man walk test feature. Allow audible or silent testing. Signal alarms and troubles during test. Ensure receipt of alarms and programmed operations for alarms from areas not under test.
- B. Provide internal system diagnostics and maintenance user interface controls to display/report the power, communication, and general status of specific panel components, detectors, and modules.
- C. Provide loop controller diagnostics to identify common alarm, trouble, ground fault, NFPA 72 Class A fault, and map faults. Map faults include wire changes, device type changes by location, device additions/deletions and conventional open, short, and ground conditions. Ground faults on the circuit wiring of remote module shall be identified by device address.
- D. Allow the user to display/report the condition of addressable analog detectors. Include device address, device type, percent obscuration, and maintenance indicator. The maintenance indicator shall provide the user with a measure of contamination of a device upon which cleaning decisions can confidently be made.
- E. Allow the user to report history for alarm, supervisory, monitor, trouble, smoke verification, watchdog, and restore activity. Include Facility Name, Licensee, Project Program Compilation date, Compiler Version, Project Revision Number, and the time and date of the History Report.
- F. Allow the user to disable/enable devices, zones, actions, timers and sequences. Protect the disable function with a password.
- G. Allow the user to activate/restore outputs, actions, sequences, and simulate detector smoke levels.
- H. Allow the service user to enter time and date, reconfigure an external port for download programming, initiate auto programming and change passwords. Protect these functions with a password.
- I. WMATA shall retain complete rights and ownership to all software running in the system. The fire alarm equipment vendor shall provide useable hard and soft copies of the software database to WMATA at the end of the warranty period. The database provided shall be useable by any authorized and certified distributor of the product line, and shall include all applicable passwords necessary for total and unrestricted use and modification of the database.

END OF SECTION

## SECTION 16733

### COMMUNICATIONS - KIOSK SYSTEMS

#### PART 1 GENERAL

##### 1.01 SECTION DESCRIPTION AND BASIC REQUIREMENTS

- A. The purpose of the Kiosk System is to provide the kiosk with the equipment needed to monitor and control passenger station Communications Systems, Fire and Intrusion Alarm Systems, to provide data signals to fare collection equipment, elevators and escalators, and to provide an effective communications interface with the public (customers).
- B. At least one kiosk is located in each passenger station of the Washington Metropolitan Area Transit Authority (WMATA) Rail Rapid Transit System. It is the focal point of activity at each passenger station. At large passenger stations, each operational level may contain more than one kiosk. Where more than one kiosk is located on a single level, one kiosk is designated as the "Major Kiosk." All other kiosks are designated "Minor Kiosks." In those stations where a single kiosk exists, it is considered to be the "Major Kiosk."
- C. Facilities are to be provided in each kiosk for the station manager to monitor and control passenger station systems. The contractor shall provide a complete "Kiosk Facility" which shall include kiosk cabinets, system interface panels, cables, cable termination facilities, loudspeakers, wiring and all hardware needed to complete the installation of Station Monitor/Control Systems in the kiosk. The requirements for the individual monitor/control panels and systems, to be installed in the kiosk under this contract, are included in the respective System Specification Sections.
- D. The contractor shall provide Cabinet Bays #1 through #6 in the Kiosk(s) included in this contract, as indicated on the contract drawings. Kiosk Cabinet Bay #7 will be furnished and installed by other trades.
- E. The contractor shall provide a Cable Termination Rack in Cabinet Bay # 3 of the kiosk(s) covered by this contract. The kiosk Cable Termination Rack shall consist of seven Terminal Strips and a Line Terminal Block. Terminal Strips shall be equally spaced on the Termination Rack. Each Terminal Strip within the kiosk Cable Termination Rack shall consist of sixty (60) individual terminals. The kiosk Cable Termination Rack shall be provided in the kiosk(s) to terminate all cables and wires that are to be installed into the kiosk(s) under this contract, with the following exceptions:
  - 1. Coaxial video cables.
  - 2. Automatic Public Address Announcement System cables.
  - 3. Passenger Emergency Reporting System cables.
  - 4. Kiosk Multiline Telephone Cable Connections.
- F. The coaxial cables from the station Communications Equipment Room are terminated on the Coaxial Cable Termination Panel in Bay # 3. The coaxial cables from the kiosk video equipment shall also be terminated on the Coaxial Cable Termination Panel. The Automatic Public Address Announcement System cables and the Passenger Emergency Reporting System cables are terminated on the Emergency Communications Kiosk Terminal Panel.
- G. The Contractor shall provide an Emergency Communications Kiosk Terminal Panel in Bay # 3 of the cabinetry in the kiosk(s) included in this contract. The Emergency

Communications Kiosk Terminal Panel shall be the interface point for cables from the station Communications Equipment Room to the kiosk control panels, for the Automatic Public Address Announcement System and the Passenger Emergency Reporting System. The Emergency Communications Kiosk Terminal Panel shall consist of three terminal blocks mounted on a 16-gauge steel plate. Two blocks shall have a minimum of 23 miniature terminals, and the other block shall have a minimum of 20 miniature terminals. Details on the layout, mounting and lettering of the Emergency Communications Kiosk Terminal Panel are included on the contract drawings.

- H. The contractor shall provide a 24-Vdc Power Supply in the Public Address System Equipment Rack located in the station(s) Communications Equipment Room, and shall interconnect it to the kiosk Cable Termination Rack. The 24-Vdc Power Supply will be used to power the Escalator Display Panel in the kiosk(s).
- I. The contractor shall engineer, draw, print and deliver to the Authority, Kiosk Data Files for the passenger station(s) under this Contract. The Kiosk Data Files shall be designed to be a convenient source of information on the layout of the following systems:
  - 1. Passenger Station Telephones.
  - 2. Right-of-Way and Ancillary Building Telephones.
  - 3. Passenger Station Fire Zones.
  - 4. Ancillary Building Fire Zones.
  - 5. Passenger Station Intrusion Zones.
  - 6. Ancillary Building Intrusion Zones.
  - 7. Escalators.
  - 8. Closed Circuit Television System.
  - 9. Passenger Emergency Reporting System.
- J. Contractor shall also provide laminated Fire and Intrusion Zone tables for the passenger station(s).
- K. The Escalator Display Panel provides four status indicators and one identification indicator for each of up to 16 escalators. The following indicators are provided for each escalator:
  - 1. Direction of Travel - "UP" or "DOWN."
  - 2. Automatic Operation - "AUTO OPER."
  - 3. Out of Service - "OUT SERV."
  - 4. Escalator Identification - "ESC XX" where "XX" is the number of the escalator.
- L. The Escalator Display Panel also includes a momentary, non-illuminating, pushbutton switch to permit a lamp test of all indicators on the panel.
- M. Kiosk Monitor/Controls provide the station manager with a means to effectively manage passenger station activities. The operation of the monitor/control panels and systems, to be installed in the kiosk under this contract (except the Escalator Control Panel described in this Section), is described in the individual system specifications.

## **1.02 SECTION INCLUDES**

- A. Kiosk Cabinet Bays #1 through #6C in the Kiosk(s).
- B. 24-Vdc Power Supply.
- C. Escalator Display Panel.
- D. Kiosk Data File.

- E. Kiosk Cable Termination Rack.

### **1.03 UNIT PRICES**

- A. Unit Prices include all required conduits and fittings, junction boxes, feeder wires, branch circuit wiring, and cabling to the communications systems and facilities and incidental items, not specifically mentioned, but required for complete and proper system operation.

### **1.04 RELATED SECTIONS**

- A. Section 14200 - Hydraulic Elevators.
- B. Section 14240 - Traction Elevators.
- C. Section 14300 - Heavy-Duty Escalator.
- D. Section 16705 - Communications Standard Specifications - Equipment & Material.
- E. Section 16706 - Communications System Submittals & Services..
- F. Section 16707 - Communications Systems Quality Assurance & Testing
- G. Section 16710 - Communications Grounding.
- H. Section 16715 - Communications Electrical Power Distribution.
- I. Section 16721 - Communications - Telephone System
- J. Section 16727 - Communications - Passenger Emergency Reporting System.
- K. Section 16771 - Communications - Carrier Transmission System
- L. Section 16776 - Communications - Fiber Optic System..
- M. Section 16731 - Communications - Fire Alarm System..
- N. Section 16820 - Communications - Public Address System..
- O. Section 16821 - Communications - Automatic Public Address Announcement System.
- P. Section 16851 - Communications - Passenger Station Closed-Circuit Television System.

### **1.05 REFERENCES**

- A. National Electric Code (NEC).

### **1.06 SYSTEM DESCRIPTION**

- A. Description: The Kiosk System provides the kiosk with the equipment needed to monitor and control passenger station Communications Systems, Fire and Intrusion Alarm Systems, to provide data signals to fare collection equipment, elevators and escalators, and to provide an effective communications interface with the public (customers).

- B. Capacity:
1. The Contractor shall furnish and install a 24-Vdc Power Supply for the kiosk that is sufficient to power all the 24-Vac equipment located in the kiosk, plus 50% spare capacity.
  2. The Contractor shall furnish and install kiosk Cabinet Bays #1 through #6C in the kiosk(s).
  3. The Contractor shall install the Escalator Display Panel(s) furnished by other trades.
  4. The Contractor shall author, publish and furnish one set of Kiosk Data Files for each kiosk in each passenger station, and 12 additional sets of Kiosk Data Files to the Authority for each passenger station.
  5. The Contractor shall furnish and install a Kiosk Cable Termination Rack in each kiosk.
  6. The Contractor shall furnish and install an Emergency Communications Kiosk Terminal Panel in each kiosk.
  7. The contractor shall install an Elevator Control Panel (provided under Section 14200 - Hydraulic Elevators or Section 14240 - Traction Elevators) in the kiosk.
- C. The Kiosk Cable Termination Rack consists of seven Terminal Strips and a Line Terminal Block in Cabinet Bay 6B. Each Terminal Strip within the Kiosk Cable Termination Rack consists of sixty (60) individual terminals. The Kiosk Cable Termination Rack terminates all cables and wires that are to be installed into the kiosk(s) in this contract, with the following exceptions:
1. Coaxial video cables.
  2. Automatic Public Address Announcement System cables.
  3. Passenger Emergency Reporting System cables.
  4. Kiosk Multi-line Telephone Cable Connections.
- D. The coaxial cables from the station Communications Equipment Room are terminated on the Coaxial Cable Termination Panel in Bay 6B. The coaxial cables from the kiosk video equipment are also terminated on the Coaxial Cable Termination Panel. The Automatic Public Address Announcement System cables and the Passenger Emergency Reporting System cables are terminated on the Emergency Communications Kiosk Terminal Panel.
- E. The Emergency Communications Kiosk Terminal Panel in Bay 6B is the interface point for cables from the station Communications Equipment Room to the Kiosk control panels, for the Automatic Public Address Announcement System and the Passenger Emergency Reporting System.
- F. A 24-Vdc Power Supply in the Public Address System Equipment Rack located in the station(s) Communications Equipment Room, and interconnects to the kiosk Cable Termination Rack to provide power to the Escalator Display Panel in the kiosk(s).
- G. The Kiosk Data Files provide a convenient source of information on the layout of the following systems:
1. Passenger Station Telephones.
  2. Right-of-Way and Ancillary Building Telephones.
  3. Passenger Station Fire Zones.
  4. Ancillary Building Fire Zones.
  5. Passenger Station Intrusion Zones.
  6. Ancillary Building Intrusion Zones.
  7. Escalators.
  8. Closed Circuit Television System.
  9. Passenger Emergency Reporting System.

- H. The Escalator Display Panel provides four status indicators and one identification indicator for each of up to 16 escalators. The following indicators are provided for each escalator:
1. Direction of Travel - "UP" or "DOWN."
  2. Automatic Operation - "AUTO OPER."
  3. Out of Service -"OUT SERV."
  4. Escalator Identification - "ESC XX" where "XX" is the number of the escalator.

#### **1.07 SUBMITTALS**

- A. Submit under provisions of Section 16706.
- B. Shop Drawings: Indicate electrical characteristics and connection requirements, including system wiring diagram and mechanical layout.
- C. Product Data: Provide data showing electrical characteristics and connection requirements for each component.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.
- E. Submitted to the Engineer for approval prior to reproduction, lamination and assembly a draft copy of each Kiosk Data File for the passenger station(s).
- F. Furnish a complete set of Mylar reproducible drawings for the Kiosk Data File of the passenger station(s), and electronic copies (in AutoCAD, latest release format) on diskette and compact disk.

#### **1.08 QUALIFICATIONS**

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Supplier: Authorized distributor of specified manufacturer with minimum three years documented experience.
- C. Installer: Service facilities within 50 miles of Project.

#### **1.09 MAINTENANCE SERVICE**

- A. Furnish service and maintenance of Kiosk Systems until Final Completion.

### **PART 2 - PRODUCTS**

#### **2.01 TERMINALS**

- A. Manufacturers:
1. Weidmuller, Model No. SAKC4 Complete with Channel Mounting System (or approved equal).
- B. Ratings:
1. Terminal Type: Modular Micro Terminal with Screw Clamp Connection.
  2. Wire size accommodated: #22 thru #12-AWG.
  3. Rated Current: 27-Amps.

4. Rated Voltage: 300-Vdc.
5. Center-to-Center Spacing: 6-mm.

## **2.02 LINE TERMINAL BLOCK**

- A. Manufacturers:
  1. Siecor, Model No. A0293268 (or approved equal).
- B. Ratings:
  1. Terminal Type: Wire Wrapping Terminals.
  2. Terminal Configuration: 4 rows x 26 clips.
  3. Mounting Base: Adjustable from 7-inches to 9-inches.

## **2.03 24-VDC POWER SUPPLY**

- A. Manufacturers:
  1. Acopian, Model No. 24PH30 (or approved equal).
- B. Ratings:
  1. Input Voltage: 105-125 Vac, 60 Hz, Single Phase.
  2. Output Voltage: 24-Vdc  $\pm$  .5-Vdc (adjustable).
  3. Output Current (minimum): 30-Amps @ 40°C. 23-Amps @ 55°C.
  4. Ambient Operating Temperature: -20 to +55° C.
  5. Regulation (line/load):  $\pm$  .05%.
  6. Size: Not greater than 3 vertical rack units (19-inch rack).
  7. Standard RETMA 19-inch cabinet rack mount.

## **2.04 KIOSK CABINET BAY ASSEMBLY**

- A. Manufacturers:
  1. Custom made.
- B. Ratings:
  1. Frame Material: 16-Gauge Galvanized Steel.
  2. Exposed Metal Finish: Metro Bronze Color 20040 (Federal Standard 595B).
  3. Desk Tops: 1-inch Marine Plywood (MARINE AA EXT-APA).
  4. Hardware: Cadmium Plated.
  5. Desk-Top Laminate: Formica Grade 10 (or approved equal).
  6. Desk-Top Laminate Color: Neutral White #918.

## **2.05 KIOSK DATA FILE**

- A. Manufacturers:
  1. Custom made.
- B. Description: Each Kiosk Data File shall consist of eight or more 11" x 17" drawings.
- C. Prepared Kiosk Data File drawings to document each of the following subjects:
  1. Telephones (passenger station) - A cross-reference of telephone numbers and telephone locations within a passenger station.
  2. Telephones (Right-of-Way and Ancillary Facilities) - A cross-reference, by telephone numbers and locations, of the telephones along the right-of-way and in ancillary facilities associated with a passenger station.

3. Fire Zones (Passenger Station) - A cross-reference of the designated fire zones, room numbers and room descriptions for all areas within a passenger station, including ancillary facilities within the passenger station limits.
  4. Fire Zones (Ancillary Facilities) - A cross-reference of the designated fire zones in remote ancillary facilities associated with a passenger station.
  5. Intrusion Zones (passenger station) - A cross-reference of the designated intrusion zones, room numbers and room descriptions for all areas of a passenger station, including ancillary facilities within the passenger station limits.
  6. Intrusion Zones (Ancillary Facilities) - A cross-reference of the designated intrusion zones in remote ancillary facilities associated with a passenger station.
  7. Escalators - A cross-reference of assigned escalator numbers and escalator locations within a passenger station.
  8. CCTV - A cross-reference of television monitor assignments and arrangements, and television camera designations, locations and areas of coverage for all television cameras and television monitors within a passenger station.
  9. Passenger Emergency Reporting System - A layout of platform(s) showing locations and designations of call stations.
- D. Ratings:
1. Seal Kiosk Data File drawings in a protective plastic laminate.
  2. Each Kiosk Data File set shall be in loose-leaf booklet form.
  3. Covers: 11" x 17", minimum of 60-pound punched paper with holes reinforced with plastic, cloth or metal, and sealed in a protective plastic laminate.

## **2.06 EMERGENCY COMMUNICATIONS KIOSK TERMINAL PANEL**

- A. Manufacturers:
1. Custom made.
- B. Description: The Emergency Communications Kiosk Terminal Panel consist of three terminal blocks mounted on a 16-gauge steel plate and have the following characteristics:
1. Two of the terminal blocks shall each have a minimum of 23 miniature terminals.
  2. The other terminal block shall have a minimum of 20 miniature terminals.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. Kiosk cabinet bay assembly installation
1. Install the assembled kiosk cabinetry in the kiosk of the passenger station(s). Cabinet assembly installation shall be as follows: Bays #1, #2A, 2B, 2C and #3 as a single unit; Bays #4, #5, and #6A, 6B, and 6C as a single unit. Secured to the floor of the kiosk. Kiosk cabinets may be secured to the kiosk sides with the approval of the Engineer; however, the securing hardware shall not carry any vertical load. Hardware installed in the kiosk sides shall only be used to prevent horizontal movement.
- B. Kiosk cable termination rack installation
1. Install a Kiosk Cable Termination Rack in Kiosk Cabinet Bay 6B of the kiosk. Install structure elements in the Kiosk Cabinet Bay 6B to accommodate the Terminal Strips and the Line Terminal Block of the Kiosk Cable Termination Rack.
- C. Emergency communications kiosk terminal panel

1. Install an Emergency Communications Kiosk Terminal Panel in Kiosk Cabinet Bay 6B of the kiosk, as indicated on the contract drawings. Installation shall not interfere with the Cable Termination Rack Terminal Strips. Secure Cables to the Emergency Communications Kiosk Terminal Panel to the panel to prevent interference with the Kiosk Cable Termination Rack wiring and cabling.
- D. Escalator display panel
1. Install an Escalator Display Panel in Cabinet Bay 3 of the Kiosk. install the required wiring harness(es) between the panel and the Kiosk Cable Termination Rack in Bay 6B, and make all necessary connections and cross-connections. Install one 9-conductor, 18-AWG, shielded cable for each escalator associated with the passenger station(s) between the Kiosk Cable Termination Rack in Bay 6B of the Kiosk and the Escalator Terminal Box in the escalator wellways. Terminate the cables in the kiosk and at the escalators and make all necessary connections and cross-connections.
- E. Standard time cable
1. Install a six-pair individually shielded "Standard Time" cable between the TC/COMM Interface Cabinet in the station Communications Equipment Room and the kiosk. Terminate the pairs at the TC/COMM Interface Cabinet and at the kiosk Cable Termination Rack in Bay 6B of the kiosk cabinets and make all necessary connections and cross-connections.
- F. Kiosk 24-vdc power facility
1. Install the 24-Vdc Power Supply in the Public Address System Equipment Rack located in the station Communications Equipment Room.
  2. Install the required cabling and connectors and make the necessary connections and cross-connections between the 24-Vdc Power Supply in the Communications Equipment Room and the Kiosk Cable Termination Rack in the kiosk.
- G. Elevator control panel
1. The Elevator Control Panel will be installed in Bay 3 of the kiosk under Section 14200 or Section 14240..

### **3.02 MANUFACTURER'S FIELD SERVICES**

- A. Prepare and start systems under provisions of Section 16707.
- B. Supervise final wiring connections and system adjustments.

### **3.03 ADJUSTING**

- A. Adjust operating Products and equipment to ensure smooth and unhindered operation.

### **3.04 DEMONSTRATION**

- A. Demonstrate operation and maintenance of Products to WMATA personnel two weeks prior to date of Substantial Completion.
- B. Demonstrate Project equipment by a qualified person who is knowledgeable about the Project.

- C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with WMATA personnel in detail to explain all aspects of operation and maintenance.
- D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at equipment location.
- E. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction
- F. Demonstrate system operation.
- G. Conduct walking tour of Project and briefly describe function, operation, and maintenance of each component.

**END OF SECTION**

**SECTION 16733**  
**KIOSK SYSTEMS**

**PART 1 – GENERAL**

**1.01 SUMMARY**

- A. The purpose of the Kiosk System is to provide the kiosk with the equipment needed to monitor and control passenger station Communications Systems, Fire and Intrusion Alarm Systems, to provide data signals to fare collection equipment, elevators and escalators, and to provide an effective communications interface with the public (customers).
- B. Facilities shall be provided in each kiosk for the station manager to monitor and control passenger station systems. A complete “Kiosk Facility” shall be provided including kiosk cabinets, system interface panels, cables, cable termination facilities, loudspeakers, wiring and all hardware needed to complete the installation of Station Monitor/Control Systems in the kiosk. The requirements for the individual monitor/control panels and systems, to be installed in the kiosk, are included in the respective System Specification Sections.
- C. Cabinet Bays #1 through #6 shall be provided in the Kiosk(s) included in this Contract, as indicated on the Contract Drawings. Kiosk Cabinet Bay #7 will be furnished and installed by other trades.
- D. A Cable Termination Rack shall be provided in Cabinet Bay # 3 of the kiosk(s).
  - 1. The kiosk Cable Termination Rack shall consist of seven Terminal Strips and a Line Terminal Block. Terminal Strips shall be equally spaced on the Termination Rack. Each Terminal Strip within the kiosk Cable Termination Rack shall consist of sixty individual terminals. The kiosk Cable Termination Rack shall be provided in the kiosk(s) to terminate all cables and wires that are to be installed into the kiosk(s), with the following exceptions:
    - a. Call for Aid
    - b. Kiosk Multiline Telephone Cable Connections.
    - c. Fire and Intrusion Alarm System cables
    - d. Public Address System cables
    - e. 24-MM Optical Cable
- E. The fiber optic cables from the station Communications Room are terminated on the kiosk fiber optic patch panel.
- F. Kiosk Data Files for the passenger station(s) shall be engineered, drawn, printed, and delivered to the Contracting Officer Representative. The Kiosk Data Files shall be designed to be a convenient source of information on the layout of the following systems:
  - 1. Passenger Station Telephones
  - 2. Right-of-Way and Ancillary Building Telephones
  - 3. Passenger Station Fire Zones
  - 4. Ancillary Building Fire Zones
  - 5. Passenger Station Intrusion Zones
  - 6. Ancillary Building Intrusion Zones
  - 7. Escalators

8. Closed Circuit Television System
  9. Call for Aid System
- G. Laminated Fire and Intrusion Zone tables shall be provided for the passenger station(s).
- H. The Escalator Display Panel provides four status indicators and one identification indicator for each of up to 16 escalators. The following indicators are provided for each escalator:
1. Direction of Travel - "UP" or "DOWN"
  2. Automatic Operation - "AUTO OPER"
  3. Out of Service -"OUT SERV"
  4. Escalator Identification - "ESC XX" where "XX" is the number of the escalator
- I. The Escalator Display Panel also includes a momentary, non-illuminating, pushbutton switch to permit a lamp test of all indicators on the panel.
- J. Kiosk Monitor/Controls provide the station manager with a means to effectively manage passenger station activities. The operation of the monitor/control panels and systems, to be installed in the kiosk (except the Escalator Control Panel described in this Section), is described in the individual system specifications.
- K. Kiosk Information Display System (KIDs) shall be furnished, installed, and tested by the Contractor. KIDs shall consist of, but not be limited to, the following components:
1. 47-inch flat LCD panel (Ciil CL-47PLCC68/CL-47PLC68-S or approved equal):
    - a. 1920 x 1080 resolution
    - b. IP68 rated
    - c. 120 VAC power input
    - d. Anti-reflective impact-resistant and UV protected glass
    - e. Ambient light
    - f. UL Listed
    - g. Weight of 120 lbs maximum
  2. HDMI cable, male to male: Blackbox EVHDMI01T or approved equal
    - a. 28 AWG conductors
    - b. Copper contacts with gold plate
    - c. Black PVC jacket
    - d. Aluminum Mylar and tinned copper shielding
    - e. Rated for high bandwidth uncompressed video
  3. Cisco Edge 300 or approved equal
    - a. Shall be installed in adjacent or in same bay cabinet as kiosk LAN switch.

## 1.02 SYSTEM DESCRIPTION

- A. Description: The Kiosk System provides the kiosk with the equipment needed to monitor and control passenger station Communications Systems, Fire and Intrusion Alarm Systems, to

provide data links for fare collection equipment, elevators and escalators, and to provide an effective communications interface with the public (customers).

**B. Capacity**

1. Kiosk Cabinet Bays #1 through #6C shall be furnished and installed in the kiosk(s).
2. Furnish and install the Escalator Display Panel(s) and associated conduit and cabling.
3. One set of Kiosk Data Files for each kiosk in each passenger station, and twelve additional sets of Kiosk Data Files shall be created, published, and delivered for each passenger station
4. A Kiosk Cable Termination Rack shall be furnished and installed in each kiosk.
5. An Emergency Communications Kiosk Terminal Panel shall be furnished and installed in each kiosk, Bay 2C.
6. An Elevator Control Panel (provided under Section 14240, ELECTRIC TRACTION ELEVATORS) shall be installed in the kiosk, Bay 3.
7. A Remote Fire Annunciator panel shall be furnished and installed in each Kiosk. Refer to Section 16732, FIRE ALARM SYSTEM, for description, Bay 6B.
8. A Closed Circuit Television console shall be furnished and installed in each Kiosk. Refer to Section 16851, CLOSED CIRCUIT TELEVISION SYSTEM, Bay 2B.
9. A Public Address System console shall be furnished and installed in each Kiosk. Refer to Section 16820, PUBLIC ADDRESS SYSTEM, Bay 3
10. Cat6 cables for New Electronic Payment Program (NEPP) shall land in Bay 1.
11. The fiber optic cables from the station Communications Room and Cat6 (yellow) from local cameras shall be terminated on the appropriate patch panels in Bay 2A.
12. Equipment for video management and KIDS shall be placed in Bay 2B
13. Electrical panel of appropriate size shall be provided.

C. The Kiosk Cable Termination Rack consists of seven Terminal Strips and a Line Terminal Block in Cabinet Bay 6B. Each Terminal Strip within the Kiosk Cable Termination Rack consists of sixty individual terminals. The Kiosk Cable Termination Rack terminates all cables and wires that are to be installed into the kiosk(s), with the following exceptions:

1. Fiber-optic video cables
2. Integrated Intercommunications' System cables
3. Kiosk Multi-line Telephone Cable Connections

D. The fiber optic cables from the station Communications Room are terminated on the fiber optic patch Panel in Bay 2A.

**1.03 RELATED SECTIONS**

- A. Section 14200, HYDRAULIC ELEVATORS
- B. Section 14240, ELECTRIC TRACTION ELEVATORS
- C. Section 16705, COMMUNICATION EQUIPMENT AND MATERIAL
- D. Section 16710, GROUNDING AND BONDING FOR COMMUNICATION SYSTEMS

- E. Section 16715, COMMUNICATION ELECTRICAL POWER DISTRIBUTION
- F. Section 16820, PUBLIC ADDRESS SYSTEM
- G. Section 16851, CLOSED CIRCUIT TELEVISION SYSTEM
- H. Section 16732, FIRE ALARM SYSTEM
- I. Section 16728, CALL FOR AID SYSTEM
- J. Section 16740, ACCESS CONTROL SYSTEM

#### 1.04 REFERENCES

- A. Code of Federal Regulations, Title 47 Telecommunications, Part 15 – Radio Frequency Devices (47 CFR 15), Subparts A and B
- B. UL 50 – Enclosures for Electrical Equipment, Non-Environmental Considerations
- C. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
- D. NEMA KS 1 - Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum)
- E. ITU-T and EIA/TIA Recommendations
- F. Standard for Fixed Guideway Transit and Passenger Rail Systems (NFPA 130)
- G. National Electric Code (NEC, NFPA 70) 2014 edition

#### 1.05 QUALITY ASSURANCE

- A. Design and production tests: Refer to the Contract Documents. Submit certified test results, or provide certified test results on identical units. Furnish certified test reports showing test data and results as well as manufacturer's comments on tests.
- B. Interchangeability: Refer to the Contract Documents. Furnish products of a manufacturer regularly engaged in the manufacture of applicable systems. In addition:
  1. Standard commercial products shall be furnished whenever such equipment and materials will satisfy the stated specifications. Suitable modified standard commercial devices shall be furnished when required to satisfy specification requirements. Custom developed and fabricated equipment units and devices shall be confined to those items for which suitable commercial off-the-shelf (COTS) products are not available to guarantee compliance with the Specifications. When custom design, fabrication, or assembly is required, every effort shall be made to minimize the number of different modules, solid-state devices used.
  2. With each system, subsystem, and facility, two or more like functions shall be performed by identical units. In no case shall the equipment or hardware used in one portion of a system, subsystem or facility be different from that used in another portion to perform the same function under similar operating and environmental conditions (outdoor systems are distinct from indoor systems).
  3. Equipment shall be physically and plug compatible with recent versions of existing WMATA equipment performing similar functions and used for comparable applications elsewhere in similar WMATA's facilities, insofar as possible. The use of adapter plugs, interface boxes, and replacement mounting brackets or enclosures that fit available space and mounting holes may be allowed by the Authority to maintain interchangeability when competitive products that do not require such devices are determined to be unavailable (applicable to COTS major equipment items only). Custom designed and fabricated equipment must be fully interchangeable without requiring the use of such devices. If a determination is made to allow use of such devices, all

necessary adapters and interface devices shall be provided with each item of equipment furnished, at no additional cost to the Authority.

4. Equipment shall be software compatible with recent versions of existing WMATA equipment performing similar functions and used for comparable applications elsewhere in similar WMATA facilities.
  5. Major items of equipment furnished shall be within the physical size and configuration limitations specified in provisions of this Subcontract. If such specifications are not included in the provisions, major items of equipment shall be of a physical size and configuration closely comparable to equipment currently in use of comparable applications elsewhere in similar WMATA facilities.
  6. Exception: Lighter weight and smaller sized more modern versions of equipment are sought by the Authority where their use presents significant advantages. The use of new generations of equipment that differ in size and are not fully interchangeable will be considered for approval by the Authority, in order to take advantage of significant technological improvements developed by industry.
- C. Qualifications of Instructor for Operation and Maintenance Training: Perform operation and maintenance training for applicable systems. Qualifications will be considered adequate when the following is demonstrated:
1. Instructor has in-depth knowledge of the design, packaging, operations, maintenance, and trouble-shooting of the systems to be taught.
  2. Instructor has been trained in teaching methods or has previous satisfactory experience in teaching with emphasis on the subject matter to be covered in the course of instruction.

#### 1.06 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the Products specified in this Section with minimum 3 years documented experience.
- B. Supplier: Authorized distributor of specified manufacturer with minimum 3 years documented experience.

#### 1.07 MAINTENANCE SERVICE

- A. Furnish service and maintenance of Kiosk Systems until final Acceptance.

#### 1.08 FLOOR COVERING

- A. This Article specifies the furnishing and installation of rubber floor covering and stair treads.
- B. Qualifications of Manufacture: Provide the Product of an established manufacture regularly engaged in the production of the floor covering specified.
- C. Deliver products to the job site in their original unopened containers clearly labeled with the manufactures' name, brand designation, and type as applicable.
- D. Store products in a dry area protected from contact with soil and from exposure to the elements.
- E. Handle the products in a manner that will prevent breakage of containers, damage to products and moisture intrusion.

## **PART 2 – PRODUCTS**

### **2.01 TERMINALS**

#### **A. Ratings**

1. Terminal Type: Modular Micro Terminal with Screw Clamp Connection
2. Wire size accommodated: #22 through #12-AWG
3. Rated Current: 27 Amps
4. Rated Voltage: 300 VDC
5. Center-to-Center Spacing: 6 mm

### **2.02 KIOSK CABINET BAY ASSEMBLY**

#### **A. Ratings**

1. Frame Material: 16-Gauge Galvanized Steel
  1. Exposed Metal Finish: Metro Bronze color 20040 (Federal Standard 595B)
2. Desk Tops: 1-inch Marine Plywood (MARINE AA EXT-APA)
3. Hardware: Cadmium Plated
4. Desk-Top Laminate: DuPont Corian with bull nose edge
5. Desk-Top Laminate Color: Neutral White #918.Aurora
6. Blank Panels-16-Gauge Galvanized Steel, painted to match kiosk cabinets

### **2.03 KIOSK DATA FILE**

- A. Description: Each Kiosk Data File shall consist of eight or more 11-inch by 17-inch drawings.
- B. Prepared Kiosk Data File drawings to document each of the following subjects:
  1. Telephones (passenger station) - A cross-reference of telephone numbers and telephone locations within a passenger station
  2. Telephones (Right-of-Way and Ancillary Facilities) - A cross- reference, by telephone numbers and locations, of the telephones along the right-of-way and in ancillary facilities associated with a passenger station
  3. Fire Zones (Passenger Station) - A cross-reference of the designated fire zones, room numbers and room descriptions for all areas within a passenger station including ancillary facilities within the passenger station limits.
  4. Fire Zones (Ancillary Facilities) - A cross-reference of the designated fire zones in remote ancillary facilities associated with a passenger station.
  5. Intrusion Zones (passenger station) - A cross-reference of the designated intrusion zones, room numbers, and room descriptions for all areas of a passenger station, including ancillary facilities within the passenger station limits.
  6. Intrusion Zones (Ancillary Facilities) - A cross-reference of the designated intrusion zones in remote ancillary facilities associated with a passenger station.
  7. Escalators - A cross-reference of assigned escalator numbers and escalator locations within a passenger station.

8. CCTV - A cross-reference of television monitor assignments and arrangements, and television camera designations, locations and areas of coverage for all television cameras and television monitors within a passenger station.
9. Integrated Intercommunications System - A layout of platform(s) showing locations and designations of call stations

C. Rating

1. Seal Kiosk Data File drawings in a protective plastic laminate
2. Each Kiosk Data File set shall be in loose-leaf booklet form
3. Covers: 11-inch by 17-inch minimum of 60-pound punched paper with holes reinforced with plastic, cloth or metal, and sealed in a protective plastic laminate

2.04 EMERGENCY COMMUNICATIONS KIOSK TERMINAL PANEL

A. Description: The Emergency Communications Kiosk Terminal Panel consists of three terminal blocks mounted on a 16-gauge steel plate and has the following characteristics:

1. Two of the terminal blocks shall each have a minimum of 23 miniature terminals
2. The other terminal block shall have a minimum of 20 miniature terminals

2.05 FLOOR COVERING

- A. Floor Covering: Heavy-duty rubber mat with ribbed surface and smooth back, all rubber compound 3/16-inch thick, terra cotta color.
- B. Rubber Stair Tread: Molded tread, all rubber compound, free of blemishes, 5/16 inch thick; with light color nosing 1/2 inch wide, terra cotta color. Abrade at least 80 percent of back of tread and nosing to assure adhesion to substrate.
- C. Stair Tread Adhesive: Permanent, as recommended by tread manufacturer for adhesion to galvanized steel substrate.
- D. Fabricate floor covering in five pieces to fit area shown, with edges square and true, without overlapping.
- E. Verify configuration of equipment in Kiosk to ensure fit of flooring within 1/16-inch tolerance.
- F. Fabricate nosing of stair tread to wrap around curved ends of step, to provide uniform elevation appearance on three sides of step. Fabricate and adhere nosing so that it will not delaminate or otherwise separate from the stair tread material.

**PART 3 – EXECUTION**

3.01 INSTALLATION

A. Kiosk Cabinet Bay Assembly Installation

1. Install the assembled kiosk cabinetry in the kiosk of the passenger station(s). Cabinet assembly installation shall be as follows:
  - a. Bays # 1, #2A, 2B, 2C and #3 as a single unit; Bays #4, #5, and #6A, 6B, and 6C as a single unit, secured to the floor of the kiosk. Kiosk cabinets may be secured to the kiosk sides with approval; however, the securing hardware shall not carry any vertical load. Hardware installed in the kiosk sides shall only be used to prevent horizontal movement.

B. Kiosk Cable Termination Rack Installation

1. Install a Kiosk Cable Termination Rack in Kiosk Cabinet Bay 6B of the kiosk. Install structure elements in the Kiosk Cabinet Bay 6B to accommodate the Terminal Strips and the Line Terminal Block of the Kiosk Cable Termination Rack.
- C. Emergency Communications Kiosk Terminal Panel
1. Install an Emergency Communications Kiosk Terminal Panel in Kiosk Cabinet Bay 6B of the kiosk, as indicated on Contract Drawings. Installation shall not interfere with the Cable Termination Rack Terminal Strips. Secure Cables to the Emergency Communications Kiosk Terminal Panel to the panel to prevent interference with the Kiosk Cable Termination Rack wiring and cabling.
- D. Escalator Display Panel
1. Install an Escalator Display Panel in Cabinet Bay 3 of the Kiosk.
    - a. Install the required wiring harness (es) between the panel and the Kiosk Cable Termination Rack in Bay 6B, and make all necessary connections and cross-connections. Install one 9-conductor, 18-AWG, shielded cable for each escalator associated with the passenger station(s) between the Kiosk Cable Termination Rack in Bay 6B of the Kiosk and the Escalator Terminal Box in the escalator wellways. Terminate the cables in the kiosk and at the escalators and make all necessary connections and cross-connections.
- E. Elevator Control Panel
1. The Elevator Control Panel will be installed in Bay 3 of the kiosk under Section 14240, ELECTRIC TRACTION ELEVATORS.
- F. 24-MM/ Optical Cable
1. A fiber-optic cable containing twenty-four multi-mode fibers shall be installed between the Kiosk and the Communications Room. The multimode fiber shall be 50  $\mu$ m laser optimized (OM3). The cable should be terminated, on Type SC bulkhead adapters on an optical patch/termination panel on both ends, in Bay 2A.
- G. One 25 pair VF plenum rated copper twisted pair cable shall be installed from the main communications room to the kiosk. This cable shall terminate on a wall mount style 110 termination block at each end and will be used to extend emergency telephone service to the Kiosk in the event of VoIP system failure. Cable must be NFPA 130 compliant.
- H. Public Address Control Panel
1. Install a Public Address Control Panel in Cabinet Bay 3 of the Kiosk.
    - a. Install the required wiring harness (es) between the panel and the Public Address equipment located in the communication room, and make all necessary connections and cross-connections.
- I. Closed Circuit Television
1. Install 2 touch screen monitors above Cabinet Bays 2B, and 2C. Install 4 viewing monitor on a mounting beam at the top of the window above Bays 2A and 2B. Install the required wiring to the workstation in Bay 2B. The Video Management Server shall be located in the communication room, connect via network switch.
- J. Fire and Intrusion Control Panel
1. Install a remote Annunciator Fire and Intrusion Panel in Cabinet Bay 6B. Install all required parallel wiring to the Common Control Unit located in the communication room, and the connection to the LAN/WAN that is connected to the Head-End in the Jackson Graham/Carmen Turner Buildings OCCs.

K. Kiosk Information Display System (KIDS)

1. KIDs display shall be mounted on face of station entrance kiosk. Mounting bracket for display is preferred to be built into structure of kiosk. Location of display shall be coordinated with location of kiosk-mounted cameras. Color of display body shall match that of the kiosk. Maximize visibility to riders in the kiosk area. The unique lighting conditions, including glare, at each kiosk shall be considered to optimize visibility. Typically the KID shall be mounted on the kiosk front face. The Contractor may recommend another kiosk face if it thinks it may provide better utility, visibility and usefulness to passengers. WMATA shall have final approval of any recommended deviations, and approval must be received before installation may begin. HDMI cables shall not exceed 30 feet in length. Final integration of KIDs will be performed by WMATA.

3.02 MANUFACTURER'S FIELD SERVICES

- A. Prepare and start systems
- B. Inspect final wiring connections and supervise or perform system adjustments

3.03 ADJUSTING

- A. Adjust operating Products and equipment to ensure smooth and unhindered operation

3.04 FLOOR COVERING

- A. After installation, prohibit traffic and protect floor covering with plastic sheets or heavy building paper with taped joints. Use plywood protection boards when moving equipment. Maintain protection until Acceptance.

**END OF SECTION**

## SECTION 16740

### COMMUNICATIONS – ELECTRONIC ACCESS CONTROL SYSTEM

#### PART 1 - GENERAL

##### 1.01 SUMMARY

- A. This section specifies a complete and operational Access Control system for Authority-wide including WMATA's rail system, parking garages, bus divisions, and support facilities.
- B. Related Sections:
  - 1. Section 08331 – Overhead Coiling Doors
  - 2. Section 08710 - Finish Hardware
  - 3. Section 16703 – Communications Standard Specifications-Engineering Services
  - 4. Section 16704 – Communications Standard Specifications-Installation
  - 5. Section 16705 – Communications Standard Specifications-Equipment & Material
  - 6. Section 16706 – Communications System Submittals & Services
  - 7. Section 16707 – Communications Quality Assurance & Testing
  - 8. Section 16710 – Communications Grounding
  - 9. Section 16715 – Communications Electrical Power Distribution
  - 10. Section 16120 - Wire Cable, and Busways
  - 11. Section 16733 – Communications – Kiosk Systems

##### 1.02 REFERENCES

- A. Code, Regulations, Reference Standards, and Specifications:
  - 1. National Electrical Code (NEC)
  - 2. NFPA 130 – Standard for Fixed Guideway Transit Systems
  - 3. UL 1076 – Proprietary Burglar Alarm Units and Systems
  - 4. ADA Standards
  - 5. Electronics Industries Alliance (EIA) Standard RS 170
  - 6. Federal Standard 595B, Colors Used in Government Procurement
  - 7. WMATA Design and Wiring Standards rev1 May 2014
  - 8. WMATA Standards Access Control drawings

##### 1.03 QUALITY ASSURANCE

- A. Qualifications:
  - 1. Equipment manufacturer: Select a manufacturer who is engaged in production of similar Access Control products and accessories.
  - 2. Equipment supplier: A manufacturer authorized distributor of specified products with minimum of three years documented experience.
  - 3. Equipment installer: A manufacturer authorized installer of specified products with service facilities within 100 miles of WMATA.

- B. Coordination
  - 1. Installer shall coordinate Access Control installation with all other concurrently running work at the location specified under this task.
- C. The Contractor shall develop test procedures and obtain Engineer approval prior to final acceptance testing.
- D. The Contractor shall perform progressive tests in accordance with the approved test procedure to verify compliance with specified system performance requirements, including but not limited to proper component operation, and software operations.
  - 1. The Contractor's Quality Assurance Engineer shall witness all progressive testing.
  - 2. All discrepancies found during testing shall be corrected and test reports submitted prior to scheduling end-to-end testing.
  - 3. The Contractor shall notify the Engineer prior to commencing progressive testing and shall offer the Engineer the opportunity to witness the testing. Witnessing of any portion of the progressive testing by the Engineer shall not relieve the contractor from responsibility for any portion of follow-on testing.
- E. End-to-End Test:
  - 1. The Contractor shall demonstrate the proper functioning of the completed Access Control system.
  - 2. Each access control device shall operate as specified in the design drawings and be properly configured on the access control software.
  - 3. The Contractor shall submit certified test reports within 10 working days after completion of field tests.

**1.04 SUBMITTALS**

- A. Submit the following for approval in accordance with Section 16706 and with the additional requirements as specified for each:
  - 1. Design Drawings
    - a. Proposed changes and revised equipment layouts
    - b. System riser diagrams to include source of power.
    - c. Access Control equipment mounting details.
    - d. Completed door controllers and equipment schedules
  - 2. Product Data: Provide product data sheets for each item of equipment and resubmittal for equipment which changes as a result of required modification.
  - 3. Manufacturer's Installation Instructions
    - a. Indicate application conditions and limitations of use, stipulated by Product testing agency.
    - b. Include instructions for storage, handling, protection, examination, preparation, installation, and start-up of Product.
- B. As-Built Documents: Prior to Substantial Completion, develop As-Built documents as follows:
  - 1. As-Built Drawings of the Access Control system installation to include, but not be limited to camera layouts, communication and power cable pathways and wiring, equipment details and equipment schedules.
  - 2. Approved copies of each submittal

- C. Operation and Maintenance (O & M) manuals
  - 1. Complete printed operating instructions in manual or handbook form, completely and clearly indexed for ready reference during actual operation and for use as text during instruction of personnel.
  - 2. Include descriptions of systems, background information, and complete procedures for adjustment, calibration, replacement, and repair of components in system.
  - 3. Make data contained specific for and exclusive to the systems and equipment for the work of this Contract.
  - 4. Field test data and reports.
- D. Certification
  - 1. Certificates from manufacturers verifying that equipment conforms to the specified requirements.

**1.05 OPERATION AND MAINTENANCE TRAINING**

- A. In accordance with the General Requirements.

**PART 2 - PRODUCTS**

**2.01 SECTION INCLUDES:**

- A. Access Control Hardware
- B. Software Licensing

**2.02 PoE DOOR CONTROLLER**

- A. Make and Model: Honeywell PW6K1ICE or approved equal
- B. Power Input:
  - 1. Power over Ethernet (PoE) 12.95W
  - 2. 12 VDC, 200 mA min, 900 mA max
- C. Power Output:
  - 1. 12 VDC @ 650 mA (reader and AUX outputs combined)
  - 2. 10.3 – 12.6 VDC reader output @ 150 mA max
  - 3. 10.7 – 13.0 VDC AUX power output @ 700 mA max
- D. Environmental Factors:
  - 1. Operating temperature: 0°C to 70°C (32°F to 158°F)
  - 2. Humidity: 10 - 95% RHNC
  - 3. Storage conditions: -55°C to 85°C (-67°F to 185°F)
- E. Host Communication: RJ-45 for 10BASE-T/100BASE-TX PoE interface
- F. Inputs: 2 supervised, programmable end of line resistors, 1k/1k-ohm 1% 1/4 watt standard, and dedicated tamper switch
- G. Relays: 2 outputs, Form-C contacts: 2A @ 30 VDC
- H. Reader Module:
  - 1. Configuration: wiegand or OSDP
  - 2. Reader Power: 12VDC 10% or local power supply
  - 3. Reader Data Inputs: Two TTL reader ports or one 2-wire RS-485 reader port

capable of supporting two readers

- I. Cable Requirements:
  - 1. Power: 1 twisted pair, 18 AWG
  - 2. Ethernet: CAT-6
  - 3. Reader Data (TTL): 18 AWG – 6 conductors, 500 ft. (150 m) max
  - 4. Reader Data (RS-485): 24 AWG, 120Ω impedance, twisted pair with shield, 4,000 ft. (1,219 m) max
  - 5. Alarm Input: 1 twisted pair per input (30Ω max loop resistance)
- J. Compatibility:
  - 1. Access Control Software: the door controller shall be compatible with the access control server. The access control software configures the door controller. The door controller sends a transaction log on real time to the access control server through the WMATA's WAN network.
  - 2. Card Readers: the reader module which is part of the door controller shall be compatible with the wiegand output of Mifare Plus S and 125 kHz proximity readers.
- K. Warranty: 1-year warranty

### **2.03 PoE DOWNSTREAM DOOR CONTROLLER**

- A. Make and Model: Honeywell PW6K1R1E or approved equal. Up to 26 PW6K1R1E downstream boards can be connected to PW6K1ICE controller board
- B. Power Input:
  - 1. Power over Ethernet (PoE) 12.95W
  - 2. 12 VDC, 200 mA min, 900 mA max
- C. Power Output:
  - 1. 12 VDC @ 700 mA max (reader and AUX outputs combined)
  - 2. 10.3 – 12.6 VDC reader output @ 150 mA max
  - 3. 10.7 – 13.0 VDC AUX power output @ 700 mA max
- D. Environmental Factors:
  - 1. Operating temperature: -40°C to 75°C (-40°F to 167°F)
  - 2. Humidity: 10 - 95% RHNC
  - 3. Storage conditions: -55°C to 85°C (-67°F to 185°F)
- E. Host Communication: RJ-45 for 10BASE-T/100BASE-TX PoE interface
- F. Inputs: 4 unsupervised/supervised, Programmable End of Line resistors, 1k/1k-ohm 1% 1/4 watt standard, and dedicated tamper switch
- G. Relays: 2 outputs, Form-C contacts: 5A @ 28 VDC
- H. Reader Module:
  - 1. Reader Power: 12VDC 10% or local power supply
  - 2. Reader Data Inputs: Two TTL reader ports or one 2-wire RS-485 reader port capable of supporting two readers
- I. Cable Requirements:
  - 1. Power: 1 twisted pair, 18 AWG

2. Ethernet: CAT-5 (minimum)
  3. Reader Data (TTL): 18 AWG – 6 conductors, 500 ft. (150 m) max
  4. Reader Data (RS-485): 24 AWG, 120Ω impedance, twisted pair with shield, 4,000 ft. (1,219 m) max
  5. Alarm Input: 1 twisted pair per input (30Ω max loop resistance)
- J. Reader Data Inputs: Two TTL reader ports or one 2-wire RS-485 reader port capable s:
- K. Compatibility:
1. Access Control Software: the downstream door controller shall be compatible with the access control server. The access control software configures the downstream door controller. The downstream door controller sends a transaction log to the access control server on real time through the WMATA's WAN network.
  2. Card Readers: the reader module which is part of the door controller shall be compatible with the wiegand output of Mifare Plus S and 125 kHz proximity readers.
- L. Warranty: 1-year warranty

#### **2.04 CARD READER WITH KEY PAD**

- A. Make and Model: Oberthur ID One Secure Pac reader. Model 125 14443 DF PIN 500-5045 with WMATA profile or approved equal
- B. Power Supply: 7 – 24 VDC (12 VDC recommended)
- C. Current Consumption @ 12 VDC:
  1. Average: 110 mA
  2. Peak: 171 mA
- D. Typical Read Range:
  1. Mifare ISO card: 60 mm (2.4 inch)
  2. LF Proximity ISO card: 30 – 60 mm (1.2 – 2.4 inch)
- E. Host Communication: RJ-45 for 10BASE-T/100BASE-TX PoE interface
- F. Operating Temperature: -25°C - 65°C (-15°F - 150°F)
- G. Protection Class: IP54
- H. Cards: Mifare Plus S, 26-Bit and 37-Bit 125 kHz proximity cards.
- I. Warranty: 2-year warranty

#### **2.05 CARD READER WITHOUT KEY PAD**

- A. Make and Model: Oberthur ID One Secure Pac reader. Model 125 14443 DF 500-5045 with WMATA profile
- B. Power Supply: 7 – 24 VDC (12 VDC recommended)
- C. Current Consumption @ 12 VDC:
  1. Average: 110 mA
  2. Peak: 146 mA
- D. Typical Read Range:
  1. Mifare ISO card: 60 mm (2.4 inch)
  2. LF Proximity ISO card: 30 – 60 mm (1.2 – 2.4 inch)

- E. Host Communication: RJ-45 for 10BASE-T/100BASE-TX PoE interface
- F. Operating Temperature: -25°C - 65°C (-15°F - 150°F)
- G. Protection Class: IP54
- H. Cards: Mifare Plus S, 26-Bit and 37-Bit 125 kHz proximity cards.
- I. Warranty: 2-year warranty

## **2.06 MOTION SENSORS**

All motion sensors shall be able to be powered by either 12VDC or 24 VDC.

- A. Ceiling Mount: high performance panoramic, dual element sensor Bosch DS938Z or approved equal
- B. Wall Mount: high performance panoramic, dual element sensor Bosch DS778Z or approved equal
- C. Request to Exit (REX) Motion Sensor: Bosch DS150i or Securitron XMS, or approved equal

## **2.07 CREDENTIALS**

- A. Mifare Plus S which supports ISO/IEC 14443 Type A with communication speed up to 848 kbit/s. Make and Model: NXP model MF1SPLUS6001DA4 in MOA4 module form

## **2.08 REQUEST TO EXIT (REX) PUSHBUTTON**

- A. Plastic button: Alarm Controls TS-2 or approved equal
- B. Metal button: Schlage Locknetics 620 series or approved equal

## **2.09 DOOR STRIKES**

- A. Refer to the Access Control Standard Drawings for door details and door strikes type. Door strikes to be able to be powered by either 12VDC or 24VDC.

## **2.010 MAGNETIC LOCKS (MAGLOCKS)**

- A. All Maglocks shall be able to be powered by either 12VDC or 24VDC. Make/Model: Securitron M62 series or approved equal

## **2.011 DOOR POSITION SWITCH**

- A. Make and Model: Sentrol 1076C or approved equal. Similar color of the door frame.

## **2.012 POWER SUPPLY**

- A. All power supplies to deliver at least 2 Amps @ 12VDC or 24 VDC. Make/Model: SDC 602RF or approved equal

## **2.013 ACCESS CONTROL ENCLOSURE**

Refer to the access control enclosure standard drawing for devices installed inside and mounting details

## **2.014 SOFTWARE LICENSE**

- A. Stand Alone Applications: access control software compatible with card readers described above and the use of Mifare Plus S cards. Pro-Watch corporate edition or approved equal
- B. Addition to the existing system: new access controlled doors shall be configured on the existing access control software adding the proper amount of card licenses

## **PART 3 - EXECUTION**

### **3.01 DESIGN**

- A. Submit the optimum design layout of the new access controlled doors and devices specifications prior to installing any equipment. The Contractor will use the layout to determine the adequacy of the design and, in conjunction with a field survey, determine the exact location of each Access Control device

### **3.02 INSTALLATION**

- A. Installation of devices covered by these specifications shall comply with the Access Control Standard drawings
- B. Installation of access control devices shall be performed in a neat and professional manner and retain all elements of the rail and bus system's architectural excellence
- C. Installation of access control devices shall be coordinated with work of other trades
- D. Access Control equipment shall be installed in accordance with manufacturer's instructions
- E. Access Control equipment shall not be installed over tracks or extend beyond the inside of the platform edge granite unless otherwise specified and approved.
- F. All cables shall be installed and tested in accordance with the most current WMATA Design and Wiring Standards
- G. For conduit, raceways and cabinet installation see Section 16130
- H. For wire cable and busways installation, see Section 16120

### **3.03 SOFTWARE CONFIGURATION**

- A. Configure and document all parameters chosen during the configuration of all new devices the access control software
- B. The Contractor shall configure new devices on the access control software with the supervision of the WMATA engineer

### **3.04 FIELD QUALITY CONTROL**

- A. Design and Performance Testing: Perform tests and submit results in accordance with the General Provisions, certified test results for the Access Control system installed under this contract
- B. Acceptance Testing:
  - 1. Furnish equipment required to perform tests
  - 2. Comply with WMATA approved system testing
  - 3. Perform approved tests to verify that the Access Control systems comply with requirements shown and specified
- C. The Contractor is responsible for testing all power and communications signals in accordance with WMATA's Design and Wiring Standards

### **3.05 DEMONSTRATION**

- A. Conduct walking tour of Project and briefly describe function, operation and maintenance of the system components
- B. Demonstrate operation and maintenance of the system to WMATA personnel two weeks prior to date of Substantial Completion
- C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with WMATA personnel in detail to explain all aspects of operation and maintenance
- D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing,

maintenance and shutdown of each item of equipment at equipment location

- E. Prepare and insert additional data in operations and maintenance manuals as needed for additional data becomes apparent during instruction

**3.06 SPARE PARTS**

- A. In accordance with special conditions and the following:

- 1. Provide spare parts and/or equipment for no less than 10% of new items that are added to WMATA's inventory under this task

**PART 4 - END OF SECTION**

## SECTION 16771

### COMMUNICATIONS - CARRIER TRANSMISSION SYSTEM

#### PART 1 - GENERAL

##### 1.01 SECTION DESCRIPTION AND BASIC REQUIREMENTS

- A. This Section describes the basic requirements for the installation of the Carrier Transmission System (CTS). The CTS System consists of Integrated Access Device (IAD) terminals and/or related equipment in Passenger Stations. The Carrier Transmission System is an integral part of the WMATA telecommunications network used to multiplex voice and data transmissions of the WMATA Rail Rapid Transit System into a dedicated digital carrier. The CTS uses a T1 digital format to transmit trunked information between the CTS hub at the Jackson Graham Building and terminal locations (passenger stations, yards and selected buildings) along the WMATA right-of-way
- B. The transmission medium for the Telecommunications Network shall be fiber-optic cable.
- C. At each terminal location, the equipment associated with the Carrier Transmission System is powered from a 48-Vdc power system. (See Power System Specifications.)

##### 1.02 SECTION INCLUDES

- A. Integrated Access Device (IAD) Equipment.
- B. Fuse, Alarm and Distribution Panel.
- C. Multi-Section Main Distribution Frame

##### 1.03 UNIT PRICES

- A. Unit Prices include incidental items, not specifically mentioned, but required for complete and proper system operation.

##### 1.04 RELATED SECTIONS

- A. Section 16705 - Communications Standard Specifications - Equipment & Material
- B. Section 16706 - Communications System Submittals & Services
- C. Section 16707 - Communications Systems Quality Assurance & Testing
- D. Section 16710 - Communications Grounding.
- E. Section 16715 - Communications Electrical Power Distribution.
- F. Section 16776 - Communications - Fiber Optics System.

##### 1.05 REFERENCES

- A. Bell Communications Research (Bellcore) Publication 43801, Digital Channel Bank - Requirements and Objectives.
- B. FCC Part 15, Radio Frequency Devices.

## 1.06 SYSTEM DESCRIPTION

- A. Description: The CTS uses a T1 digital format to transmit trunked information between the CTS hub at the Jackson Graham Building and terminal locations (passenger stations, yards and selected buildings) along the WMATA right-of-way using the Fiber Optic System described in Section 16776.
- B. An Integrated Access Device (IAD) terminal is connected to the fiber-optic terminal at each location to convert information into a format suitable for transmission on the fiber-optic system. In the transmit direction, channel units and common equipment shall convert data, voice and signaling information from base band channels into a digital bit stream. In the receive direction, the received digital bit stream shall be converted into base band channels of data, voice and signaling information. A single terminal can support up to 64 voice channels, each of which can be allocated or reallocated to any desired time slot within a T-1 bit stream, using the terminal's firmware. Additionally, DSO signals can be cross connected from one T-1 bit stream to another, using the terminal's software. The 1518 IAD Multiplex Equipment consists of the following equipment and channel cards mounted in a connectorized multiplex shelf:
1. The chassis provides 18 card slots, front and rear load, not counting ring generator cards or power supply units. The front side supports connectivity for up to two CPU cards, three server cards, and four WAN cards, (Ref. Dual T1/E1 Line Interface Unit). Additionally, there are two slots available for Power Supply Units. The rear side supports connectivity for up to one Interface card (Ref. T1/E1 Interface Card) and up to eight voice cards. Additionally, there are five slots available for optional Power Supply units and Ringing Generator cards.
  2. The Interface Card provides the interface between the IAD and the Network Management System (Computer, WAN, or VT-100 Terminal). Connectivity is available on the card at the RJ-11 Modem Port, RS-485 Node Port, RS232 Ports, and the T1/E1 WAN Link Connector
  3. The DC Power Supply provides the -48Vdc to the system, including the Ringing Generator Unit.
  4. The Ringing Generator Unit provides the 105Vac, 20Hz ringing voltage required for FXO/FXS card operation. The unit is capable of driving 11 simultaneously ringing voice ports.
  5. The Dual T-1/E-1 Line Interface Unit (WAN CARD) terminates T1 and/or E1 lines and generates and receives network timing clocks. Additionally, the unit operates in conjunction with the CPU card, to perform cross connecting of DSO time slots from a T1 or E1 line to another, as required. Two cross connections are supported per card.
  6. The DSX/CEPT Plug In Module plugs into the Line Interface Unit (WAN Card) and provides the near-end termination point for the T1 or E1 line. Two modules are required for every Line Interface Unit.
  7. The FXS/FXO cards manage the flow of FXS voice traffic over the network. Subscriber cards (FXS) installed in 1518 IAD terminals at passenger stations and Office cards (FXO) installed in IAD terminals at the Central Office (JGB) encodes analog voice signals to a digital bit stream for transmission over the T1/E1 network. Each card also decodes the digital bit stream to an analog voice signal, sent by the remote terminal. Each card has 8 ports and can support up to 8 voice channels.
  8. The 5 Port OCU-DP provides direct access to a selected voice channel within the T1 /E1 digital bit stream.
  9. The E/M cards manage the flow of toll grade voice traffic through the T1/E1 network. Traffic flow is dependent on status of the signals on the card's E (Ear) and M (Mouth) pins. Each unit encodes an analog voice signal to a digital bit stream for transmission over the T1/E1 network. Each unit also decodes the digital bit stream to an analog

voice signal, sent by the remote terminal. Each unit has 8 ports and can support up to 8 voice channels.

10. The CPU Card performs a self-test on all cards plugged into the chassis, processes all incoming operator commands, stores the system software in flash memory, includes a test pattern generator for T1 and E1 line testing, and works in conjunction with the Dual T1/E1 Line Interface Unit, to provide cross connecting of DSO time slots from one T1 or E1 line to another as required.
- C. A Multi-Section Main Distribution Frame, located in each Communications Equipment Room, is used to house protector blocks and terminal blocks required to protect and terminate all communications cables.
- D. Capacity:
  1. The Contractor shall furnish and install Integrated Access Device (IAD) multiplex carrier systems in quantities mandated by the design of the overall communications system for each station, and design goals outlined in this specification.
  2. The Contractor shall furnish and install Fuse, Alarm and Distribution Panels in each equipment rack in which 48-Vdc equipment is installed.
  3. The Contractor shall design, furnish, and install a Multi-Section Main Distribution Frame in each Station Communications Equipment Room.

#### 1.07 SYSTEM PERFORMANCE REQUIREMENTS

- A. The Contractor shall be responsible for the overall performance of the Carrier Transmission System. The following overall System performance requirements are designed to ensure that the Carrier Transmission System, delivered under these Specifications, meets the performance requirements of the Washington Metropolitan Area Transit Authority.
  1. Total System Error Rate: less than 1 in  $10^{-6}$
  2. Crosstalk Coupling Loss: 65-dB minimum (700 to 1100 Hz)
  3. Loss Stability:  $\pm 0.6$  dB over life in 95% of the circuits.
  4. Tracking: -37 to +3 dBm<sub>0</sub> Input: 0.6 dB maximum deviation
  5. Tracking: -50 to -37 dBm<sub>0</sub> Input: 1.2 dB maximum deviation
  6. Idle Channel Noise: 25-dBm<sub>0</sub> maximum
  7. Frequency Response 4-Wire E&M Channel Units (Referenced 1020 Hz end to end):
    - a. 200-Hz: +0.3 to -3.2 dB
    - b. 300-Hz to 3000-Hz: +0.4 dB
    - c. 3200-Hz: +0.4 to -1.5 dB
    - d. 3400-Hz: +0.3 to -3.2 dB
  8. Frequency Response 2-Wire E&M Channel Units (Referenced at 1000 Hz at 0 dBm<sub>0</sub>, end to end):
    - a. 600-Hz to 2400-Hz: +1.2 dB
    - b. 300-Hz to 3400-Hz: +1.2 to -3.2 dB
  9. Frequency Response 2-Wire FXO/FXS Channel Units (Referenced 1020 Hz end to end):
    - a. 60-Hz: 20.0 dB minimum loss
    - b. 600-Hz to 2400-Hz: +1.0 dB
    - c. 300-Hz to 3400-Hz: -1.0 to -3.0 dB

#### 1.08 SUBMITTALS

- A. Submit under provisions of Section 16706.
- B. Shop Drawings: Indicate electrical characteristics and connection requirements, including system wiring diagram.

- C. Product Data: Provide showing electrical characteristics and connection requirements for each component.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

#### **1.09 QUALIFICATIONS**

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Supplier: Authorized distributor of specified manufacturer with minimum three years documented experience.
- C. Installer: Authorized installer of specified manufacturer with service facilities within 50 miles of Project.

#### **1.10 REGULATORY REQUIREMENTS**

- A. Conform to requirements of Bellcore Pub. 43801 and FCC Part 15.

#### **1.10 MAINTENANCE SERVICE**

- A. Furnish service and maintenance of Carrier Transmission System until Final Completion.

### **PART 2 - PRODUCTS**

#### **2.01 CTS MULTIPLEX SHELF (18 CARD SLOT)**

- A. Manufacturers:
  - 1. Alcatel part number 259-8004-523 (or approved equal)
- B. 19 inch rack mount with ear adaptors for 23 inch rack
- C. Front and rear load
  - 1. 9 front (plus 2 for power supply)
  - 2. 9 rear (plus 5 for ringing generator and generator supply)
- D. Meets requirements of FCC rules, part 15.

#### **2.02 INTERFACE CARD WITH MODEM (INF+M)**

- A. Manufacturers:
  - 1. Alcatel part number 259-8004-197 (or approved equal)
- B. Internal MODEM with 32K non-volatile RAM
- C. Connectors as follows:
  - 1. One RJ-1 1 (connects to phone line)
  - 2. One RS-485 (provides contacts to report alarms)
  - 3. One RS-233 Terminal Port (connects to VT1 00 terminals)
  - 4. One RS-232 Computer Port (connects to computer)
  - 5. One T-1/E-1 WAN Port (up to 8 connections supported)

#### **2.03 DC POWER SUPPLY (-48 VDC)**

- A. Manufacturers:
  - 1. Alcatel part number 259-5001-099 (or approved equal)
- B. Compatible with multiplex shelf and all plug-in modules
- C. Adequate power for fully equipped multiplex shelf

#### **2.04 -48 VOLT RINGING GENERATOR**

- A. Manufacturers:
  - 1. Alcatel part number 259-8004-725 (or approved equal)
- B. Compatible with multiplex shelf and all plug-in modules
- C. Ringing voltage = 105 Vac @ 20 Hz (up to 11 simultaneous ports)
- D. Includes master/slave jumpers for ganging signals together

#### **2.05 DUAL T-1/E-1 LINE INTERFACE UNIT (WAN CARD)**

- A. Manufacturers:
  - 1. Alcatel part number 259-8004-205 (or approved equal)
- B. WAN-Dual (S60) installed in slots W1, W2, or W3
- C. WAN-R (S60) installed in slot W4. Includes relays for auto activation upon failure of cards in slots W1, W2, or W3.
- D. Connects to two T1/E1 ports or combination thereof
- E. Power consumption
  - 1. WAN-Dual (S60)=1.5 watts
  - 2. WAN-R(S60) = 2 watts

#### **2.06 DSX/CEPT PLUG-IN MODULES**

- A. Manufacturers:
  - 1. Alcatel part number 259-8004-314 (or approved equal)
- B. Provides termination point for near-end T-1/E-1 line
- C. Two modules required per Interface Unit, WAN Dual (S60)
- D. Power consumption = 0.45 watts per module

#### **2.07 2 WIRE FXO CHANNEL UNIT (8 PORTS)**

- A. Manufacturers:
  - 1. Alcatel part number 2598004275 (or approved equal)
- B. Compatible with multiplex shelf
- C. Eight ports per unit

- D. Jumpers for Foreign Exchange (FXO) or Manual Ring-down (MRD) operation
- E. Frequency response (referenced to 1020 Hz, end to end) from 300 to 3000 Hz: +0.5 to 1.0 dB, or better
- F. Idle channel noise (end to end); 23 dBrcO maximum
- G. Termination impedance = 600 ohms (each port)
- H. Power consumption = 9.7 watts

#### **2.08 2 WIRE FXS CHANNEL UNIT (8 PORTS)**

- A. Manufacturers:
  - 1. Alcatel part number 259-8004-274 (or approved equal)
- B. Compatible with multiplex shelf
- C. Eight ports per unit
- D. Frequency response (referenced to 1020 Hz, end to end) from 300 to 3000 Hz: +0.5 to -1.0 dB, or better
- E. Idle channel noise (end to end); 23 dBmcO maximum
- F. Termination impedance = 600 ohms (each port)
- G. Power consumption = 9.7 watts

#### **2.09 OFFICE CHANNEL UNIT DATA PORT (5 PORTS)**

- A. Manufacturers:
  - 1. Alcatel part number 259-8004-519 (or approved equal)
- B. Compatible with multiplex shelf five (5) ports
- C. Multiple data rates up to 56 KBPS

#### **2.10 4 WIRE E&M CHANNEL UNIT**

- A. Manufacturers:
  - 1. Alcatel part number 259-8004-207 (or approved equal)
- B. Compatible with multiplex shelf
- C. Eight (8) ports with associated switches (S1-S4) for selecting E&M signaling type
- D. Termination impedance = 600 ohms (each port)
- E. Extended Transmit Range (TLP) included: provides -17.5 to+15 dB for dedicated 4 wire modem applications (required for data speeds of 19.2 KBPS and higher)
- F. Power consumption = 3.5 watts

#### **2.11 CPU CARD WITH CROSS CONNECTS**

- A. Manufacturers:
  - 1. Alcatel part number 259-8004-746 (or approved equal)
- B. Compatible with multiplex shelf
- C. Power consumption = 3.63 watts

## **2.12 FUSE, ALARM AND DISTRIBUTION PANEL**

- A. Manufacturers:
  - 1. Hendry Model Number HMW 06020-05, (or approved equal).
- B. Universal mounting for 19-inch or 23-inch relay rack
- C. Designed for -48 Vdc power supply distribution.
- D. Minimum of 10 fuse positions.
- E. 40 amp panel capacity.
- F. Alarm circuit with visual alarm indication(s), and external alarm contacts.
- G. Fuses:
  - 1. Appropriate type GMT complement panel alarm circuitry/visual indication(s).
  - 2. Each fuse shall be appropriately rated for the corresponding equipment to which it distributes power.
  - 3. Quantity of fuses to be provided within each fuse panel shall correspond to the number of equipment items requiring -48 Vdc power within the associated equipment rack.

## **2.13 MULTI-SECTION MAIN DISTRIBUTION FRAME**

- A. Manufacturers:
  - 1. Sun West Model PBI-50V zinc coated steel (NEMA-3R) terminal housing with hinged access door (or approved equal).
- B. With 3/4" plywood backboard.
- C. Stainless Steel Hinge.
- D. Ground Bar.
- E. With 66 type distribution blocks, as required.

## **2.14 PROTECTOR BLOCKS**

- A. Manufacturers:
  - 1. Reliable Electric (RELTEC) Model R128VSR2 (or approved equal).
- B. 2-electrode fail-short gas arrestors.
- C. Arrestor striking voltage 350-400 Vdc.
- D. Two-pair protection.

## **2.15 STATION TELEPHONE WIRE**

- A. Manufacturers:
  - 1. Champlain Cable Part Number Plus-24-4UTP (or approved equal).
- B. Ratings:
  - 1. Size: Four-Pair.
  - 2. Gauge: 24-AWG, Unshielded Twisted Pair (UTP).
  - 3. Conforms to NEC CMP Category five
  - 4. NEC Plenum Rated.
  - 5. Insulation: (non-PVC) FEP Teflon (or approved equal).
  - 6. Jacket: (non-PVC), Halar<sup>®</sup> (or approved equal).

## **PART 3 - EXECUTION**

### **3.01 PASSENGER STATION INSTALLATION**

- A. Install and wire the following equipment on the fiber optics 23-inch equipment rack in the Communications Equipment Room of Passenger Station:
  - 1. CTS Terminal Equipment
  - 2. Fuse, Alarm and Distribution Panel.
- B. Install the cabling, connectors, and plugs to provide 120-Vac, 60-Hz power to the various equipment from the ac power receptacle strip on the equipment rack.
- C. Install the required cabling and connectors to distribute the -48 Vdc to the appropriate equipment via the Fuse, Alarm and Distribution Panel
- D. Mount the Multi-Section Main Distribution Frame Cabinets to the wall of the Communications Equipment Room of the Passenger Stations, in a location approved by the Engineer.
- E. Wire the channel units, including audio, data and signaling information from channels of the IAD CTS terminal assemblies, to the Multi-Section Main Distribution Frame in the Communications Equipment Room.
- F. Connect 4-wire E&M channel, Channel Number 18 for the Passenger Information Display System. Tag the Multi-Section Main Distribution Frame for this channel "PIDS".

### **3.02 JACKSON GRAHAM BUILDING INSTALLATIONS**

- A. The Contractor shall install the following equipment on an existing 19-inch equipment rack in the Communications Equipment Room of the Jackson Graham Building:
  - 1. IAD CTS Terminal Equipment.
  - 2. Fuse, Alarm and Distribution Panel.
- B. Install the cabling, connectors, and plugs to provide 120-Vac, 60-Hz power to the various equipment from the ac power receptacle strip on the equipment rack.
- C. Install the required cabling and connectors to distribute the -48-Vdc from the Main 48-Vdc Power Distribution Bus to the appropriate equipment via the Fuse, Alarm and Distribution Panel.
- D. Wire the channel units of the IAD CTS Terminal Assemblies to the existing Combined Distribution Frame (CDF).

- E. Connect the IAD CTS Terminal Assemblies to the FOS terminals.

**3.03 MANUFACTURER'S FIELD SERVICES**

- A. Prepare and start systems under provisions of Section 16707.
- B. Supervise final wiring connections and system adjustments.

**3.04 ADJUSTING**

- A. Adjust operating Products and equipment to ensure smooth and unhindered operation.

**3.05 DEMONSTRATION**

- A. Demonstrate operation and maintenance of Products to Owner's personnel two weeks prior to date of Substantial Completion.
- B. Demonstrate Project equipment by a qualified person who is knowledgeable about the Project.
- C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with Owners' personnel in detail to explain all aspects of operation and maintenance.
- D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at equipment location.
- E. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.
- F. Demonstrate system operation.
- G. Conduct walking tour of Project and briefly describe function, operation, and maintenance of each component.

**3.06 TABLES**

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**TABLE 3.06-1**  
( ) PASSENGER STATION  
RAIL OPS TELECOMM NETWORK

CHANNEL NO.	ASSIGNMENT NO.	CHANNEL UNIT	ASSIGNMENT
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1	DS-1-1	EM-4	DTS
2	DS-1-2	FXO/FXS-See Note	ETS Telephone
3	DS-1-3	FXO/FXS-See Note	ETS Telephone
4	DS-1-4	FXO/FXS-See Note	ETS Telephone
5	DS-1-5	FXO/FXS-See Note	ETS Telephone
6	DS-1-6	FXO/FXS-See Note	ETS Telephone
7	DS-1-7	FXO/FXS-See Note	ETS Telephone
8	DS-1-8	FXO/FXS-See Note	ETS Telephone
9	DS-1-9	FXO/FXS-See Note	ETS Telephone
10	DS-1-10	FXO/FXS-See Note	ETS Telephone
11	DS-1-11	FXO/FXS-See Note	ETS Telephone
12	DS-1-12	FXO/FXS-See Note	Kiosk
13	DS-1-13	FXO/FXS-See Note	COMM/TC Room
14	DS-1-14	FXO/FXS-See Note	Operations Room
15	DS-1-15	FXO/FXS-See Note	[TBS]/TPSS
16	DS-1-16	FXO/FXS-See Note	Elevator Machine Rooms
17	DS-1-17	FXO/FXS-See Note	Area of Rescue/Stairs
18	DS-1-18	EM-4	PIDS
19	DS-1-19	EM-4	MRS-OPS
20	DS-1-20	EM-4	MRS-MAINT.
21	DS-1-21	EM-4	MRS-TPAS
22	DS-1-22	EM-4	MRS-TPAS AUX REC.
23	DS-1-23	EM-4	PA
24	DS-1-24	FXO/FXS-See Note	[Parking Garage Police Room]
25	DS-2-1	Multi-rate OCUDP	AFC-UFT
26	DS-2-2	Multi-rate OCUDP	Data Circuits
27	DS-2-3	FXO/FXS-See Note	Cleaners /Water Service/[Sewage Ejector] Rooms
28	DS-2-4	FXO/FXS-See Note	AC Switchboard Rooms/Electrical Rooms
29	DS-2-5	FXO/FXS-See Note	Mechanical Rooms
30	DS-2-6	FXO/FXS-See Note	Maintenance Room
31	DS-2-7	FXO/FXS-See Note	Future [Fan Shafts]

NOTE: FXS Channel Units shall be installed in the IAD CTS Terminal Assemblies located in the passenger stations. FXO Channel Units shall be installed in the JGB IAD CTS Terminal Assemblies.

**TABLE 3.06-1 CONTINUED**  
 ( ) PASSENGER STATION  
 RAIL OPS TELECOMM NETWORK

CHANNEL NO.	ASSIGNMENT NO.	CHANNEL UNIT	ASSIGNMENT
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32	DS-2-8	FXO/FXS-See Note	Future [Air Handling/Chiller Room/Pump Room]
33	DS-2-9	FXO/FXS-See Note	Future [Parking Booth]
34	DS-2-10	FXO/FXS-See Note	COMM Room
35	DS-2-11	FXO/FXS-See Note	[Parking Garage Elevator Machine Room]
36	DS-2-12	FXO/FXS-See Note	[GETS]
37	DS-2-13	FXO/FXS-See Note	[GETS]
38	DS-2-14	FXO/FXS-See Note	[GETS]
39	DS-2-15	EM-4	Future
40	DS-2-16	EM-4	Future
41	DS-2-17	EM-4	Future
42	DS-2-18	EM-4	Future
43	DS-2-19	Multi-rate OCUDP	Future
44	DS-2-20	EM-4	Future
45	DS-2-21	FXO/FXS-See Note	Future
46	DS-2-22	FXO/FXS-See Note	[Parking Garage Service Rooms]
47	DS-2-23	FXO/FXS-See Note	[Dispatcher Room/Trainperson's Room]
48	DS-2-24	EM-4	AEMS
49	DS-3-1	EM-4	Future
50	DS-3-2	EM-4	Future
51	DS-3-3	EM-4	Future
52	DS-3-4	EM-4	Future
53	DS-3-5	FXO/FXS-See Note	Future
54	DS-3-6	FXO/FXS-See Note	Future
55	DS-3-7	FXO/FXS-See Note	Future
56	DS-3-8	FXO/FXS-See Note	Future

NOTE: FXS Channel Units shall be installed in the IAD CTS Terminal Assemblies located in the passenger stations. FXO Channel Units shall be installed in the JGB IAD CTS Terminal Assemblies.

**END OF SECTION**

## SECTION 16776

### COMMUNICATIONS - FIBER OPTIC SYSTEM

#### PART 1- GENERAL

##### 1.01 SECTION DESCRIPTION AND BASIC REQUIREMENTS

- A. This Section describes the basic requirements for the design and installation of the Fiber-Optic System (FOS). The Fiber-Optics System will provide the transmission medium for multiplexed voice and data signal transmissions between the Jackson Graham Building and the passenger station(s). The Carrier Transmission System (CTS), described in Section 16771, is utilized to multiplex voice and data signals into T1 data formats prior to being interconnected to the FOS. To maintain maximum reliability, route diversity is required for the fiber-optic (PRIMARY) and (REDUNDANT) cable installations.
- B. New fiber optic cables shall be installed under this contract to provide a medium for the FOS. The contractor shall design a system that has optical-fiber paths all the way from each passenger station to the Jackson Graham Building. Depending on the location of the passenger station being designed, the contractor shall install redundant fiber-optic cables from the passenger stations being built to the nearest location where previously installed optical-fiber cables have been designed to support the new passenger station, or in the worst case, the contractor shall install new redundant fiber-optic cables all the way to the Jackson Graham Building Communications Equipment Room.
- C. The FOS shall be designed to operate in a two-fiber, unidirectional, path-switched, ring configuration, in accordance with the requirements defined in Bellcore's GR-1400-CORE, SONET Dual-Fed Unidirectional Path Switch Ring Equipment Generic Criteria. In this ring configuration, one fiber carries information in one direction (say clockwise), and the second fiber carries information in the opposite direction (counter-clockwise). This ring design shall provide reliable and efficient network protection from cable cuts or node failures. In addition, it shall minimize disruption of unaffected traffic by performing switching at the VT1.5 as well as the STS-1/DS3 levels.
- D. The FOS in conjunction with the Carrier Transmission System, is designed to provide voice and data transmission capabilities to accommodate the communications requirements of each of the passenger stations, as well as other selected buildings along the WMATA rights-of-way.
- E. The FOS shall also provide for CCTV video transmission from the new passenger stations to the Jackson Graham Building.
- F. The multiplexed voice and data transmission facility shall be independent from the video transmission facility of the FOS. However, both facilities shall share a common fiber optic cable plant.
- G. The voice and data transmission equipment of the FOS described herein includes, but is not limited to, the following components:
  - 1. Fiber Optic Cable Plant.
  - 2. Optical/Multiplex Equipment.
  - 3. Optical Fiber Termination Facilities.
  - 4. Maintenance Facilities.
  - 5. Power Facilities.

- H. The fiber optic cable plant shall be composed of separate fiber optic cable runs for the various WMATA transit routes from the Jackson Graham Building. In some cases, locations associated with different transit routes are combined in a single fiber optic cable run.
  - 1. The fiber optic cable runs shall be composed of individual fiber optic cable spans installed along the WMATA rights-of-way between the Communications Equipment Rooms of the Jackson Graham Building, passenger stations, yards and selected buildings.
  - 2. The fiber optic PRIMARY and REDUNDANT cable runs shall contain the necessary optical fibers (including spares) for the voice and data transmission requirements, in both directions of transmission, and for the video transmission requirements of the associated transit route. In addition, the fiber optic PRIMARY and REDUNDANT cables shall contain optical fibers for future use.
    - a. The quantity of spare optical fibers for the voice and data transmission within each fiber optic cable span shall be based on a one-to-one ratio with the active optical fibers within the span.
    - b. Two optical fibers will be provided for the video transmission facility within each fiber optic PRIMARY cable run. All groups in a cable run shall share the video fibers.
    - c. The fiber optic cables shall be installed within fiber optic cable innerducts in all conduits, cable ducts and cable troughs along the rights-of-way and within all passenger stations.
- I. The fiber optic terminal at the Jackson Graham Building shall multiplex at least twenty-eight (28) DS1 circuits onto the OC-12 digital transmission bit stream associated with the group of five passenger stations, sharing a dedicated pair of optical fibers in a ring configuration.
- J. The optical fiber termination facilities shall consist of fiber splice panels and fiber patch panels in the passenger stations and the Jackson Graham Building for the PRIMARY and REDUNDANT fiber cables. Fiber termination facilities shall allow the appropriate optical fibers of the fiber optic cables to be terminated and shall provide splice panel organizers for the splicing of optical fibers that "pass through" any location.
- K. The maintenance facilities shall consist of Digital Signal Cross-Connect (DSX) jackfields and Digital Service Units in the passenger station(s) and in the Jackson Graham Building.
  - 1. The Digital Signal Cross-Connect jackfields provide capabilities to test/monitor the DS1 circuits associated with the Optical/Multiplex Equipment at each location.
  - 2. The Digital Service Units provide a voice and data maintenance communications channel among the various locations that share the dedicated pair of fibers to/from the Jackson Graham Building.
- L. The power facilities in the passenger stations shall include a redundant output -48 Vdc power supply unit and a Fuse, Alarm and Distribution Panel. Power facilities shall provide and/or distribute necessary power to the equipment of the FOS from the filtered side of the Fuse, Alarm and Distribution Panel.
- M. All equipment of the Fiber Optic System at the passenger stations shall be mounted on equipment racks within the Communications Equipment Room.

## **1.02 SECTION INCLUDES**

- A. Fiber Optic Cable Plant.
- B. Optical/Multiplex Equipment.
- C. Optical Fiber Termination Facilities.

- D. Maintenance Facilities.
- E. Power Facilities

### **1.03 UNIT PRICES**

- A. Unit Prices include incidental items, not specifically mentioned, but required for complete and proper system operation.

### **1.04 RELATED SECTIONS**

- A. Section 16705 - Communications Standard Specifications - Equipment & Material..
- B. Section 16706 - Communications System Submittals & Services
- C. Section 16707 - Communications Systems Quality Assurance & Testing.
- D. Section 16710 - Communications Grounding..
- E. Section 16715 - Communications Electrical Power Distribution.
- F. Section 16771 - Communications - Carrier Transmission System.

### **1.05 REFERENCES**

- A. Bell Communications Research (Bellcore) Publication 43801, Digital Channel Bank - Requirements and Objectives.
- B. FCC Part 15, Radio Frequency Devices.
- C. Bellcore GR-1400-CORE, SONET Dual-Fed Unidirectional Path Switch Ring Equipment Generic Criteria..
- D. Bellcore GR-253-CORE, SONET Transport Systems: Common Generic Criteria.
- E. Bellcore GR-499-CORE, SONET Transport Systems: Generic Requirements.
- F. IEEE. RS-422.

### **1.06 SYSTEM DESCRIPTION**

- A. Description: The FOS provides the transmission medium for multiplexed voice and data signal transmissions between the Jackson Graham Building, passenger station(s) and yards. The Carrier Transmission System (CTS), described in Section 16771, is utilized to multiplex voice and data signals. To maintain maximum reliability, route diversity for the fiber-optic (PRIMARY) and (REDUNDANT) cable installations is used.
- B. Capacity:
  - 1. The contractor shall design, furnish, and install fiber optic Add/Drop Repeaters at each new passenger station, and rail yard.
  - 2. The contractor shall design, furnish, and install a fiber optic terminal at the Jackson Graham Building to service each new group of passenger stations and/or rail yard. In some cases, an existing fiber optic terminal at the Jackson Graham may already be configured to accommodate an additional passenger station. The contractor shall be responsible for any design/modifications to interface new passenger stations to existing systems.

3. The contractor shall design, furnish, and install new Digital Service Unit (Service Channel Equipment) at new passenger stations/yards to provide two-way voice and data communications for maintenance purposes.
4. The Contractor shall design, furnish, and install DSX jackfields at the new fiber-optic terminal locations to interconnect/service the new digital circuits.
5. The contractor shall design, furnish, and install fiber splice and/or patch panels at the new fiber-optic terminal locations, and at interface locations along the fiber cable route to interconnect/service the new fiber-optic circuits.
6. The contractor shall furnish and install Fuse, Alarm And Distribution Panels in each new equipment rack containing 48-Vdc equipment.
7. The contractor shall furnish fiber optic patch cords in quantities to accommodate all patch possibilities on each furnished patch panel.

C. Configuration: Mode 3 Operation.

## 1.07 SYSTEM PERFORMANCE REQUIREMENTS

- A. The Contractor shall be responsible for the overall performance of the FOS. The following overall system performance requirements are designed to ensure that the FOS, delivered in accordance with these Specifications, meet the requirements of the Washington Metropolitan Area Transit Authority.
1. Optical Line Rate: Shall support an OC-12 digital line rate of (622.08) Mb/s supporting at least 84 multiplexed DS1 circuits (1.544Mb/s) plus a service channel
  2. Crosstalk Coupling Loss: 65 dB minimum (700 to 1100 Hz)
  3. Span Line Transmission: 1300 nanometer optical wavelength on two optical fibers; one in each direction.
  4. Span Line Gain:
    - a. Optical link adequate to support a minimum of 9 dB of margin in the span line loss budget (for equipment degradation, temperature variation and future splices) and maintain a Bit Error Rate (BER) of less than 1 in  $10^{10}$ . There shall be no inter-nodal repeaters.
    - b. Optical Attenuation: Receiver optical line input shall be regulated with optical attenuators to ensure that the input optical power to the receiver (without the loss margin) does not exceed the maximum allowable input power indicated by the manufacturer.
    - c. Splice Losses: 0.20 dB or less average, 0.30 dB max.
    - d. Connector Losses: No greater than 0.70dB per connector.

## 1.08 SUBMITTALS

- A. Submit under provisions of Section 16706.
- B. Shop Drawings: Indicate electrical characteristics and connection requirements, including system wiring diagram.
- C. Product Data: Provide showing electrical characteristics and connection requirements for each component.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

## 1.09 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

- B. Supplier: Authorized distributor of specified manufacturer with minimum three years documented experience.
- C. Installer: Authorized installer of specified manufacturer with service facilities within 50 miles of Project.

#### **1.10 REGULATORY REQUIREMENTS**

- A. Conform to requirements of FCC Part 15.

#### **1.11 MAINTENANCE SERVICE**

- A. Furnish service and maintenance of Fiber Optic System until Final Completion.

### **PART 2 - PRODUCTS**

#### **2.01 48-CHANNEL CTS MULTIPLEX SHELF**

- A. Manufacturers:
  - 1. Alcatel Part Number 1603 SM SONET (or approved equal).
- B. 23-inch rack mount.
- C. OC-12 Optical Interfaces:
  - 1. Transmit Parameters:
    - a. Data Rate: 622.08 Mb/s (OC-12).
    - b. Frequency Tolerance: 20 ppm.
    - c. Line Code: SONET, NRZ.
    - d. Jitter: Category II (per GR-253).
    - e. Optical Device: FP-MLM Laser.
  - 2. Operational Parameters:
    - a. Protection: 1+1, nested switching
    - b. Switching Time: 50 ms max after detection of fault
    - c. Reframe Time: 250  $\mu$ s max
  - 3. Connectors.
    - a. SC
- D. DS3/STS-1 Electrical Interfaces.
  - 1. Electrical Parameters
    - a. Data Rate: 44.736 Mb/s (DS3) or 51.84 Mb/s (STS-1)
    - b. Frequency Tolerance: 20 ppm
    - c. Line Code: B3ZS encoded SONET
    - d. Signal-to-Noise Ratio: >25 dB, at unit input
    - e. Return Loss: >20 dB, at unit input (with redundant configuration)
    - f. Output Power Level: Defined at cross-connect point per GR-499
    - g. Pulse Specifications: Defined at cross-connect point per GR-499 and GR-253 (STS-1)
    - h. Impedance: 75 ohms unbalanced
    - i. Physical Interface: BNC connectors
    - j. Max. Distance to Cross Connect: 450 feet (with AT&T 728A) or equivalent cabling)
  - 2. Operational Parameters
    - a. Protection: 1+1 (nested switching)
    - b. Switching Time: 50 ms after detection of fault
    - c. Reframe Time: 250  $\mu$ s

- d. Equipment Loopback: Yes
  - e. Facility Loopback: Yes
- E. DS1 Interfaces
1. Electrical Parameters
    - a. Data Rate: 1.544 Mb/s
    - b. Frequency Tolerance: 130 ppm
    - c. Line Code: B8ZS, AMI
    - d. Electrical Interface: DSX-1 (Per GR-499)
    - e. Interface Impedance: 100 ohms  $\pm$  5%
    - f. Physical Interface: Connector
    - g. Max Distance to DSX-1 Cross Connect: 655 feet
    - h. Cross Connect Cable Requirements: ABAM
  2. Operational Parameters
    - a. Capacity: At least
    - b. Grooming: DS1 (any DS1 to/from any VT
    - c. VT type: Floating
    - d. VT Format: Asynchronous
    - e. Protection: 1:7
    - f. Facility Loopback: Yes
    - g. Equipment Loopback: Yes
- F. Transmission Delay Characteristic:
1. High Speed (RX + TX) - VT grooming: 50 us max
  2. High Speed (RX + TX) - no VT grooming: 25 us max
  3. Add/Drop: 100 ms max (DS1)
- G. Synchronization:
1. Inputs:
    - a. 1.544Mb/s (pri, sec)
    - b. OC-3 or OC-12 loop/line timing
    - c. Low-speed interface group (OC-12, OC-3, STS-1)
    - d. Internal 4.6 ppm oscillator
  2. Outputs: 1.544 Mb/s sync and composite clock outputs
- H. USI Interface
1. Local
    - a. Electrical Interface: RS232.
    - b. Speed: 300, 1200, 2400, 4800, 9600, 19,200, and autobaud.
    - c. Number of Interfaces: 1 with TBOS or X.25 2 without TBOS or X.25.
    - d. Physical Interface
      - 1) Front Access: 9-pin "D" connector.
      - 2) Rear Access: Wire-wrap pins.
    - e. Modem Interface: Duplex interface type DCE or DTE
  2. Remote: Remote login via D1-D3 overhead channels
  3. LAN: 10BaseT
- I. Orderwire Interfaces
1. Coding:  $\mu$  255.
  2. Interface: 4-wire.
  3. Transmit Level at 1.02 kHz: 0 dBm  $\pm$  0.25 db (25°C), 0 dBm  $\pm$  0.60 db (40°C to 65°C).
  4. Receive Level at 1.02 kHz: 0 dBm  $\pm$  0.25 db (25c), 0 dBm  $\pm$  0.40 db (40°C to 65°C).
  5. Frequency Response: 300 Hz to 3,000 Hz  $\pm$  0.25 dB (25°C).
  6. Impedance: 600 ohms  $\pm$  5%.
  7. Physical Interface: Connector.

- J. Office Alarm Interfaces.
  - 1. Visual Indicator Alarms: Critical major, minor.
  - 2. Audible Alarms: Critical, major, minor.
  - 3. Relay Contact Types: Form "C" contacts (rated 48V, 1A).
  - 4. Physical Interface: Wire-wrap pins or connector.
  
- K. E2A Interfaces.
  - 1. Parallel E2A:
    - a. Non-multiplied: Critical, major, minor.
    - b. Multiplied: Critical, major, minor, ID.
    - c. Contact Capacity: Rated 48V, 25 mA
    - d. Physical Interface: Wire-wrap pins or connector
  - 2. TBOS (Serial E2A).
    - a. Electrical Interface: RS422/RS422 tri-state.
    - b. Number of Displays:
      - 1) Outputs: 1 alarm/status.
      - 2) Inputs: 1 control.
    - c. Speed: 2400 baud.
    - d. Protocol: TBOS.
    - e. Physical Interface: Wire-wrap.
  
- L. Site Alarms and Controls (CDAC).
  - 1. Number of Input Alarms: 12.
  - 2. Input Sensing: Open/ground.
  - 3. Control Points:
    - a. With TBOS: 12 control points total; 4 control points with readable status (rated 48V, 1A).
    - b. With OS: 12 control points with readable status (4 rated 48V, 1 A and 8 rated 48V, 25 mA).
  - 4. Interface Contact Type: Form "C".
  - 5. Physical Interface: Wire-wrap pins.
  
- M. Power
  - 1. Input Voltage Range: -40 to -57 Vdc.
  - 2. Transient Input Voltage: -200 Vdc @ 1 ms -100 Vdc @ 10 ms.
  - 3. Physical Interface: Screw lugs with optional power and ground cable assembly.
  - 4. Consumption (depending on options): 250 watts.

## **2.02 FIBER OPTIC TERMINAL**

- A. The fiber optic terminal shall be the same as the add/drop repeater, except that it shall be equipped to handle 28 DS1 circuits. The 1301 NM User System Interface software and 1301 On-line Troubleshooting Guide software shall also be furnished with the terminal.

## **2.03 DIGITAL SERVICE UNIT (SERVICE CHANNEL EQUIPMENT)**

- A. DANTEL B-13-14096-01 - three Circuit Order Wire Control and Speaker Monitor Panels to include DTSS3A Order Wire Terminals. This is required to interface with the existing Order Wire.
- B. Provides two independent voice and data channel capabilities.
- C. Data channel interface: RS-232.
- D. Contains alarm circuitry with external alarm contacts

- E. The Digital Service Unit Mounting: 23-inch EIA Standard rack.

#### **2.04 DSX JACKFIELD**

- A. Manufacturers:
  - 1. ADC Telecommunications, Inc. Model No. Mini-DSX-1/Q (or approved equal).
- B. Mounting: 23-inch EIA standard rack.
- C. Jackfield suitable for operation of DS1 (1.544 Mb/s) line rate with better than -50 dB isolation.
- D. Provides termination and test/monitor facilities for a minimum of four DS1 circuits (transmit and receive).
- E. Test/monitor facilities shall provide jacks for each DS1 circuit to test both circuit line directions (IN and OUT) and to monitor/bridge without circuit interruption.
- F. Jacks construction: Steel frame, with cad-chromate finish; nickel silver springs with gold cross bar contacts.

#### **2.05 FIBER SPLICE PANEL**

- A. Manufacturers:
  - 1. Telect Model No. 055-2310-0000 with three 015-0000-0301 (or approved equal).
- B. Mounting: 23-inch EIA standard rack.
- C. The Splice Panel includes:
  - 1. At least three splice trays; each splice tray shall accommodate a minimum of 12 fusion type splices.
  - 2. Storage of excess lengths of the pigtail assemblies and buffer tubes/optical fibers of Fiber optic cables.
  - 3. Sufficient tray areas for excess optical fiber storage with provisions to assure that the remaining unassigned optical fibers do not exceed a 2-inch bend radius.
- D. Provide cable clamps to secure fiber optics cables to the chassis. Cable clamps include the necessary hardware to ground the metallic central strength members (if provided) and corrugated steel shield armor of the fiber optic cables.

#### **2.06 FIBER PATCH PANEL**

- A. Manufacturers:
  - 1. Telect Model No. 055-2630-0000 with six 055-0000-6010 (or approved equal).
- B. Mounting: 23-inch EIA standard rack.
- C. The termination/distribution cable trays includes:
  - 1. 36 optical bulkhead adapters; single-mode optical fiber Type SC.
  - 2. 36 corresponding single-mode optical fiber pigtail assemblies with appropriate type optical connectors to mate with optical bulkhead adapters
  - 3. Designation strips for identification of the 36 optical bulkhead adapters.

#### **2.07 FUSE, ALARM AND DISTRIBUTION PANEL**

- A. Manufacturers:

1. Hendry Model Number HMW 06020-05, (or approved equal).
- B. Universal mounting for 19-inch or 23-inch relay racks.
- C. Designed for -48 Vdc power supply distribution.
- D. Minimum of 10 fuse positions.
- E. 40-amp panel capacity.
- F. Alarm circuit with visual alarm indication(s), and external alarm contacts.
- G. Fuses:
  1. Appropriate type GMT complement panel alarm circuitry/visual indication(s).
  2. Each fuse shall be appropriately rated for the corresponding equipment to which it distributes power.
  3. Quantity of fuses to be provided within each fuse panel shall correspond to the number of equipment items requiring -48 Vdc power within the associated equipment rack.

## 2.08 FIBER OPTIC CABLES

- A. General.
  1. The fiber optic cables shall be of an open-channel type configuration or of a loose-tube type configuration.
  2. The quantity of optical fibers within each fiber optic cable shall be chosen to fulfill the operational requirements of the Authority, and continue the fiber-optic design philosophy for operational and spare fibers used in prior constructed rail sections/stations, and depicted in a typical configuration on the contract drawings.
  3. Shall conform to REA PE-90.
- B. Cable Composition - Loose Tube Type Configuration
  1. Central Strength Member:
    - a. Stranded galvanized steel wire with polyethylene overcoat or dielectric glass fiber reinforced plastic (overcoat is optional).
  2. Over-length Loose Tubes:
    - a. Hard, abrasion-resistant compound
    - b. Provides mechanical and environmental protection of the optical fiber
    - c. Appropriate quantity to accommodate optical fiber requirements.
    - d. Each loose tube individually color-coded.
  3. Single-mode Optical Fibers.
  4. Water-Blocking Compound:
    - a. Provided within and between the over-length loose tubes.
    - b. Compound to be non-toxic, non-nutrient to fungus and non-conducting.
  5. Core Wrap:
    - a. Polyester core tape applied longitudinally over slotted-core to contain water-blocking compound.
  6. Inner Jacket:
    - a. Medium-density polyethylene.
    - b. Carbon black in color for protection against ultraviolet radiation.
  7. Corrugated Steel Shield Armor:
    - a. Electrochrome steel coated with ethylene-acrylic copolymer on both sides.
    - b. Applied longitudinally over inner jacket.
    - c. Electrically continuous.
  8. Outer Jacket:
    - a. Low smoke and zero halogen..

- b. Carbon black in color for protection against ultraviolet radiation.
- C. Overall Physical Cable Characteristics
  1. Pulling load (Installation):  $\geq 600$ -lbf (2669-Newtons).
  2. Operating Load:  $\geq 225$ -lbf (1000-Newtons).
  3. Crushing Resistance:  $\geq 344$ -lb/in (600-Newtons/cm).
  4. Operating Temperature Range:  $-40^{\circ}$  C to  $+70^{\circ}$  C.
- D. Optical Fiber Characteristics
  1. Type: Single-mode.
  2. Operating Wavelength: 1310-nm.
  3. Attenuation @ 1310-nm: 0.5-dB/km maximum.
  4. Maximum Dispersion:  $<3.5$  ps/km-nm over the wavelength range of 1285-nm to 1335-nm.
  5. Cut-off Wavelength:  $1200 + 70$  nm.
  6. Fiber Mode Diameter:  $8 + 1$   $\mu$ m.
  7. Fiber Outer Diameter:  $125 + 3$   $\mu$ m.
  8. Protective-Coating Diameter:  $250 + 20$   $\mu$ m (minimum coating thickness of 40  $\mu$ m).
  9. Each optical fiber shall be individually color-coded.

## **2.09 FIBER OPTIC PATCH CORD**

- A. Manufacturers:
  1. ADC Communications, Inc., Model No. FPC-SPSC-S-3M (or approved equal).
- B. Connector: Type SC on one end and SC or equipment related on the other end; single-mode fiber.
- C. Length: Three meters.

## **2.10 FIBER OPTIC CABLE WARNING TAG**

- A. Manufacturers:
  1. Uticom System, Inc. Model No. 807-41C (or approved equal).
- B. Weatherproof.
- C. 22-Mil PVC with UV inhibitors with silicon adhesives.
- D. UV Type II Ink Graphics.
- E. Graphics to include "CAUTION-FIBER-OPTIC CABLE - PROPERTY OF WMATA".

## **2.11 FIBER OPTIC CABLE INNERDUCT**

- A. Manufacturers:
  1. Carlon Optic/Gard Model No. DF4X1C (or approved equal).
- B. Color: Orange.
- C. Nominal Size: 1" diameter; O.D. =1.3"; I.D. =1.05".

## **2.12 FIBER OPTIC CABLE ATTENUATORS**

- A. Manufacturers:

1. Telect Attenuators Model Nos. 106676, 106677, 106678 or 106679 No. FOA-SDXdb (or approved equal).
- B. Attenuators direct-mount into patch panel mounting holes.
- C. Attenuator adapter style "D4."
- D. Decibel Level: 5db, 10db, 15db, 20db (as required) to meet receiver specifications.

### **PART 3 - EXECUTION**

#### **3.01 FIBER OPTIC CABLE - GENERAL INSTALLATION**

- A. Installation practices shall conform to the fiber-optic cable manufacturer's installation recommendations, especially those concerning allowable bending radius of the cable and/or individual fibers.

#### **3.02 PASSENGER STATION INSTALLATION**

- A. Install the following equipment in the Communications Equipment Room of the passenger station (exact location to be approved by the Engineer) on a 23-inch EIA standard equipment rack:
  1. Fiber optic Add/Drop Repeater.
  2. Digital Service Unit.
  3. DSX Jackfield.
  4. Primary Fiber Splice Panel.
  5. Redundant Fiber Splice Panel.
  6. Primary Fiber Patch Panel.
  7. Redundant Fiber Patch Panel.
  8. Fuse, Alarm and Distribution Panel.
- B. Provide 120-Vac, 60-Hz to the appropriate equipment from the ac power receptacle strip on the equipment rack.
- C. Distribute the -48 Vdc of the station power supply unit to the appropriate equipment, via the Fuse, Alarm and Distribution Panel.
- D. Connect the DS1 circuits of the Fiber optic Add/Drop Repeater assigned to the passenger station to the DSX Jackfield.
- E. Install assembled optical fiber patch cords to connect the Fiber optic Add/Drop Repeater to the Fiber Patch Panels.
- F. Install appropriate optical attenuators at the Fiber Patch Panels.
- G. Connect all terminal assemblies of the Carrier Transmission System to the appropriate DS1 circuits of the Fiber optic Add/Drop Repeater at the DSX Jackfield. Each of the two digroups of the D448 terminal assembly shall be connected as a separate DS1 circuit.
- H. Provide appropriate type fiber optic hazard warning signs/tags (approved by the Engineer) on the Fiber Splice Panel, the Fiber Patch Panel, the Fiber optic Add/Drop Repeater, and the optical fiber patch cords.

#### **3.03 EXISTING PASSENGER STATION INSTALLATION**

- A. The Contractor shall install the following equipment in an existing passenger station, as required to provide the fiber-optic cable connectivity contained in his system design:
  - 1. PRIMARY and REDUNDANT Fiber Splice Panel.
  - 2. PRIMARY and REDUNDANT Fiber Patch Panel.
- B. Provide appropriate type fiber optic hazard warning signs/tags (approved by the Engineer) on the Fiber Splice Panel, the Fiber Patch Panel and the optical fiber patch cords.

### **3.04 INSTALLATION ALONG THE RIGHTS-OF-WAY**

- A. Fiber Optic Cable Innerduct
  - 1. Install fiber optic cable innerduct in all conduits, cable ducts within duct banks, and cable troughs along the rights-of-way and within the passenger station, to facilitate the installation and protection of the fiber optic cables in accordance with the contractor's system design.
  - 2. Fiber optic cable innerduct shall not be provided for the installation of fiber optic cables that are to be secured to tunnel walls.
  - 3. Provide appropriate fiber optic hazard warning tags (approved by the Engineer) for the fiber optic cable innerduct. Installed hazard warning tags on the fiber optic cable innerduct:
    - a. Every 100 feet within the cable troughs.
    - b. At each manhole location in the duct bank of the rights-of-way.
- B. Fiber Optic Cable
  - 1. Install the PRIMARY fiber optic cables following the track plans for the PRIMARY side of the cable plant. Install the REDUNDANT fiber-optic cables along a different physical route than the PRIMARY fiber-optic cables following the REDUNDANT cable track plan for the entire cable run, including cable troughs and duct banks. Install the fiber optic cables along the tunnel walls on existing channel inserts (exposed), in contractor furnished conduit, and in duct banks and cable troughs, on existing rights-of-way, along the rights-of-way.
  - 2. Route the fiber optic cables through the passenger station in cable ducts, conduit, cable troughs and/or air plenums under passenger station platforms. Conduit plants should be utilized when available. Provide independent conduit plant dedicated for fiber optic cable under the passenger station platforms and in plenums. Furnish other conduit and hardware as required.
  - 3. Connect the PRIMARY fiber optic cables to the PRIMARY Fiber Patch Panels within each passenger station Communications Equipment Room. Connect the REDUNDANT fiber optic cables to the REDUNDANT Fiber Patch Panels within each passenger station Communications Equipment Room and the Jackson Graham Building.
  - 4. Provide appropriate weatherproof fiber optic cable warning tags. Install hazard warning tags on the fiber optic cables:
    - a. Every 100 feet within the tunnel areas
    - b. Every 10 feet within the passenger station Communications Equipment Rooms, and the Jackson Graham Building
    - c. At each location where the fiber optic cables enter/exit the conduit plant and cable ducts.
  - 5. Ground the armor and the steel central strength member (if applicable) of all fiber optic cables using a single-point grounding scheme.
- C. Splicing
  - 1. All splices within the passenger stations Communications Equipment Rooms shall be fusion type and arranged within the splice trays of the Fiber Splice Panels, in accordance with the organizational design of the splice trays.

2. Splices along the rights-of-way will not be permitted unless specifically approved by the Engineer, in writing, on a case-by-case basis.
  - a. Splices Type: Fusion.
  - b. Contain splices within re-enterable splice enclosures that are designed specifically for the splicing of fiber optic cables. Provide appropriate type splice tray(s) within each splice enclosure.
  - c. The armor and the steel central strength member (if applicable) of the fiber optic cables shall be electrically continuous across the splices.
3. Applied appropriate protective coating to all fusion splices.
4. If splices are not made immediately after cable installation, seal the ends of the cables as recommended by the manufacturer to prevent entry of moisture.

### **3.05 JACKSON GRAHAM BUILDING INSTALLATION**

- A. Install the fiber optic terminal equipment on a 23-inch rack(s) in the Communications Equipment Room in locations approved by the Engineer.
- B. Provide 120-Vac, 60-Hz to the appropriate equipment from the ac power receptacle strip on the equipment rack.
- C. Connect the Jackson Graham Building -48 Vdc to the appropriate equipment, via the Fuse, Alarm and Distribution Panel.
- D. Connect the DS1 circuits of the fiber optic terminal to the DSX Jackfield.
- E. At the REDUNDANT Fiber Patch Panel within the Communications Equipment Room, terminate the optical fibers of the REDUNDANT fiber optic cables to the optical bulkhead adapters, via the corresponding single-mode optical-fiber pigtail assemblies. Splice the optical fibers to the single-mode optical-fiber pigtail assemblies within the REDUNDANT splice tray(s).
- F. Install assembled optical-fiber patch cords to connect the fiber optic terminal to the PRIMARY and REDUNDANT Fiber Patch Panel.
- G. Provide appropriate optical attenuators at the PRIMARY and REDUNDANT Fiber Patch Panel, if needed, to avoid over driving the terminal input circuits.
- H. Connect all terminal assemblies of the Carrier Transmission System to the appropriate DS1 circuits of the fiber optic terminal at the DSX Jackfield. Each of the two digroups of the D448 terminal assemblies shall be connected as a separate DS1 circuit.
- I. Connect the output contacts of all major alarms of the fiber optic terminal to the appropriate terminal block on the Main Distribution Frame.
- J. Provide appropriate fiber optic hazard warning signs/tags (approved by the Engineer) on the Fiber Splice Panel, the Fiber Patch Panel, the Fiber optic Terminal, the REDUNDANT fiber optic cable and the optical-fiber patch cords.

### **3.06 MANUFACTURER'S FIELD SERVICES**

- A. Prepare and start systems under provisions of Section 16707.
- B. Supervise final wiring connections and system adjustments.

### **3.07 ADJUSTING**

- A. Adjust operating Products and equipment to ensure smooth and unhindered operation.

**3.08 DEMONSTRATION**

- A. Demonstrate operation and maintenance of Products to WMATA personnel two weeks prior to date of Substantial Completion.
- B. Demonstrate Project equipment by a qualified person who is knowledgeable about the Project.
- C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with WMATA personnel in detail to explain all aspects of operation and maintenance.
- D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at equipment location.
- E. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.
- F. Demonstrate system operation.
- G. Conduct walking tour of Project and briefly describe function, operation, and maintenance of each component.

**END OF SECTION**

## SECTION 16791

### COMMUNICATIONS - MOBILE RADIO SYSTEM

#### PART 1 - GENERAL

##### 1.01 SECTION DESCRIPTION AND BASIC REQUIREMENTS

- A. This Section describes the basic components of the WMATA Mobile Radio System (MRS). The WMATA Mobile Radio System consists of a Metrorail Mobile Radio Subsystem, a Primary Local Jurisdictional (PLJ) Radio Subsystem, and a Terminal Supervisor's Radio at End-Of-Line Stations.
- B. The purpose of the WMATA Metrorail Mobile Radio Subsystem is to provide two-way voice communications between control consoles, provided by others, located within the WMATA Rail Operations Control Center (RAIL OCC), and portable, vehicular and rail car radios, utilized throughout the WMATA Rail Rapid Transit System and the Washington Metropolitan Area.
- C. The purpose of the Primary Local Jurisdictional (PLJ) Radio Subsystem is to provide two-way voice communications between control center facilities of local Fire Department, Police Department, and Emergency Medical Services (EMS) authorities and their corresponding portable radios, when utilized within the tunnel and underground station areas of the WMATA Rail Rapid Transit System.
- D. The purpose of an End-Of-Line Terminal Supervisor's Radio is to provide limited communications between the End-Of-Line Terminal Supervisor and train operators near or at the station platform.
- E. The WMATA Rail Mobile Radio Subsystem (MRS) is a frequency modulated voice radio system operating in the 490 MHz portion of the frequency band. The WMATA MRS consists of five networks: Operations 1, 2, 3, Maintenance, and Metro Transit Police Department (MTPD). Each network operates as a separate system with its individual transmitter/receiver (T/R) equipment, control consoles, control logic, frequency(s), and portable and vehicular radios.
- F. The WMATA Rail MRS consists of surface and underground radio base stations located along the WMATA right-of-ways to provide radio coverage for the entire WMATA Rail Rapid Transit System. Surface radio base stations (not included in this contract) provide coverage for all surface and aerial portions, while underground radio base stations (required under this contract) cover underground passenger stations and tunnel areas of the WMATA Rail Rapid Transit System.
- G. Each underground radio base station includes one transmitter/receiver for the Operations Network, the Maintenance Network, and the MTPD Normal Network. In addition, the MTPD Emergency Network includes a second receiver.
- H. All network radios and the second MTPD receiver are multiplexed onto a single slotted coaxial cable antenna system installed in underground stations and tunnels. Each radio is connected to the Rail OCC by a 4-wire, 4 kHz voice channel of the Carrier Transmission System (CTS).
- I. The Operations and Maintenance Network radios are connected to master control consoles located in the Jackson Graham Building. The MTPD Network is connected to its master

control console through an interface arrangement in the Communications Equipment Room at the Jackson Graham Building.

- J. The PLJ Radio Subsystem is a frequency-modulated voice radio system operating in the 150-155 MHz, the 450-512 MHz, and in the 850 MHz portions of the frequency band. The PLJ radio base stations shall be co-located in the passenger station Communications Equipment Rooms with the WMATA Rail MRS base stations. The PLJ radios provide coverage for PLJ portable radios in underground stations and tunnels.
- K. The PLJ radio base stations are multiplexed onto the same slotted coaxial cable antenna system used by the WMATA Rail MRS. Each PLJ network radio base station is connected to its Local Jurisdiction Radio Control Facility by leased telephone lines within the station.
- L. The Slotted Coaxial Cable Antenna System shall act as the medium for receiving/transmitting the radio frequency waves to/from the WMATA Rail Mobile Radio Subsystem and the PLJ Radio Subsystem Base Stations.
- M. A WMATA Rail End-Of-Line Terminal Supervisor's Radio Subsystem facility shall be provided in the Terminal Supervisor's Office in an End-Of-Line passenger station. The WMATA Rail End-Of-Line Terminal Supervisor's Radio Subsystem facility is completely independent and provides two-way voice communications between the Terminal Supervisor's Office and WMATA personnel within the passenger station.
- N. Vehicular and portable radios shall be provided under this contract. The contractor shall program and test the portable radios for operation with the MRS.
- O. Metro Transit Police Department Network (MTPD) Operation
  1. In the normal mode of operation, a call can be initiated by a portable radio, a vehicular radio, or the MTPD Network Master Control Console using the primary frequency (Channel 1 on the portable and vehicular radios). The operation is simplex, push-to-talk. The call is initiated by operating the push-to-talk switch and speaking into the microphone.
  2. Emergency Mode Operation - In emergency mode operation, a call can be initiated by a portable radio or a vehicular radio using the auxiliary frequency (Channel 2). The call is initiated by operating the push-to-talk switch and speaking into the microphone.
  3. The MTPD Network Master Control Console monitors the normal mode channel and the emergency mode channel simultaneously at all times. An emergency mode call will be received by the MTPD Network Master Control Console even if a normal mode call is in progress. Transmission from the MTPD Network Master Control Console is on the primary frequency.
  4. When a portable radio or a vehicular radio is in the Channel 2 position, it receives on Channel 1 (primary frequency) and transmits on Channel 2 (auxiliary frequency).
  5. In the emergency mode operation, simplex cross-patch is also available by operator initiation at the MTPD Network Master Control Console by interconnecting selected base stations. In this function, the received transmissions on the auxiliary frequency (Channel 2) from a portable or vehicular radio are retransmitted on the primary frequency (Channel 1) by Voice Operated Relay (VOX) console circuitry. This function permits portable-to-portable communications on a limited basis between radios located in other tunnel areas and the surface.
- P. Each Primary Local Jurisdictional Radio Subsystem network operates as duplex, push-to-talk. A call can be initiated by a portable radio or the control facility by operating the push-to-talk switch and speaking into the microphone. Portable-to-portable radio operation is available for each network within the tunnel and underground passenger station areas. (In

addition, communications between portable radios in the tunnel and underground passenger station areas and vehicular and portable radios above ground is available).

#### **1.02 SECTION INCLUDES**

- A. WMATA Rail Mobile Communications System
- B. Primary Local Jurisdictional Radio Subsystem
- C. End-Of-Line Terminal Supervisor's Radio.

#### **1.03 UNIT PRICES**

- A. Unit Prices include incidental items, not specifically mentioned, but required for complete and proper system operation.

#### **1.04 RELATED SECTIONS**

- A. Section 16705 -Communications Standard Specifications - Equipment & Material
- B. Section 16706 - Communications System Submittals & Services
- C. Section 16707 - Communications Systems Quality Assurance & Testing
- D. Section 16710 -Communications Grounding
- E. Section 16715 - Communications Electrical Power Distribution.

#### **1.05 REFERENCES**

- A. National Electric Code (NEC).
- B. Federal Communication Commission (FCC).

#### **1.06 SYSTEM DESCRIPTION**

- A. Description: The WMATA Rail End-Of-Line Terminal Supervisor's Radio Subsystem facility is completely independent and provides two-way voice communications between the Terminal Supervisor's Office and WMATA personnel within the passenger station.
- B. Capacity:
  - 1. The contractor shall design, furnish, and install an End-Of-Line Terminal Supervisor's mobile radio in each end-of-line passenger being built.
  - 2. The contractor shall design, furnish, and install an End-Of-Line Terminal Supervisor's mobile radio antenna in each end-of-line passenger station being built.
  - 3. The contractor shall design, furnish, and install RF coaxial cable between the mobile radio and the antenna in each end-of-line passenger being built.
  - 4. The contractor shall design, furnish, and install the necessary PLJ Radio Subsystem within the tunnels and under ground passenger stations.
  - 5. The contractor shall design, furnish, and install the necessary MRS Radio System within the tunnels and under ground passenger stations.

#### **1.07 SYSTEM PERFORMANCE REQUIREMENTS**

- A. Frequency Stability:  $\pm 0.0002\%$  of assigned carrier frequency between 30°C and +60°C.

- B. Audio Response: Within +1 and -3dB of 6dB per octave pre-emphasis 300-3000Hz referenced to 1000 Hz.
- C. Audio Distortion: Less than 3% deviation @ 1000 Hz @ 1 kHz.
- D. RF Impedance: 50 ohms.
- E. Modulation: 16F3,  $\pm$  5 kHz for 100% deviation at 1 kHz.

#### **1.08 SUBMITTALS**

- A. Submit under provisions of Section 16706.
- B. Shop Drawings: Indicate electrical characteristics and connection requirements, including system wiring diagram.
- C. Product Data: Provide showing electrical characteristics and connection requirements for each component.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

#### **1.09 QUALIFICATIONS**

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Supplier: Authorized distributor of specified manufacturer with minimum three years documented experience.
- C. Installer: Authorized installer of specified manufacturer with service facilities within 50 miles of Project.

#### **1.10 MAINTENANCE SERVICE**

- A. Furnish service and maintenance of Mobile Radio System until Final Completion.

### **PART 2 - PRODUCTS**

#### **2.01 END-OF-LINE TERMINAL SUPERVISOR'S MOBILE RADIO**

- A. Manufacturers:
  - 1. Ericsson-GE MVS Mobile Radio Model No. MLS II with Model No. MLMK1P control panel.
  - 2. Motorola MaxTrac 300, 40-Watt, 16-Channel Radio.
  - 3. Or approved equal.
- B. Ratings:
  - 1. Frequency: 490 MHz band
  - 2. RF Input impedance: 50-ohms.
  - 3. Power Input: 120-Vac, 60-Hz.
  - 4. Equipped with desk microphone.

#### **2.02 TERMINAL SUPERVISOR'S MOBILE RADIO ANTENNA**

- A. Manufacturer:
  1. Decibel Products Model DB201 (or approved equal)
- B. Description: Omni-directional, roof-mounted, UHF ground-plane antenna complete with mounting hardware.
- C. Ratings:
  1. Impedance: 50-ohms.
  2. Minimum power: 100-watts.
  3. Frequency Range: 490 MHz band
  4. Minimum Vertical beamwidth: 75-degrees

**2.03 PLJ POLICE, FIRE DEPARTMENT, and EMS RADIO BASE STATIONS**

- A. Manufacturers:
  1. Ericsson-GE Master III Base Station
  2. Motorola MRS 2000
  3. Or approved equal.
- B. Description:
  1. Equipped for PLJ Police and Fire Department frequencies as indicated under Frequency Assignments.
  2. Equipped with four channels for duplex operation
  3. Rated Power of 100 watts RF output power on a continuous basis
  4. Receiver shall be equipped for operations utilizing low noise pre-amplifiers
  5. Tone controlled.
  6. Continuous
  7. Shall be shielded against problems due to collocated site RF sources
  8. Shall have a receiver voting encoder.
  9. Shall have control line protection and compensation
  10. Shall have power line protection
  11. The PLJ Police Department Radio Base Station, PLJ Fire Department Radio Base Station, and the PLJ EMS Radio Base Station shall be enclosed in a single equipment cabinet

**2.04 FLEXIBLE FOAM-DIELECTRIC ½-INCH COAXIAL CABLE**

- A. Manufacturers:
  1. Andrew Corporation Superflexible HELIAX Model No. FSJ4RN-50B (or approved equal).
- B. Ratings:
  1. Impedance: 50 ohms.
  2. Jacket: Non-halogenated, flame-retardant and smoke-resistant

**PART 3 - EXECUTION**

**3.01 INSTALLATION**

- A. End-Of-Line Terminal Supervisor's Office
  1. Install the End-Of-Line Terminal Supervisor's Mobile Radio, as shown on the contract drawings, in a location approved by the Engineer.
  2. Install the required power cable, connectors, and associated hardware to provide 120-Vac, 60-Hz power for the Mobile Radio from an available ac receptacle in the Terminal Supervisor's Office.

3. Adjust the transmitter for minimum power output to minimize interference to other WMATA frequencies.
- B. PLJ Police, Fire Department, and EMS Radio Base Stations
1. Install the PLJ Radio Subsystem, as shown on the contract drawings, in a location approved by the Engineer.
  2. Install the required power cable, connectors, and associated hardware to provide 120-Vac, 60-Hz power for the Mobile Radio from an available ac receptacle in the Terminal Supervisor's Office.
  3. Adjust the transmitter for minimum power output to minimize interference to other WMATA frequencies.
- C. Metrorail Mobile Radio Subsystem
1. Install the Metrorail Radio Subsystem, as shown on the contract drawings, in a location approved by the Engineer.
  2. Install the required power cable, connectors, and associated hardware to provide 120-Vac, 60-Hz power for the Mobile Radio from an available ac receptacle in the Terminal Supervisor's Office.
  3. Adjust the transmitter for minimum power output to minimize interference to other WMATA frequencies.

### **3.02 MANUFACTURER'S FIELD SERVICES**

- A. Prepare and start systems under provisions of Section 16707.
- B. Supervise final wiring connections and system adjustments.

### **3.03 ADJUSTING**

- A. Adjust operating Products and equipment to ensure smooth and unhindered operation.

### **3.04 DEMONSTRATION**

- A. Demonstrate operation and maintenance of Products to WMATA personnel two weeks prior to date of Substantial Completion.
- B. Demonstrate Project equipment by a qualified person who is knowledgeable about the Project.
- C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with WMATA personnel in detail to explain all aspects of operation and maintenance.
- D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at equipment location
- E. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.
- F. Demonstrate system operation.
- G. Conduct walking tour of Project and briefly describe function, operation, and maintenance of each component.

**END OF SECTION**

**SECTION 16791  
COMMUNICATIONS - COMPREHENSIVE RADIO COMMUNICATION SYSTEM**

**PART 1 - GENERAL**

**1.1 SECTION DESCRIPTION AND BASIC REQUIREMENTS**

- A. This Section describes the basic components of the WMATA Comprehensive Radio Communication System (CRCS). The WMATA Radio Communication System consists of a Comprehensive Radio Communication System (CRCS) Subsystem above and below Ground, a Public Safety Radio System (PSRS) Subsystem below ground, a Terminal Supervisor's Radio at End-Of-Line Stations, a Mobile Radio at Rail Yard Tower stations and Gate House, a Distributed Antenna System for providing Coverage at WMATA Stations, buildings and Wayside Structures and Tunnels.

**1.2 SECTION INCLUDES**

- A. End-Of-Line Terminal Supervisor's Radio.
- B. Mobile Radio at Rail Yard Tower stations and Gate House
- C. Distributed Antenna System for providing Coverage at WMATA Stations, buildings and Wayside Structures

**1.3 RELATED SECTIONS**

- A. Section 16705 - Communications Standard Specifications - Equipment & Material
- B. Section 16706 - Communications System Submittals & Services
- C. Section 16707 - Communications Systems Quality Assurance & Testing
- D. Section 16710 - Communications Grounding
- E. Section 16715 - Communications Electrical Power Distribution.

**1.4 REFERENCES**

- A. National Electric Code (NEC - latest).
- B. Federal Communication Commission (FCC part 15).
- C. National Fire Protection Association (NFPA 130 / NFPA 101)
- D. Underwriters Laboratories (UL)

## 1.5 SYSTEM DESCRIPTION

- A. Description: The WMATA Rail End-Of-Line Terminal Supervisor's Radio Subsystem facility is completely independent and provides two-way voice communications between the Terminal Supervisor's Office and WMATA personnel (usually train operators) within the passenger station interfacing with the existing WMATA Simulcast radio system.

Capacity: An End-Of-Line Terminal Supervisor's mobile radio, antenna and RF coaxial cable shall be designed, furnished, and installed in the end-of-line passenger station (Station).

- B. Description: The WMATA Mobile Radio at Rail Yard Tower stations and Gate House Provides two-way voice communications between the Rail Yard Tower towers, gate House and WMATA personnel (train operators, maintenance personnel within the yard facility interfacing with the existing WMATA Simulcast radio system.

Capacity: The Rail Yard Tower and Gate House mobile radio, antenna and RF coaxial cable shall be designed, furnished, and installed at those locations.

- C. Description: The WMATA Distributed Antenna System (DAS) shall provide mobile radio coverage in poor radio coverage areas by repeating existing above-ground simulcast radio signal communications in areas of metro rail facilities having deficient radio coverage. The Off-The-Air Radio Repeater System shall be designed to support rail operations and maintenance, transit police, and support the Integration of the Public Safety Radio System (PSRS)

Capacity: The contractor shall use the installed Radiax Cable provided by WMATA to create a Distributed Antenna System (DAS) for use in the underground sections of WMATA rail system. The DAS shall consist of Below Station Bi-Directional Amplifier (BDA) sites and Tunnel BDA sites. The Contractor shall perform a link budget analysis to determine the placement of BDAs, cabling, and radiating elements. The contractor shall expand the WMATA supplied Radiax system to obtain required coverage. The Contractor shall be responsible for installation of additional radiating cable and or antennas (Omni or panel), in the ancillary spaces, sufficient to achieve stated system requirements for minimum acceptable coverage. All rooms and spaces accessible to personnel within or near the ancillary location shall be provided with minimum acceptable coverage. This includes the entire egress route to the surface (stairs or ladder); if such a personnel egress shaft exists. Ancillary Space DAS components shall meet the following minimum requirements:

Radiating Cable: Same specifications as the existing tunnel "WMATA DAS" radiating cable  
Antennas: Omni or Panel, as required for area covered 490 to 1000 MHz  
broadband or better.

- D. The purpose of the WMATA CRCS Subsystem is to provide two-way voice communications between control consoles to Rail Operations Control Center (RAIL OCC), and portable, vehicular and rail car radios, the Washington Metropolitan Area Transit Police Department (MTPD), Bus, Maintenance departments utilized throughout the WMATA Transit System in tunnels, stations and all areas above ground where the WMATA service extends.
- E. The purpose of the Public Safety Radio System (PSRS) Radio Subsystem is to provide two-way voice communications between control center facilities of local Fire Department, Police Department, and Emergency Medical Services (EMS) authorities and their corresponding portable radios, when utilized within the tunnel and underground station areas of the WMATA Transit System.

- F. The purpose of the Mobile Radio at Rail Yard Tower station and guard booth is to provide limited communications between the tower, train operators entering and leaving yard buildings and other areas within the facility.
- G. The purpose of an End-Of-Line Terminal Supervisor's Radio is to provide limited communications between the End-Of-Line Terminal Supervisor and train operators near or at the station platform.
- H. The purpose of the Distributed Antenna System Stations, buildings, Wayside Structures and tunnels is to provide adequate radio communications coverage to each room, public and non-public space within these facilities to which MTPD, emergency responders, maintenance or WMATA employees can access using their radios throughout the CRCS coverage area.
- I. The WMATA Comprehensive Radio Communication System (CRCS) is a frequency modulated, UHF T-Band, (operating in the 470-512 MHz portions of the frequency band) digital, single-cell simulcast trunked Motorola Smart Zone 3.0z radio system, used for communicating with radio users throughout the entire WMATA service area. The WMATA CRCS consists of several networks: Operations 1, 2, 3, 4, Metro Transit Police Department (MTPD) Maintenance and Bus. Each network operates as a separate system with its individual transmitter/receiver (T/R) equipment, control consoles, portable and vehicular radios.
- J. The WMATA CRCS consists of surface and underground Bi-Directional Amplifier (BDA) network located along the WMATA right-of-ways to provide radio coverage for the entire WMATA Transit System. The Surface design composed of 10 remote above ground sites, 15 voice channels, 4 data AVL (bus) channels, one mobile data channel and one paging channel to provide coverage for all surface and aerial portions, while an underground BDA system cover underground passenger stations and tunnel areas of the WMATA Transit System.
- K. The underground CRCS is divided up into 26 segments. Each segment consists of several Bi-Directional Amplifiers (BDA) cascaded together. The first Amplifier in the chain is a fiber-fed BDA connected to the main Prime site location at JGB. All BDAs are cascaded along the tunnel segment using a single slotted coaxial cable antenna system installed in underground stations and tunnels.
- L. The PSRS Radio Subsystem is a frequency-modulated voice radio system operating in the 850 MHz portions of the frequency band. The Public Safety Radio System (PSRS) is multiplexed into the same radiating cable used by WMATA CRCS using a Cross-Band Coupler (CBC). The PSRS subsystem is similar design utilizing the 850 MHz frequency band and associated components. The PSRS Head-end equipment shall be co-located in the passenger station Communications Equipment rooms and BDAs inside the tunnels. The PSRS radios provide coverage for PSRS portable radios in underground stations and tunnels.
- M. The Slotted Coaxial Cable Antenna System shall act as the medium for receiving/transmitting the radio frequency waves to/from the WMATA Comprehensive Radio Communication Subsystem and the Public Safety Radio System (PSRS) Subsystem. T
- N. The Slotted Coaxial Cables Antenna System shall be installed as required to achieve 95% coverage at a 3.4 DAQ level requirements throughout the Metrorail Project coverage area.
- O. A WMATA Rail End-Of-Line Terminal Supervisor's Radio Subsystem facility shall be provided in the Terminal Supervisor's Office in an End-Of-Line passenger station. The WMATA Rail End-Of-Line Terminal Supervisor's Radio Subsystem facility is completely independent and provides two-way voice communications between the Terminal Supervisor's Office and WMATA personnel within the passenger station.

- P. Distributed Antenna System shall be designed using any combination of BDAs (fiber-fed, off-air or RF-fed), Optical master units, Antennas ( Omni, Yagi, Flat panel), radiating coax and non-radiating coax for providing Coverage at WMATA Stations, buildings, Wayside Structures and tunnel segments.
- Q. Vehicular and portable radios shall be provided to interface and operate over the CRCS system built on Motorola Smartzone technology
- R. Each Public Safety Radio System Subsystem network operates as duplex, push-to- talk. A call can be initiated by a portable radio or the control facility by operating the push-to- talk switch and speaking into the microphone. Portable-to-portable radio operation is available for each network within the tunnel and underground passenger station areas. (In addition, communications between portable radios in the tunnel and underground passenger station areas and vehicular and portable radios above ground is available).

## 1.6 SYSTEM PERFORMANCE REQUIREMENTS – RADIO

### A. Radio:

1. Frequency range: 450-520 MHz
2. Channel Spacing: 12.5/25 KHz
3. Maximum Frequency Separation: Full Band split
4. Rated RF Output Adj: 1 to 5 Watts
5. Frequency Stability:  $\pm 0.0002\%$  of assigned carrier frequency between 30°C and +60°C.
6. Audio Response: Within +1 and -3dB of 6dB per octave pre-emphasis 300-3000Hz referenced to 1000 Hz.
7. Emissions (Conducted and Radiated): -70 dBc
8. Audio Distortion: Less than 3% deviation @ 1000 Hz @ 1 kHz.
9. RF Impedance: 50 ohms.
10. Modulation: 16F3,  $\pm 5$  kHz for 100% deviation at 1 kHz.
11. Receive Analog Sensitivity (12 dB SINAD): 0.25 $\mu$ V
12. Receive Digital Sensitivity (1% BER/ 5% BER): 0.35 $\mu$ V / 0.25 $\mu$ V

### B. Distributed Antenna System (DAS)

1. Frequency range: U/L (489.5125 – 490.9625 MHz, 496.3375 – 496.6125MHz)  
D/L (492.5125 – 493.9625 MHz, 499.3375 – 499.6125MHz)
2. Channel Spacing: 12.5/25 KHz
3. Channel Bandwidth: User selectable, 15 KHz, 30 KHz DSP filters Both either Low Selectivity or High Selectivity 400 KHz or 1.5 MHz band select filter
4. Rated RF Output Adj: 1 to 5 Watts per Band
5. RF Impedance: 50 ohms.
6. Maximum Gain: 80 dB
7. Gain Adjustment: 0 – 30dB in 1dB steps per channel
8. Passband Ripple: +/-2dB
9. Uplink Noise Figure: < 8dB (at maximum gain).

## **PART 2 - PRODUCTS**

### **2.1 END-OF-LINE TERMINAL SUPERVISOR'S MOBILE RADIO ANTENNA RAIL YARD TOWER RADIO ANTENNA AND GATE HOUSE RADIO ANTENNA**

- A. Manufacturers:
1. Motorola APX4500 (M22SSS9PW1AN) radio R2 with:
    - Dash mount (G66AW)
    - Control station desk mic(W382AM)
    - Control Station Power supply ( G91AE)
    - Trunking Baud Single System (QA01749AB)
    - Base Station APEXWWM ( W665BJ)
    - Dash mount 02 wwm (G66AW)
    - APX 02 Control Head (GA00804AB)
  2. Or approved equal.
- B. Ratings:
1. Frequency: 450-520 MHz band
  2. RF Input impedance: 50-ohms.
  3. Power Input: 120-Vac, 60-Hz. adaptor
  4. Equipped with desk microphone and tray.

### **2.2 FLEXIBLE FOAM-DIELECTRIC ½-INCH COAXIAL CABLE FOR DAS**

- A. Manufacturers:
1. Commscope FXL-540-NHR
  2. Or approved equal
- B. Ratings:
1. Impedance: 50 ohms.
  2. Jacket: Non-halogenated, fire retardant polyolefin
  3. Dielectric Material: Foam PE
  4. Operating Temperature -30 °C to +70 °C (-22 °F to +158 °F)
  5. Peak Power: 41.8 kW
  6. Operating Frequency Band: 100 – 8800 MHz
  7. Fire Retardancy Test Method: IEC 60332-3-24 | UL 1666/CATVR/CMR
  8. Smoke Index Test Method : IEC 61034
  9. Toxicity Index Test Method : IEC 60754-1 | IEC 60754-2

### **2.3 RADIAX COAXIAL RADIATING CABLE 1-5/8-INCH for DAS**

- A. Manufacturers:
1. Commscope RCT7-WBC-2A-RNAM
  2. Or approved equal
- B. Ratings:
1. Impedance: 50 ohms.
  2. Jacket: Non-halogenated, fire retardant polyolefin
  3. Tape Barrier: Mica
  4. Dielectric Material: Foam PE
  5. Operating Temperature -30 °C to +80 °C (-22 °F to +176 °F)
  6. Peak Power: 302.0 kW
  7. Operating Frequency Band: 50 – 2700 MHz
  8. Fire Retardancy Test Method: IEC 60332-3-24 | IEC 60332-3C-24 | NFPA-130-2010

9. Smoke Index Test Method : IEC 61034
10. Toxicity Index Test Method : IEC 60754-1 | IEC 60754-2

**2.4 RADIO REPEATER AND DONOR ANTENNAS FOR DAS SYSTEM**

- A. Manufacturers:
  1. MARS Antenna and RF system - MA-CQ27-1X ( OMNI 490/800 MHz)
  2. Sunol Sciences – LP425PCB ( Broadband Directional Antenna 490/800 MHz)
  3. Sunol Sciences – LP425 ( Broadband Directional Antenna 490/800 MHz)
  4. Telewave, Inc. – ANT450D ( Freq: 406-512 MHz Dipole Antenna / Off- Air)
  5. PCTEL - BMOY4705 (470-512 MHz 9dBd 5 Element Yagi Antenna/ Off-Air)
  6. Or approved equal.
- B. Ratings:
  1. Impedance: 50 ohms.
  2. Frequency Range: 490 MHz / 800 MHz

**2.5 OFF-THE-AIR RADIO REPEATER SYSTEM COMPONENTS FOR DAS**

- A. The nature of the Off-The-Air Radio Repeater Systems mandate custom- designed and fabricated components tailored around the required operating frequencies. Detailed specifications shall be provided for each custom-designed component for approval prior to fabrication.  
Manufacturers:
  1. Axell Wireless BDA: 50-206801
  2. Andrew/Commscope BDA: Node A4
  3. Or approved equal
- B. The coaxial cables, radiating cables, and/or fixed antennas selected for use in this system shall be submitted for approval prior to procurement. The cables shall be rated Low-Smoke, Halogen-Free (LSHF)
- C. The Off-The-Air Radio Repeater Systems shall be provided with a backup power system that will assure the system will continue to provide service during interruptions of commercial power to the system lasting up to 8-hours
- D. Ratings:
  1. Impedance: 50 ohms.
  2. Frequency:

TDR Channel No.	Band	Tx Channels (MHz)	Rx Channels (MHz)
1	LB	490.8625	493.8625
2	LB	490.7875	493.7875
3	HB	496.4375	499.4375
4	HB	496.5375	499.5375
5	HB	496.6125	499.6125
6	HB	496.5625	499.5625
7	HB	496.4875	499.4875
8	HB	496.3375	499.3375
9	LB	490.9625	493.9625
10	LB	490.9125	493.9125
11	LB	490.8875	493.8875
12	LB	490.8375	493.8375
13	LB	489.5375	492.5375

14	LB	489.5125	492.5125
15	HB	496.5875	499.5875
AVL 1	HB	496.4625	499.4625
AVL 2	LB	489.0875	492.0875
AVL 3	LB	489.1625	492.1625
AVL 4	LB	490.7625	493.7625
MTPD	LB	490.9375	493.9375
SMNT	HB	496.5125	499.5125

### **PART 3 - EXECUTION**

#### **3.1 INSTALLATION**

- A. End-Of-Line Terminal Supervisor's Office / Rail Yard Tower Office / Gate House
  - 1. Install the End-Of-Line Terminal Supervisor's Mobile Radio / Rail Yard Tower Radio and Gate House Radio, as shown on the contract drawings, in a location approved by the Engineer.
  - 2. Install the required power cable, connectors, and associated hardware to provide 120-Vac, 60-Hz power for the Mobile Radio from an available ac receptacle at the different locations.
  - 3. Adjust the transmitter for minimum power output to minimize interference to other WMATA frequencies.
  
- B. The WMATA Distributed Antenna System (DAS)
  - 1. Install the Metrorail CRCS Radio Subsystem, as shown on the contract drawings, in a location approved by the Engineer.
  - 2. Install the required power cable, connectors, and associated hardware to provide 120-Vac, 60-Hz power for the Mobile Radio from an available ac receptacle at the different locations.
  - 3. Adjust the transmitter for minimum power output to minimize interference to other WMATA frequencies.

#### **3.2 MANUFACTURER'S FIELD SERVICES**

- A. Prepare and start systems under provisions as specified in the contract documents.
- B. Supervise final wiring connections and system adjustments.

#### **3.3 ADJUSTING**

- A. Adjust operating Products and equipment to ensure smooth and unhindered operation.

#### **3.4 TEST**

- A. All End-Of-Line Terminal Supervisor's Radio, Yard Tower Radios and Gate house radios shall be tested for 2-way communication. For measuring the audio quality of the communications during the RF coverage tests, the Delivered Audio Quality (DAQ) levels from ANSI/TIA Technical Service Bulletin (TSB)-88 were used. A DAQ of 3.4 or better is expected
  
- B. All Distributed Antenna Systems (DAS) installed in stations and other WMATA facilities to provide supplemental coverage shall be tested for 2-way communication and maintain a signal level exceeding -95 dBm for 95% of the time in the entire station and provide Delivered Audio Quality rating of 3.4 (DAQ 3.4) or better in all

areas specified in this document . Open areas shall be divided up into 5 feet x 5 feet grids. Radio checks and downlink control channel levels will be measured in each grid. Two or more radio check failures after moving 3 feet in either direction within a grid will be considered a failure. Radio coverage shall also be performed in all station public areas, service rooms and other non-public areas that are part of the station or facility as defined in drawings.

C. Test Requirement for DAQ (3.4 and better) :

DAQ 5.0	Speech easily understood.
DAQ 4.5	Speech easily understood. Infrequent noise/distortion.
DAQ 4.0	Speech easily understood. Occasional noise/distortion.
<b>DAQ 3.4</b>	<b>Speech understandable with repetition only rarely required. Some noise/distortion.</b>

**3.5 DEMONSTRATION**

- A. Demonstrate operation and maintenance of Products to WMATA personnel two weeks prior to date of Substantial Completion.
- B. Demonstrate Project equipment by a qualified person who is knowledgeable about the Project.
- C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with WMATA personnel in detail to explain all aspects of operation and maintenance.
- D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at equipment location
- E. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.
- F. Demonstrate system operation.
- G. Conduct walking tour of Project and briefly describe function, operation, and maintenance of each component.

## SECTION 16793

### COMMUNICATIONS - PUBLIC SAFETY SERVICE DISTRIBUTED ANTENNA SYSTEM

#### PART 1 - GENERAL

##### 1.01 SECTION DESCRIPTION AND BASIC REQUIREMENTS

- A. This Section describes the purpose, basic components, and requirements of the WMATA Public Service System (PSS) Radio Tunnel Antenna.
- B. The purpose of the WMATA PSS Radio Tunnel Antenna is to provide a seamless extension of the external radio coverage throughout the WMATA Rail Rapid Transit System underground tunnel and station areas. The PSS System repeats the aboveground two-way RF communications for all existing Public Service 800 MHz band radio systems located within the Washington Metropolitan Area.
- C. Beginning in 1993, WMATA installed an 800 MHz 75 ohm leaky antenna system throughout the under ground rail and passenger station system. This system, known as the Public Service System or PSS, consists of 5/8-inch leaky feeder running along the tunnel walls at train window level in each of the two tunnels to maximize portable coverage on the trains. The PSS antenna system uses 800 MHz band bi-directional Radio Frequency(RF) amplifiers to boost the radio signals along the tunnel route and in the underground stations and ancillary areas. Also, discrete antennas in the stations are interconnected with 1/2-inch non-radiating cable to provide radio coverage in selected areas.
- D. The existing 800 MHz PSS system occupies most of the approximately 102 miles of WMATA underground single-track tunnels and passenger stations. This system was implemented for use by the public safety forces in the WMATA area. Currently Arlington County, VA, the District of Columbia Fire Department and Montgomery County have plans to use the PSS cable antenna system. The Bell Atlantic cellular system, also installed throughout WMATA underground facilities, is a similar, parallel radio system but is not connected in any way to the PSS radio tunnel antenna system.
- E. Each of the existing PSS radio segments have been custom designed. It consists of a head-end location at the end of a passenger station and 5000 to 7500 feet of leaky feeder in each of the two (inbound & outbound) tunnels. Allen Telecom Systems Division Micro Fill amplifiers provide the needed amplification for the leaky feeder and for the discrete station antennas. Kaval amplifiers provide the needed amplification for the leaky feeder and for the discrete station antennas for this outer B, E, F, G, C/J and Mid E Routes. Allen Telecom Micro amplifiers support remains underlaying areas.
- F. It will be the responsibility of the contractor to perform surveys of the existing PSS system to know exactly what has been installed and gather information necessary for the design and construction of the present route extension PSS radio tunnel antenna system.
- G. The contractor shall design, provide, install, coordinate, interface, test, start-up and fully document an 800 MHz PSS Radio Tunnel Antenna System and its associated support subsystems throughout the entire tunnels, passenger stations, and all associated rail service system facilities.

- H. The PSS antenna system provided under this contract shall operate throughout the entire 800 MHz Public Safety Band (805 MHz to 870 MHz).

## **1.02 UNIT PRICES**

- A. Unit Prices include incidental items, not specifically mentioned, but required for complete and proper system operation.

## **1.03 RELATED SECTIONS**

- A. Section 16704 - Communications Standard Specifications - Installation..
- B. Section 16705 - Communications Standard Specifications - Equipment & Materials.
- C. Section 16710 – Communications Grounding.
- D. Section 16706 - Communications System Submittals & Services.
- E. Section 16707 - Communications Systems Quality Assurance & Testing
- F. Section 16715 - Communications Electrical Power Distribution
- G. Section 16791 - Communications - Mobile Radio System

## **1.04 REFERENCES, CODES, STANDARDS AND SPECIFICATIONS**

- A. Issues of the following documents, in effect at the time of solicitations of bids, form a part of this specification document. In the event of conflict between this specification and the codes, standards listed below, the most stringent requirement shall govern.
  1. Federal Communications Commission (FCC) Rules & Regulations: Part 15, Radio Frequency Devices; Part 17, Construction, Marking, and Lighting of Antenna Structures; Part 22, Public Mobile Services; Part 68, Connection of Terminal Equipment to the Telephone Network; Part 90, Private Land Mobile Radio Services; and any other relevant section.
  2. National Fire Protection Association (NFPA): NFPA 130 - Standard for Fixed Guideway Transit Systems.
  3. MIL-HDBK-419A, Grounding, Bonding and Shielding for Electronic Equipments & Facilities, Volume 1 & 2..
  4. American Society for Testing and Materials (ASTM): ASTM B8-99, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft; and ASTM B187, B187-00 Standard Specification for Copper Bar, Bus Bar, Rod, and Shapes
  5. American National Standards Institute, Inc.(ANSI): C57.12.00-2000, IEEE Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers; C57.15-1999, Regulators, Requirements, Terminology, and Test Code for Step-Voltage and Induction-Voltage; C57.93-1995, IEEE Guide for Installation of Liquid-Immersed Power Transformers; C57.94-1982, IEEE Recommended Practice for Installation, Application, Operation, and Maintenance of Dry-Type General Purpose Distribution and Power Transformers; and Z55.1, Gray Finishes for Industrial Apparatus and Equipment.
  6. National Electrical Manufacturers Association (NEMA): ST20-1992 (R1997), Dry Type Transformers for General Applications; and TR1-1993, Transformers, Regulators, and Reactors.

- B. The contractor shall be familiar with all local codes and regulations that affect the work of this Contract. Where local ordinances specify higher standards and requirements than those represented in this specification, the local ordinances shall govern.

#### **1.04 SYSTEM DESCRIPTION**

- A. Description: The PSS Radio Tunnel Antenna System to be provided under this contract shall consist of two radio segments: Segment 41 and Segment 42, as described in the enclosed drawings. Each radio segment will have underground, at grade and aerial sections. The PSS radio antenna system shall provide total, complete and seamless radio coverage to all WMATA facilities within this project area in all underground, at grade and aerial route sections, passenger stations and ancillary areas.
- B. Each radio segment shall consist of:
  - 1. A radio Head-End unit located at a passenger station that shall transmit the underground signals to the external donor repeater/receiver via an external directional antenna and receive the external donor transmitter signal to be amplified and distributed to the underground antenna system.
  - 2. Bi-directional broadband amplifiers (BDA).
  - 3. Radiating Cable (distributed) antenna system.
  - 4. Non-radiating RF signal transmission cable sections.
  - 5. PSS equipment electric UPS Power Distribution System.
  - 6. Omni-directional and directional discrete antennas for open or/and larger area coverage.
  - 7. Coupling, splitter, termination, interconnection, and matching devices.
  - 8. Installation and accessory hardware.
  - 9. Grounding System.
- C. The PSS electric UPS power distribution system to be provided by this contract shall have additional spare capacity at each Head-End and PSS amplifier location to power two additional future amplifier equipment installations.
- D. Radiating cable antenna installation shall be accomplished at both tunnel routes as shown in drawings attached to the tunnel wall at rail vehicle window elevation as to provide RF radio coverage not only to vehicle radio equipment but also to portable radio units located inside the moving rail vehicles.
- E. Contractor shall size all equipments and materials included in contract and provide information in the Final Design Submittal.

#### **1.06 SYSTEM PERFORMANCE REQUIREMENTS**

- A. Radio coverage for requirements at all WMATA facilities within the project area (using portable radio units at hip level) shall be (whichever is better radio coverage):
  - 1. Delivered Audio Quality (DAQ) equal to 4.0.
  - 2. Equivalent to 98% availability or 99.0% of the area locations 99.0% of the time.
- B. The above radio coverage performance shall be verified by field-testing before project acceptance.

#### **1.07 SUBMITTALS**

- A. Submit under provisions of Section 16706.

- B. Systems Final Design.
- C. Shop Drawings: Indicate electrical characteristics and connection requirements, including complete and detailed system-wiring diagram.
- D. Product Data: Provide showing electrical characteristics and connection requirements for each component.
- E. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.
- F. Radio coverage performance field test results.
- G. As built drawings, Operations and Maintenance Manuals.

## **1.08 QUALIFICATIONS**

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum five years documented experience.
- B. Supplier: Authorized distributor of specified manufacturer with minimum three years documented experience.
- C. Installer: Authorized installer of specified manufacturer with service facilities within 50 miles of Project and with minimum five years documented experience.

## **PART 2 - PRODUCTS**

### **2.01 MAJOR ITEMS TECHNICAL REQUIREMENTS**

- A. The Major Items listed below shall conform to the operational and performance requirements of these Specifications. Incidental items, not specifically mentioned, but required for complete and proper system operation, shall be furnished and installed by the Contractor.

### **2.02 PSS HEAD END UNIT**

- A. KAVAL Telecom Inc., 80 db Bi-Directional Amplifier BDA 1200 (or approved equal).
  1. Equipped with Microprocessor control that allows installers and technicians the ability to set and check all system parameters, and the following:
    - a. Password protected.
    - b. Self Diagnosis & Continuous Monitoring.
    - c. Battery Backup & Management Control.
    - d. Thermal Management Control.
    - e. Over current/Under current Fault Monitoring.
    - f. Automatic (AGC) and Digital DGC) Gain Controls.
    - g. RS 232 Interface.
  2. Nominal maximum gain of 80 dB and a passband ripple of +/- 2.0 dB.
  3. Digital gain control that allows up to 31 dB adjustments in 1.0 dB increments.
  4. Broad Bandwidth: equipment shall provide unlimited channel capacity within the pass-band and capable of passing both Analog and Digital protocols.
  5. Down-link pass-band of 851 MHz to 869 MHz.
  6. Up-link pass-band of 806 MHz to 824 MHz.
  7. Automatic Gain Control (AGC) Dynamic range of 40 dB.

8. Capable of a maximum RF Input of +10.0 dBm.
9. 3<sup>rd</sup> Order Intercept Point of 45 dBm and Noise Figure less than 8 dB.
10. All subsystem components shall be Modular for quick replacement.
11. Input/output Impedance of 50 Ohms.
12. Operating Temperature of -30<sup>o</sup> C to +50<sup>o</sup> C.
13. N-Female Input and Output connectors.
14. Cabinets shall be NEMA #4, with approximate dimensions of 14W X 16H X 10D inches.

### **2.03 PSS LINE AMPLIFIER UNITS**

- A. KAVAL Telecom Inc., 80 dB to 40 dB (as required by System's Final Design) Bi-Directional Amplifier BDA 1200 (or approved equal). All required parameters are equal to above Head End unit except for:
  1. Nominal maximum gain of 65 dB or 40 dB (as required by Final Design).
  2. Digital Gain Adjustment of 26 dB or 15 dB (as required by Final Design).
  3. Equipped with remote alarm modules conforming with existing WMATA Kaval Remote Alarm Monitoring System.

### **2.04 5/8 INCH LOW-LOSS CO-AXIAL SLOTTED RADIATING ANTENNA CABLE**

- A. Trilogy Communications Inc, Model No. AR058F75 (or approved equal)
- B. Non-halogenated, flame retardant and smoke resistant jacket.
- C. Complete with mounting hardware.

### **2.05 1/2-INCH LOW-LOSS CO-AXIAL TRANSMISSION CABLE**

- A. Trilogy Communications Inc, Model No. AT012F75 (or approved equal)
- B. Non-halogenated, flame retardant and smoke resistant jacket.
- C. Complete with mounting hardware.

### **2.06 COAXIAL CABLE CONNECTORS**

- A. Appropriate for each type and size of cable.
- B. Type "N" connectors.
- C. Covered with shrink sleeving or other approved waterproof covering.

### **2.07 ANTENNA POWER SPLITTER**

- A. Four way, Pasternac Inc., Model No. 2038, (or approved equal).
- B. Two-way, Mini-Circuits Inc., Model No. ZAPD-1-N, (or approved equal).
- C. Type "N" connectors.
- D. 50 ohm impedance.
- E. Frequency Range: 806-870 MHz.

**2.08 50-OHM RF TERMINATION LOAD**

- A. Mini-Circuit Inc., Model No. NTRM-50 (or approved equal).
- B. Type "N" connectors.
- C. Covered with shrink sleeving or other approved waterproof covering.

**2.09 75 TO 50 OHMS IMPEDANCE MATCHER**

- A. KAVAL Telecom Inc., Model No. A65U (or approved equal).
- B. Type "N" connectors.
- C. Covered with shrink sleeving or other approved waterproof covering.

**2.10 JUMPER CABLE WITH 2 N-Male CONNECTORS**

- A. Four feet long, Connertec RF, Inc., Model No. CNT-4-NMNM (or approved equal).
- B. Three feet long, Connertec RF, Inc., Model No. CNT-3-NMNM (or approved equal).
- C. Two feet long, Connertec RF, Inc., Model No. CNT-2-NMNM (or approved equal).

**2.11 PANEL ANTENNA**

- A. TESSCO, Model No. 65541-DB871-H120 (or approved equal).
- B. Type "N" connectors.

**2.12 TUNNEL ANTENNA**

- A. TESSCO, Model No. 70419-DB471N-XY (or approved equal).
- B. Type "N" connectors.

**2.13 CABLE RF TAP**

- A. KAVAL Telecom Inc., Model No. CCT-12 (or approved equal).
- B. Type "N" connectors.

**2.14 PSS POWER TRANSFORMER**

- A. Totally enclosed 480V/120V Single Phase Power Transformer.
- B. At least, three (3) full rated taps at 480V, 456V and 432V.
- C. High Voltage winding shall be fused.
- D. Transformer shall be totally enclosed in NEMA 3R enclosure with the core and coils completely encapsulated, with only the insulated wire leads exiting from encapsulation.

- E. Transformer shall be provided with key-hole mounting slots in mounting angles that are welded to the enclosures.
- F. Minimum allowed insulation shall be 150°C and shall withstand full wave impulse level of 10 KV.
- G. At each PSS amplifier location the contractor shall size all equipment to power three Bidirectional amplifiers, as required in Section 16793, 1.04.C, above.
- H. Submittals: As part of the required Shop Drawing Submittal, the contractor shall submit the following information concerning the power transformer: Tap Details, Name Plate Details, Mounting Details, and Physical Dimensions.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. The Contractor shall install all terminals, hardware, connectors, wiring and cabling, conduits and fittings, and make all connections and cross-connections required for a complete installation.

### **3.02 PSS HEAD END RADIO UNITS**

- A. The Contractor shall install optimum location complete PSS HEAD END Radio Units in the passenger stations, as specified herein.
- B. The Contractor shall install the PSS HEAD END Radio Units, the signal splitter units, the station panel antennas, and all related equipment and material in the passenger stations, as shown on the Contract Drawings. The Contractor shall provide and install durable permanent labels on the Head End Units to advise technicians to maintain the prescribed operating levels and parameters.
- C. The Contractor shall install the required cabling, conduit and fittings, connectors, ac receptacles, junction boxes, and hardware and make the necessary connections and cross-connections to provide 120 Vac, 60 Hz power to each Head-End radio unit at each station.
- D. The Contractor shall install the required coaxial cable, and appropriate size and RF typeconnectors, to interconnect the various coupling equipment, station panel antennas, and distribution cables at each passenger station.
- E. The Contractor shall install donor signal receive and transmit antenna on a location above the passenger station building and shall connect coaxial transmission cable to the head-end unit. Lightning arrester equipment shall be installed at the outside end of circuit to protect head end radio units. Antenna shall be oriented for optimal received signal strength.
- F. The Contractor shall install label each end of every cable run to display cable use, cable number designation, and end terminal destinations.

### **3.03 SLOTTED COAXIAL CABLE (RADIAX) ANTENNA SYSTEM**

- A. The Contractor shall install a Slotted Coaxial Cable Antenna System in the passenger station and tunnel areas, as indicated on the Contract Drawings, to serve the PSS Radio System.

- B. The Slotted Coaxial Cable Antenna System shall be installed throughout the tunnel areas, in the train room (platform area) and in underground passageways.
- C. In tunnel areas, the slotted coaxial cable antenna shall be installed on the wall on the vertical embedded channels, as indicated on the Contract Drawings. The wall with the vertical embedded channels is the one with the safety walk. The slotted coaxial cable antenna shall be trimmed and terminated to conform to a maximum allowable signal overlap of 50 feet between contiguous slotted coaxial cable antenna sections
- D. The power splitters used to connect coaxial cable and the Slotted Coaxial Cable Antenna System shall be oriented as shown on the Contract Drawings.
- E. The slotted coaxial cable antenna shall be installed at rail vehicle window level. Slotted coaxial cable antenna shall be mounted with approved hardware. In tunnel areas, the slotted coaxial cable antenna shall be attached to the supporting surface at intervals not to exceed five feet, by use of hanger kits, and may deviate upward and back down again, for short distances, to avoid objects when necessary. Cable runs may be securely clamped to existing lighting or other conduit, and may be installed over such conduit or boxes only if the antenna cable remains at least one foot outside of the authorized rail car tunnel profile. Insofar as possible, the slotted coaxial cable shall not extend beyond other items mounted in the same area.
- F. The low-loss coaxial cable shall be installed in conduit and/or conduit sleeves and duct banks between the Head-End Equipment Rooms and the tunnel areas. The Contractor shall install the necessary conduit and fittings, and passages for cable and conduit from the Head End Equipment Rooms to the tunnel areas as required. The low-loss, coaxial cable shall only be exposed within the Head End Equipment Rooms and the tunnel areas.
- G. All coaxial connectors, couplers and cable terminations used in the installation of the Slotted Coaxial Cable Antenna System shall be completely covered and moisture-sealed with shrinkable sleeving or other approved waterproof covering.
- H. The Slotted Coaxial Cable Antenna System shall be grounded to a single point communications ground.

**END OF SECTION**

## SECTION 16820

### COMMUNICATIONS - PUBLIC ADDRESS SYSTEM

#### PART 1 - GENERAL

##### 1.01 SECTION DESCRIPTION AND BASIC REQUIREMENTS

- A. Public Address Systems are used to provide information to the public in passenger stations and trains. Public Address Systems are also used to communicate with personnel in station service rooms, yards and shops. Separate public address systems shall be provided at each passenger station, on board each train, in yards, and in shops.
- B. Access to each Public Address System shall be provided to a local control station on an individual basis and to the Operations Control Center on an individual select, group select, or "all call" select condition control.
- C. Transit vehicle public address systems allow for public announcements by the train operator. Also, through intervention by the train operator, public announcements can be made directly from the Operations Control Center.
- D. The Rail Operations Control Center (OCC) in the Jackson Graham Building uses the PENTA PA Control Equipment to select and broadcast in the following ways:
  - 1. Systemwide announcements to all Metro Rail Stations.
  - 2. Announcements to selected Lines (i.e., Red Line, Green Line, or Blue/Orange Lines).
  - 3. Individual passenger stations.
- E. Each passenger station in the WMATA Rail System shall be designed to have an independent Public Address (PA) system. The passenger station PA system provides for general purpose and emergency evacuation announcements throughout the passenger station. PA announcements originate from the kiosk, the Rail Operations Control Center (OCC) in the Jackson Graham Building, Automatic Public Address Announcement System (APAAS), and end-of-line station's dispatcher's room.
- F. A line mixer shall be used to control the level of these individual inputs. A single output shall be taken from the mixer and applied to a compressor-limiter, the output of the compressor-limiter is fed to the APAAS control unit through the APAAS/PA interface unit (described below) to the final power amplification.
- G. The PA system shall provide noise compensated circuits to the platform and mezzanine areas, where train noise must be overcome by automatically adjusting the PA volume.
- H. Non-noise compensated circuits shall be provided for service rooms and non-revenue passageways, these areas normally do not require noise compensation.
- I. The PA system design shall be such that announcements that are made over the PA system will be managed in accordance with the following access priority:
  - 1. Automatic Public Address Announcement System.
  - 2. Rail Operations Control Center (OCC) in the Jackson Graham Building.
  - 3. Kiosk.
  - 4. When an announcement of a higher priority is initiated, the lower priority announcement is removed from the amplifier's input until the high priority announcement is completed.

- J. The operation of the passenger station PA system from the kiosk is accomplished by simultaneously depressing the push-to-talk pushbuttons on the hand-held microphone and the kiosk PA Control Panel, then speaking into the hand-held microphone. Certain kiosks (generally those subject to "large event" traffic) shall be designed to have a portable wireless microphone transmitter, to be worn by the kiosk attendant, and a diversity wireless receiver. The diversity wireless receiver is connected to the PA system so as to by-pass and take the place of the normal kiosk microphone when the wireless microphone is keyed. This feature is used to allow the kiosk attendant freedom of movement beyond the kiosk for various reasons including crowd control.
- K. When a selection is made by a Passenger Operations Supervisor in the Rail OCC, the audio path of the console is connected to the PA system channel of the selected passenger station's Carrier Transmission System terminal for transmission to the selected passenger station(s). At the passenger station, the audio path from the assigned PA system channel of the Carrier Transmission System is connected to the station PA Control Unit.
- L. The Dispatcher's PA Control Panel shall function in an identical manner as the kiosk Public Address Control Panel. (Loudspeaker zone selection is not available at the kiosk).
- M. The PA system's design shall have redundant power amplifiers. The power amplifiers shall be connected to the Amplifier Supervisory Control Unit. One power amplifier shall be connected to the "MAIN CHANNEL" of the Amplifier Supervisory Control Unit, and the second power amplifier shall be connected to the "auxiliary channel" of the Amplifier Supervisory Control Unit. Each Amplifier Supervisory Control Unit shall monitor the associated power amplifiers and, upon sensing a malfunction of the "main channel" power amplifier, shall automatically transfer the audio path to the "auxiliary channel" power amplifier.
- N. The passenger station PA speakers shall be designed to be wired in either noise-compensated or non-noise compensated circuits. Noise-compensated circuits shall be used in areas where train noise must be overcome by automatically adjusting the PA volume. The station mezzanine area and platform areas are of noise compensated circuits, which use Automatic Level Control. For areas where noise compensation is required, circuits shall be wired to the Loudspeaker Distribution Panel designated for noise-compensated circuits. Non-noise compensated circuits shall be used in all other areas. In areas where noise-compensated circuits are not required, circuits shall be wired to the Loudspeaker Distribution Panel designated for non-noise compensated circuits. Passenger station service rooms and non-revenue passageways are examples of areas that require non-noise compensated speaker circuits.
- O. Each kiosk in the WMATA Rail System shall be designed to have an Attendant/Passenger Interphone System. The Attendant/Passenger Interphone System shall provide for communication between passengers and the kiosk attendant at the kiosk. The Attendant/Passenger Interphone System shall serve both the "PAID" and the "UNPAID" side of each kiosk.
- P. A sufficient quantity of speakers shall be placed in passenger stations to give even volume distribution without objectionable loudness from any one speaker location.
- Q. The PA amplifiers shall have a constant voltage output of 70.7 volts. Each loudspeaker shall be equipped with an audio transformer to match the 70.7-volt line with the loudspeaker. The transformers shall have various taps to allow for adjustment of the sound

level in a particular area. Each transformer shall have a minimum of four taps. The power rating for each of the taps shall be determined during installation.

- R. Design of public address systems in stations shall be coordinated with architectural design.

#### **1.02 SECTION INCLUDES**

- A. Loudspeakers in the passenger station and services areas.
- B. Control hardware in the Kiosk and End-Of-Line dispatcher office.
- C. Control and amplification equipment in the Communication Equipment Room.
- D. Wireless Microphone System in the Kiosk.
- E. Attendant/Passenger Interphone System in the Kiosk.
- F. Intercom System in the End-Of-Line dispatcher office.

#### **1.03 UNIT PRICES**

- A. Unit Prices include all equipment racks, terminals, hardware, protector blocks, enclosures, connecting blocks, wiring and cabling, conduits and fittings, all the connections and cross-connections required for a complete operational installation of the Public Address System and incidental items, not specifically mentioned, but required for complete and proper system operation.

#### **1.04 RELATED SECTIONS**

- A. Section 16705 - Communications Standard Specifications - Equipment & Materials.
- B. Section 16706 - Communications System Submittals & Services.
- C. Section 16707 - Communications Systems Quality Assurance & Testing
- D. Section 16710 -Communications Grounding.
- E. Section 16715 - Communications Electrical Power Distribution.
- F. Section 16733 - Communications - Kiosk Systems
- G. Section 16771 – Communications Carrier Transmission System.

#### **1.05 REFERENCES**

- A. National Electric Code (NEC).
- B. UL Standard 1480, Speakers for Fire Protective Signaling Systems.

#### **1.06 SYSTEM DESCRIPTION**

- A. Description: Provides for general purpose and emergency evacuation announcements throughout the passenger station. PA announcements originate from the kiosk, the Rail

OCC in the Jackson Graham Building, Automatic Public Address Announcement System (APAAS), or end-of-line station's dispatcher's room.

- B. The Attendant/Passenger Interphone System provides for communications between passengers and the Station Manager at the kiosk. The Attendant/Passenger Interphone System services both the "PAID" and the "UNPAID" side of the kiosk.
- C. The dispatcher PA System/Intercom, in end-of-line stations, shall provide access to the passenger station PA system to make announcements to the station platform and mezzanine at any time that the PA system is not already in use. Additionally, a separate intercom system shall be provided at the dispatcher's room in end-of-line stations to provide oral communications between the Train Control Room, the Dispatcher's Room, and the Operations Room.
- D. Capacity:
  - 1. The Contractor shall design the placement of Type 1 loudspeakers using sound coverage calculations and typical drawings from the communications drawing package
  - 2. The Contractor shall design the placement of Type 2 loudspeakers using sound coverage calculations and typical drawings from the communications drawing package.
  - 3. The Contractor shall design the placement of Type 3 loudspeakers using sound coverage calculations and typical drawings from the communications drawing package.
  - 4. The Contractor shall furnish and install a kiosk PA Control Panel(s) constructed in accordance with contract specifications and drawings.
  - 5. The Contractor shall furnish and install a station PA Control Unit(s) constructed in accordance with contract specifications and drawings.
  - 6. The contractor shall furnish, and install a kiosk Attendant/Passenger Interphone(s) in accordance with contract specifications and drawings.
  - 7. The contractor shall furnish, and install a voice Pre-Amp/Processor in accordance with contract specifications and drawings.
  - 8. The contractor shall furnish, and install a Dual Zone Priority Mixer in accordance with contract specifications and drawings.
  - 9. The Contractor shall furnish, and install a Compressor/Limiter in accordance with Contract Specifications and Drawings.
  - 10. The Contractor shall furnish, and install a Audio Distribution Amplifier in accordance with Contract Specifications and Drawings.
  - 11. The Contractor shall furnish, and install a Ambient Noise Sensor in accordance with Contract Specifications and Drawings.
  - 12. The Contractor shall furnish, and install a Digital Equalizer in accordance with Contract Specifications and Drawings.
  - 13. The Contractor shall furnish, and install a 60-Watt Power Amplifier in accordance with Contract Specifications and Drawings.
  - 14. The Contractor shall furnish, and install a 120-Watt Power Amplifier in accordance with Contract Specifications and Drawings.
  - 15. The Contractor shall furnish, and install a Wireless Microphone Transmitter and Receiver in accordance with Contract Specifications and Drawings.
  - 16. The Contractor shall furnish, and install a 24-Vdc Power Supply in accordance with Contract Specifications and Drawings.
  - 17. The Contractor shall design, furnish, and install a custom Loudspeaker Distribution Panel in accordance with Contract Specifications and Drawings.
  - 18. The Contractor shall design, furnish, and install a custom Audio and Control Distribution Panel in accordance with Contract Specifications and Drawings.

19. The Contractor shall design, furnish, and install a custom Loudspeaker Zone Attenuator Assembly in accordance with Contract Specifications and Drawings.
20. The Contractor shall furnish, and install a PA Patch Panel Assembly in accordance with Contract Specifications and Drawings.
21. The Contractor shall furnish, and install a End-Of-Line Dispatcher Intercom in accordance with Contract Specifications and Drawings.

#### **1.07 SYSTEM PERFORMANCE REQUIREMENTS**

- A. The contractor shall be responsible for the overall performance of the PA system. The following overall system performance requirements are designed to ensure that the PA system, delivered under these specifications, meets the performance requirements of the Washington Metropolitan Area Transit Authority.
  1. PA Overall Frequency Response:  $\pm 5$ db or better 200-Hz to 8,000-Hz
  2. PA Sound Pressure Levels: 100dB minimum measured 1 meter from front of each speaker.
  3. PA Overall Harmonic Distortion: Less than 1% 200-Hz to 8,000-Hz.
  4. Interphone Overall Frequency Response:  $\pm 5$ db or better 200-Hz to 5,000-Hz
  5. Interphone Sound Pressure Levels: 90dB minimum measured 1 meter from kiosk wall, 1.5 meters above floor.
  6. Interphone Overall Harmonic Distortion: Less than 5% 200-Hz to 5,500-Hz.

#### **1.08 SUBMITTALS**

- A. Submit under provisions of Section 16706.
- B. Shop Drawings: Indicate electrical characteristics and connection requirements, including system wiring diagram.
- C. Product Data: Provide showing electrical characteristics and connection requirements for each component.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

#### **1.09 QUALIFICATIONS**

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Supplier: Authorized distributor of specified manufacturer with minimum three years documented experience.
- C. Installer: Service facilities within 50 miles of Project.

#### **1.10 MAINTENANCE SERVICE**

- A. Furnish service and maintenance of Public Address System until Final Completion.

### **PART 2 - PRODUCTS**

#### **2.01 SPEAKERS ASSEMBLY TYPE 1 (PYLON) and TYPE 2 (CEILING)**

- A. Manufacturers:
  - 1. QUAM Model 8C10PAOTB/TBL70(Driver) W/Quam-Nichols SE1WVP (Enclosure Type 1) w/Quam-Nichols BS8WVP (Grill Type 1) (or approved equal).
- B. Description: Speakers for use in Pylons and Passenger Station ceiling.
- C. Ratings:
  - 1. Magnet:
    - a. Weight: 10-ounces.
    - b. Material: Ceramic.
    - c. Flux Density: 9K gauss.
    - d. DC Resistance: 7.4 ohms.
    - e. Diameter: One inch.
  - 2. Electrical:
    - a. Power Handling: 15-Watts.
    - b. Transformer: 70-volt multi-tap at 4,2,1,and .5watts.
    - c. Frequency Response: 80-Hz to 8-KHz.
    - d. Sensitivity: 95db.
  - 3. Mechanical:
    - a. Depth: 3-1/4 inches.
    - b. Transformer Mounting: Min 2 inches – Max 2-13/16 inches.
    - c. Mounting Hole Circle: 7-5/8 inches.
    - d. Baffle Opening: Seven inches.
    - e. Cone: 8-inch full range moisture proof.
    - f. Grill: Custom finish color to match current WMATA pylon color.

## **2.02 SPEAKERS ASSEMBLY TYPE 3 (STAFF SERVICE AREAS)**

- A. Manufacturers:
  - 1. Atlas/Soundolier Model No. VT-27UCN (or approved equal)
- B. Description: Speakers for use in service areas.
- C. Ratings:
  - 1. Transformer: 70.7-Volts.
  - 2. Power Taps: 1 and 2 Watts
  - 3. Frequency Response: 600-Hz to 5500-Hz (± 5db).
  - 4. Sensitivity: 96.9dB (1-watt at 1-meter).
  - 5. Dimensions: 4-1/2 inches, square.
  - 6. Mounting Box: Atlas/Soundolier Model No. SEN.
  - 7. Color: Neutral Gray.
  - 8. Construction: Die-cast zinc, water/moisture sealed.

## **2.03 KIOSK PA CONTROL PANEL**

- A. Manufacturers:
  - 1. Custom Item.
- B. Description: Station Manager's Public Address System Control Panel.
- C. Furnished by WMATA. [IS THIS STILL APPLICABLE?]

## **2.04 STATION PA CONTROL UNIT**

- A. Manufacturers:
  - 1. Custom Item.
- B. Description: Control and interface unit for the PA System.
- C. Furnished by WMATA.[IS THIS STILL APPLICABLE?]

## 2.05 KIOSK ATTENDANT/PASSENGER INTERPHONE

- A. Manufacturers:
  - 1. Norcon Communications Model No. TTU-7J electronic communications system (Norcon Communications, Inc., 516-239-0300 or www.norconcomm.com) (or approved equal).
- B. Description: Intercom between Kiosk attendant and passengers.
- C. Ratings:
  - 1. Audio Power: Two watts.
  - 2. Microphone: Removable Gooseneck.
  - 3. Power: 12-Vdc battery pack.
  - 4. Speaker Enclosure Finish: Metro Bronze, Federal Standard 595B, Color No. 20040.

## 2.06 VOICE PRE-AMP/PROCESSOR

- A. Manufacturers:
  - 1. Symetrix Model No. 572E (or approved equal) with Middle Atlantic Product SC-1 security cover (or approved equal).
- B. Description: Voice processor incorporating a high-quality microphone preamp coupled to three-band parametric equalizer, high and low pass filters, and a dynamic range processor
- C. Ratings:
  - 1. Mic Input:
    - a. Impedance: Balanced transformerless, low impedance..
    - b. Gain Range: 20 to +60 dB(pad out), 5 to 45 dB (pad in).
    - c. Max Input Level: 0 dBu (pad out).
    - d. Phantom Power: +48 Volts nominal
  - 2. Line Input:
    - a. Impedance: 10k ohms transformerless, balanced bridging.
    - b. Max Input Level: +20dBu.
  - 3. Parametric Equalizer:
    - a. Frequency: Low: 16-Hz to 500-Hz, Mid: 160-Hz to 6300-Hz, High: 680-Hz to 22-KHz.
    - b. Peak/Dip Bandwidth: 0.3 octaves, measured at maximum boost.
    - c. Maximum Boost/Cut:  $\pm$  15dB.
  - 4. Filters:
    - a. Low Cut Filter Slope: 12dB/octave.
    - b. Low Cutoff Frequency Range: 6-Hz to 260-Hz @ - 3dB.
    - c. High Cut Filter Slope: 12dB/octave.
    - d. High Cutoff Frequency Range: 3-KHz to 65-KHz.
  - 5. Metering:
    - a. Type: Multi-segment LED bar graph.
    - b. Output Level: -20, -10, 0, Clip (0 VU=+4dBu), VU calibrated, peak responding.
    - c. Expander Gain Reduction: 3, 6, 12, 20 dB.
    - d. Compressor Gain Reduction: 3, 6, 12 dB.
  - 6. Dynamic Range Processor:
    - a. Type: Interactive comp/limiter-downward expander.

- b. Comp/Limiter Ratio: 1:1 to 10:1.
- c. Downward Expansion ratio (mix): 1:1.8.
- 7. Output:
  - a. Output section Type: Balanced transformerless.
  - b. Maximum Output Level: +21dBu balanced.
  - c. Output Clip LED: Fires 3dB below clipping.
  - d. Output source Impedance: 200-Ohms, Balanced.
  - e. Output Gain:  $\pm 15$ dB.
- 8. Frequency Response: 20-Hz to 20-KHz.
- 9. Power Input: 120-Vac.
- 10. Mounting: 19" rack.

## 2.07 DUAL ZONE PRIORITY MIXER

- A. Manufacturers:
  - 1. Symetrix, Inc. Model 450 (or approved equal).
- B. Description: Mixer with three levels of priority .
- C. Ratings:
  - 1. Microphone inputs: Two, low impedance, balanced.
  - 2. Microphone Common Mode Rejection: >85dB @ 1KHz, 1 Volt RMS.
  - 3. Line Inputs: Four, stereo.
  - 4. Line Input Impedance: > 10K ohms, balanced.
  - 5. Line Common Mode Rejection: >40dB @ 1KHz, 1 Volt RMS.
  - 6. Line Input Level: +24dBu balanced, +18dBu unbalanced maximum.
  - 7. Frequency Response:  $\pm 1$  dB, 20-Hz to 20-KHz any input to any output.
  - 8. Mounting: 19-inch rack.
  - 9. Power Input: 120-Vac.

## 2.08 COMPRESSOR/LIMITER

- A. Manufacturers:
  - 1. Symetrix, Inc. Model 301 (or approved equal).
- B. Description: AGC-Leveler with mic/line input.
- C. Ratings:
  - 1. Line Inputs: 20k ohms balance, 10k ohms.
  - 2. Microphone Input: XLR-female & Screw Terminals.
  - 3. Outputs: XLR-male & Screw Terminals 200 ohms balanced.
  - 4. Attack Time: 500 $\mu$ S to 100 mS.
  - 5. Release Time: 50mS to 4 seconds.
  - 6. Threshold: -40dBu to +20dBu..
  - 7. Compressor Ratio: Bypass to 10:1.
  - 8. Power Input: 120-Vac, 7-pin DIN.
  - 9. Mounting: 19-inch rack.

## 2.09 AUDIO DISTRIBUTION AMPLIFIER

- A. Manufacturers:
  - 1. Symetrix, Inc. Model 301 (or approved equal).
- B. Description: One input/four output audio distribution amplifier.

- C. Ratings:
1. Maximum Input Level: +26dBu Balanced
  2. Maximum Output Level: +26dBu Balanced (20k ohm load), +22dBm (600 ohm load).
  3. Input Impedance: 20k ohms balanced, 10k ohms unbalanced.
  4. Output Impedance: 200 ohms balanced, 100 ohms unbalanced.
  5. Frequency Response:  $\pm 0.5$ dBm, 20-Hz to 20-KHz.
  6. Input Gain Range:  $\pm 15$ dB.
  7. Output Gain Range: 0 to  $-20$ dB.

## 2.10 AMBIENT NOISE SENSOR

- A. Manufacturers:
1. Symetrix Model No 571 (or approved equal)
- B. Description: Ambient sensing automatic level controlling device to regulate the operating level of a sound system in proportion to changing noise levels in the sound system's operating area.
- C. Ratings:
1. Inputs: Two sensing mic (-40dBu nominal) CMRR => 60dB at 1-KHz, one paging mic (-40dBu nominal) CMRR => 60dB at 1-KHz, one line (0dBu nominal) CMRR =< 40dB at 1-KHz, one music (-10dBu nominal) CMRR =< 40dB at 1-KHz
  2. Maximum Input Level: -30dBu (mic inputs), +18 (line inputs).
  3. Input Impedance: Mic: electronically balanced bridging 200 ohms, nominal (not phantom powered). Line: electronically balanced bridging 20 kilo ohms nominal.
  4. Phantom Power (on all mic inputs): 15-Vdc.
  5. Output: Balanced, transformerless.
  6. Output Impedance: 100 ohms.
  7. Maximum Control Range: 40dB.
  8. Ambient noise to Gain Ratio: Variable, 2:1 to 1:2.
  9. Averaging Time: 1.2 sec. To 5 min.
  10. Page-Over Music (ducking): Variable, 0 to 14 dB.
  11. Frequency Response: 20-Hz to 20-KHZ( + 1 dB,-0 dB).
  12. Power Input: 120-Vac 60-Hz.
  13. Mounting: 19-inch rack.

## 2.11 DIGITAL EQUALIZER

- A. Manufacturers:
1. Shure Model No. DFR-11EQ (or approved equal).
- B. Description: Digital 1/3 Octave graphic equalizer, automatic and manual acoustic feedback suppression for 10 frequencies, digital delay compressor/limiter..
- C. Ratings:
1. Remote Programming: RS232C serial port.
  2. Frequency Response: 20-Hz to 20-KHz  $\pm 1.0$ dB reference 1 KHz.
  3. Dynamic Range: 104db minimum, A-weighted, 20-Hz to 20-KHz.
  4. Sampling Rate: 48-KHz.
  5. Digital-to-Analog, Analog-to-digital Conversion: 20-bit resolution.
  6. Voltage Gain:
    - a. Power Off: -1 dB  $\pm$  1dB.

- b. Equal Input And Output Sensitivities: 0dB  $\pm$  2dB.
- c. Input -10dBv, Output +4dBu: 12dB  $\pm$  2dB.
- d. Input +4dBu, Output - 10dBv: -12dB  $\pm$  2dB.
- 7. LED Signal Indicators: Clip: 6dB down from input clipping.
- 8. Feedback Filters:
  - a. Ten 1/10-octave adaptive notch filters from 60-Hz to 20-KHz.
  - b. Deployed to 1-Hz resolution of feedback frequency
  - c. Deployed in depths of 3dB, 6dB, 9dB, 12dB and 18dB (12.5 Low Q in graphic EQ mode) attenuation.
  - d. Filter shape variable between HI Q and LOW Q.
- 9. Graphic Equalizer:
  - a. Frequency Bands: 30 bands on ISO, 1/3-octave centers.
  - b. Filter Type: 1/3- octave, constant Q.
  - c. Maximum Boost: 6dB per band.
  - d. Maximum Cut: 12dB per band, high- and low-pass filters, 12dB/octave nominal.
- 10. Parametric Equalizer:
  - a. Frequency Bands: 10 bands, variable frequency, variable Q.
  - b. Boost/Cut Range: + 6 to -18 dB per band.
  - c. Q Range: 1/40-octave to 2 octave.
  - d. Shelf/Rolloff Filters: Shelf, + 6 to - 18 dB per filter. Rolloff, 6dB, 12dB, 18dB, or 24dB per octave nominal.
- 11. Delay: Up to 1300ms.
- 12. Limiter:
  - a. Threshold: - 60dBFs to - 0.5dBFs, 0.5dB resolution
  - b. Attack: 1 ms to 200 ms.
  - c. Decay: 50 ms to 100 ms.
  - d. Ratio: 4 to 1.
- 13. Mounting: 19-inch rack.
- 14. Power Input: 120-Vac 60-Hz.

## 2.12 60-WATT POWER AMPLIFIER

- A. Manufacturers:
  - 1. TOA Model No. P-906MK2 with MB 35B rack mount kit (or approved equal).
- B. Description: Audio power amplifier.
- C. Ratings:
  - 1. Output Power: 60-watts RMS.
  - 2. Frequency Response: 20-20,000 Hz, +1dB/-3 dB.
  - 3. Inputs: One input port, one direct.
  - 4. Input Sensitivity/Impedance:
    - a. Input Port: 100 mV or 1000 mV (switchable)/10 K ohms.
    - b. Direct Input: 100 mV or 1000 mV (switchable)/10 K ohms.
  - 5. Output:
    - a. Main (Transformer): 8 ohms, 25 and 70 volts, balanced.
    - b. Main(Direct): 4 ohms, unbalanced.
  - 6. Indicators: One power LED, one protect LED, one signal LED, one normal LED, one peak LED.
  - 7. Power Input: 120-Vac 60-Hz, 100-watts.
  - 8. Mounting: 19-inch rack, maximum of two EIA rack units in height.
  - 9. Input Module: TOA Model No. B01F balanced line input, 10k ohms.

### 2.13 120-WATT POWER AMPLIFIER

- A. Manufacturers:
  - 1. TOA Model No. P-912MK2 with MB 35B rack mount kit (or approved equal)
- B. Description: Audio power amplifier.
- C. Ratings:
  - 1. Output Power: 120-watts RMS
  - 2. Frequency Response: 20-20,000 Hz, +1dB/-3dB.
  - 3. Inputs: One input port, one direct.
  - 4. Input Sensitivity/Impedance:
    - a. Input Port: 100 mV or 1000 mV (switchable)/10 K ohms.
    - b. Direct Input: 100 mV or 1000 mV (switchable)/10 K ohms.
  - 5. Output:
    - a. Main (Transformer): 8 ohms, 25 and 70 volts, balanced.
    - b. Main(Direct): 4 ohms, unbalanced.
  - 6. Indicators: One power LED, one protect LED, one signal LED, one normal LED, one peak LED.
  - 7. Power Input: 120-Vac 60-Hz, 180-watts.
  - 8. Mounting: 19-inch rack, maximum of two EIA rack units in height.
  - 9. Input Module: TOA Model No. B01F balanced line input, 10k ohms.

### 2.14 WIRELESS MICROPHONE TRANSMITTER AND RECEIVER

- A. Manufacturers:
  - 1. Shure Model No. UC2/UC4 UHF microphone system with UA500 remote antenna kit and PS40 Power Supply (or approved equal).
- B. Description: UHF Wireless Microphone System with head-worn microphone transmitter.
- C. Ratings:
  - 1. RF Carrier Frequency Range: 782 – 806 MHz.
  - 2. Working Range 500 ft. minimum under typical conditions.
  - 3. Audio Frequency response: 45 to 15,000 Hz  $\pm$ 2dB.
  - 4. Gain Adjustment Range: -6 to 26 dB.
  - 5. Receiver Audio Output Level (Maximum):
    - a. Unbalanced: + 5dBu typical.
    - b. Balanced: + 14dBu typical.
  - 6. RF Sensitivity: -108dBm at 12dB SINAD.
  - 7. Image Rejection 90dB typical.
  - 8. Spurious Rejection 70dB typical.
  - 9. Power Requirements:
    - a. UC2: 9V alkaline battery.
    - b. UC4: 15-Vdc, 600-mA.
  - 10. Mounting: 19 rack

### 2.15 24-VDC POWER SUPPLY

- A. Manufacturers:
  - 1. Acopian, Model No. 24PT10 (or approved equal).
- B. Ratings:
  - 1. Nominal Voltage: 24-Vdc (regulated).
  - 2. Rated Current: Three Amperes continuous (minimum).
  - 3. Regulation: Less than 2%.

4. Ripple: Less than 10 mV rms.
5. Power Required: 105 to 125 Vac, 50/60 Hz, 170-watts (nominal).

#### **2.16 LOUDSPEAKER DISTRIBUTION PANEL**

- A. Manufacturers:
  1. Custom assembly by contractor.
- B. Metal EIA rack mount panel:
  1. Middle Atlantic Products Rack Panel- PHBL Series or approved equal.
- C. Phoenix Captive Wire Terminal Block product or approved equal.
- D. Captive wire terminal blocks rated for not less than 120-Vac, 15-amp.
- E. Provide sufficient quantity of captive wire terminal blocks to support all loudspeaker zone cabling plus 10% spare terminations for expansion.
- F. Printed permanently affixed labeling strip identifying each numbered captive wire terminal.
- G. Provide all mounting hardware and cable terminations for a complete assembly.

#### **2.17 AUDIO AND CONTROL DISTRIBUTION PANEL**

- A. Manufacturers:
  1. Custom assembly by contractor.
- B. Metal EIA rack mount panel:
  1. Middle Atlantic Products Rack Panel- PHBL Series or approved equal.
- C. Phoenix Captive Wire Terminal Block product or approved equal.
- D. Captive wire terminal blocks rated for not less than 120-Vac, 15-amp.
- E. Provide sufficient quantity of captive wire terminal blocks to support all loudspeaker zone cabling plus 10% spare terminations for expansion.
- F. Printed permanently affixed labeling strip identifying each numbered captive wire terminal.
- G. Provide all mounting hardware and cable terminations for a complete assembly.

#### **2.18 LOUDSPEAKER ZONE ATTENUATOR ASSEMBLY**

- A. Manufacturers:
  1. Custom assembly by Contractor.
- B. Description: Volume control of Staff Service Area loudspeaker zones.
- C. Metal EIA Rack Mount Panel:
  1. Middle Atlantic Products Rack Panel – PHBL series or approved equal.
- D. 70-volt Loudspeaker attenuators:

1. Atlas-Soundolier AT-10RM or AT35RM attenuator or approved equal (actual model/wattage rating determined must exceed actual load of loudspeaker zone connected).
  2. With front panel knobs.
  3. Attenuation steps of 3dB.
  4. Non-shorting rotary switch.
  5. Ten steps, plus off position.
  6. Silver plated contacts.
  7. One attenuator per loudspeaker circuit.
- E. Custom engraving (or silk screening) identifying panel as STAFF SERVICE AREA LOUDSPEAKER ZONES @, .25-in. tall letters.
- F. Custom engraving (or silk screening) identifying each loudspeaker zone for each attenuator .375-inch tall letters.
- G. Rear mounted loudspeaker cabling captive wire terminal strip.
- H. Provide all mounting hardware and cable terminations for a complete assembly

## **2.19 PA PATCH PANEL ASSEMBLY**

- A. Manufacturers:
1. AVR Communications Group VERSAPATCH Model No. II-AB (or approved equal).
- B. Description: Patch panel assembly for the audio power amplifiers and audio signal
- C. Ratings
1. Number of Jacks: Two rows of 24
  2. Insertion Loss: Less than 0.1dB
  3. Jack Circuits Configuration: Top-to-bottom row jack circuits are normalled (looped) internally (AB).
  4. Punch Block: Rear mounted proprietary 66-terminal punch block for solid and stranded wire (Flexiblock)
  5. Chassis and Brackets: Aluminum
  6. Mounting: 19-inch rack.
  7. Compatibility: Standard ¼ inch 3-conductor phone shielded audio patch cords.
- D. Provide printed designation labeling for each jack.
- E. Sealed enclosure to keep out contaminants.
- F. Rear Cable strain relief bar.
- G. Provide sufficient quantity of normalled patch circuits to patch the combined total of all individual patch points

## **2.20 PATCH PANEL PUNCH TOOL**

- A. Manufacturers:
1. AVR Communications Group Model No. S-714 (or approved equal).
- B. Compatible with wiring punchblocks included with patch panel.

- C. Contractor shall locate/ Punch Tool in rack mounted storage drawer for use by WMATA Maintenance.

## **2.21 PATCH PANEL PUNCH TOOL**

- A. Manufacturers:
  - 1. AVR Communications Group Model No. 639-100-085 (or approved equal).
- B. Description: Audio patch cord compatible mating with provided Patch Panels..
- C. Ratings:
  - 1. Plugs: TSR ¼ inch phone connectors.
  - 2. Length: 60 inches.
  - 3. Cable: 22-gauge stranded twisted pair, with shield and overall insulator.
- D. Locate/store Patch Cord in rack mounted storage drawer for use by WMATA Maintenance.

## **2.22 END-OF-LINE DISPATCHER INTERCOM**

- A. Manufacturers:
  - 1. Aiphone Communication Systems Model No. LEF-3 (or approved equal).
- B. Description: An open voice, selective calling type intercom with individual selector switches for each station.
- C. Ratings:
  - 1. Output: 800 mW @ 20 ohms (reception), 500 mW @ 20 ohms (transmission).
  - 2. Communication: Press-to-talk, release-to-listen at master station. Hands free response.
  - 3. Capacity: Up to four stations, intermixable.
  - 4. Speaker Sensitivity: 40dB.
  - 5. Total Harmonic Distortion: Less than 5% at rated output power.
  - 6. Signal to Noise Ratio: 60dB.
  - 7. Frequency Response: -3dB, 770-6,800 Hz.
  - 8. Power Source: 12-Vdc, 300-mA per station (Use Aiphone PS-12C power supply).

## **2.23 INTERCOM POWER SUPPLY**

- A. Manufacturers:
  - 1. Aiphone Communication Systems Model No. PS-1C (or approved equal).
- B. Description: DC power supply for Aiphone LEF-3 intercom.
- C. Ratings:
  - 1. Input Voltage: 120-Vac, 50/60 Hz.
  - 2. Power Consumption: 28 watts.
  - 3. Output Voltage: 12-Vdc.
  - 4. Maximum Output Current: One Amp dc.

## **2.24 INTERCOM SUB STATION**

- A. Manufacturers:
  - 1. Aiphone Communication Systems Model No. LS-NVP with SBX-NVP surface mount box (or approved equal).

- B. Description: Vandal proof sub station for Aiphone LEF-3 intercom.
- C. Ratings:
  1. Speaker: 20 ohms, three-inch diameter, water and puncture resistant, 2.5 oz. Ceramic magnet.
  2. Call Button: SPST with mechanical stop, normally open.
  3. Faceplate: 11-gauge carbon steel with powder-coated white baked epoxy finish.
  4. Communication: Hands free at sub. Master station controls push-to-talk, release-to-listen.
  5. Mounting: Surface mount with SBX-NVP box.
  6. Mounting Hardware: Tamper-proof screws
  7. Dimensions: SBX-NVP 8-5/8"H x 6-5/8"W x 2-1/4"D.
  8. Power Source: Supplied by master.

## **2.25 CARDIOD DYNAMIC MICROPHONE WITH 18" GOOSENECK**

- A. Manufacturers:
  1. Shure SM57 (microphone) with Shure A12 (mounting flange), with Shure G18-CN(18" Gooseneck), with Shure A2WS (windscreen) (or approved equal).
- B. Description: Kiosk microphone.
- C. Ratings:
  1. Type: Unidirectional Dynamic Cardioid.
  2. Impedance: 150 ohm (310 actual).
  3. Frequency Response: 40-15 KHz.
  4. Output: Balanced 3-pin male XLR.

## **2.26 AC POWER LINE CONDITIONER-20 AMP**

- A. Manufacturers:
  1. New Frontier Electronics Surge-X SX2120 (or approved equal).
- B. Description: Electrical power line surge suppressor and line conditioner.
- C. Ratings:
  1. Mounting: 19-inch rack.
  2. Current: 20 amps at 120-Vac.
  3. Rear Outlets: 12 switched, two un-switched.
  4. Front Panel Indications: Electrical service and surge fault.
  5. Front Panel Switches: One for switched outlets.
- D. Automatic internal test of circuitry.
- E. UL Listed. Meeting or exceeding UL grade A-1-1 for power line surge suppression and EMI/RFI line conditioning.
- F. Series mode circuitry rated to immediately clamp 6000-Vac line surges.
- G. Series mode circuitry rated with unlimited surge current without ground contamination.

## **2.27 AC POWER LINE CONDITIONER, 15-AMP**

- A. Manufacturers:

1. New Frontier Electronics Surge-X SX115R (or approved equal).
- B. Description: Electrical power line surge suppressor and line conditioner.
- C. Ratings:
  1. Mounting: 19-inch rack.
  2. Current: 15-amps at 120-Vac.
  3. Rear Outlets: Six switched, two un-switched.
  4. Front Panel Indications: Electrical service and surge fault.
  5. Front Panel Switches: One for switched outlets.
- D. Automatic internal test of circuitry.
- E. UL Listed. Meeting or exceeding UL grade A-1-1 for power line surge suppression and EMI/RFI line conditioning.
- F. Series mode circuitry rated to immediately clamp 6000-Vac line surges.
- G. Series mode circuitry rated with unlimited surge current without ground contamination.

#### **2.28 SHIELDED TWISTED-PAIR CABLE (16-AWG)**

- A. Description: loudspeaker cable type, for loudspeaker zones not exceeding 60 watts.
- B. UL rated. NEC Type CMR with low smoke NON-PVC jacket.
- C. Ratings:
  1. Conductors: 16-AWG stranded twisted pair ASTM tinned copper with overall 100% foil shield.

#### **2.29 SHIELDED TWISTED-PAIR CABLE (14-AWG)**

- A. Description: loudspeaker cable type, for loudspeaker zones not exceeding 120 watts.
- B. UL rated. NEC Type CMR with low smoke NON-PVC jacket.
- C. Ratings:
  1. Conductors: 14-AWG stranded twisted pair ASTM tinned copper with overall 100% foil shield.

#### **2.30 SHIELDED MULTI-TWISTED-PAIR CABLE (20-AWG)**

- A. Description: Audio cable for all audio wiring and ambient noise and paging microphones.
- B. UL rated. NEC Type CMR with low smoke NON-PVC jacket.
- C. Ratings:
  1. Conductors: 20-AWG stranded twisted pair ASTM tinned copper with overall 100% foil shield.

#### **2.31 SHIELDED MULTI-TWISTED-PAIR CONTROL SIGNALING/AUDIO CABLE**

- A. Description: control signaling multi-pair cable type, for all control and DC voltage wiring.

- B. UL rated. NEC Type CMR with low smoke NON-PVC jacket.
- C. Ratings:
  - 1. Conductors: 18-AWG stranded twisted pairs ASTM tinned copper with overall 100% foil shield.

### **2.32 AMBIENT NOISE SENSOR MICROPHONE (ANS-MIC)**

- A. Manufacturers:
  - 1. Crown Model No.PZM-11 or approved equal.
- B. Ambient Noise Sensor Microphone, phantom powered boundary microphone mounted on single-gang wallplate.
- C. Color white.
- D. Ceiling mounted at locations shown on drawings, in metal junction box provided by Contractor.
- E. Hemispherical polar pattern.
- F. Electret condenser element.
- G. Frequency response 80Hz to 20,000Hz.
- H. Signal to noise ratio 68dB at 94dB SPL.
- I. 225 ohms balanced impedance.
- J. Provide with mounting hardware, conduit pathway and cabling.

### **2.33 DISPATCHER PA FACILITY-TABLETOP INSTRUMENT CABINET**

- A. Manufacturers:
  - 1. AMCO Engineering Company, Model No. IAPDM21-19-18-PT (or approved equal).
- B. 19-inch vertical rack mounting channels.
- C. Vinyl covered aluminum construction, rubber base feet, convection cooling.
- D. Dimensions (D, W, H): 18 3/4" x 19" x 21".
- E. Color: Light Blue.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION REQUIREMENTS**

- A. Install a complete and operational passenger station Public Address System, as described herein, in the passenger station(s). This includes installations in the Kiosk(s), Communications Equipment Room(s) and Dispatcher's Facility.

- B. Install all terminals, hardware, wiring and cabling, conduits, and fittings. The Contractor shall install the required connectors, attenuators, baluns, audio isolation transformers, and inter-rack wiring between the various equipment, and make all necessary connections and cross-connections required for complete installations. All inter-rack wiring between various equipment shall be shielded, twisted-pair cable.

### **3.02 PA SPEAKER INSTALLATION**

- A. In those locations where a PA Speaker enclosure is not imbedded, the Contractor shall install the appropriate type PA speaker enclosure. PA speaker enclosures are imbedded in the ceiling of the mezzanine areas, under the mezzanine structure, and in entrance passageways of the passenger station. No speaker enclosures are imbedded in service rooms and non-revenue passageways. Install surface mounted speaker enclosures or suspended ceiling mounted enclosures as appropriate.
- B. Submit a proposed PA speaker layout for the passenger station to the Engineer for approval. This layout shall show each PA speaker, the matching transformer tap to be used and the total power per circuit.
- C. Install the PA speaker, with matching transformer and associated speaker baffles, in the PA speaker enclosures.
- D. Install the PA speaker, with matching transformer and associated speaker baffles, in the Pylon on the station platform.
- E. Install the required cabling, hardware and material to connect the speakers (via matching transformers) to the appropriate Loudspeaker Distribution Panels. Furnish and install conduit between PA speaker.

### **3.03 COMMUNICATIONS EQUIPMENT ROOM INSTALLATION**

- A. Install the equipment on a 19-inch equipment rack in the Communications Equipment Room of the passenger station(s).
- B. Distribute the 70.7-volt amplified audio to all speakers in the passenger station(s) using a Loudspeaker Distribution Panel for each zone.
- C. All PA amplifiers shall be adjusted, internally or externally, via audio attenuators, to provide the full rated audio output for a 0 dBm input signal level.
- D. Install the required cabling, connectors and plugs to provide 120-Vac, 60-Hz to the various PA equipment from the ac power receptacle strip on the PA equipment rack.

### **3.04 KIOSK INSTALLATION**

- A. Install a Kiosk Public Address Control Panel in the appropriate bay of the Kiosk cabinetry.
- B. Install the voice pre-amp/processor in the appropriate bay of the Kiosk cabinetry.
- C. Install a hand-held Gooseneck microphone on the appropriate bay of the Kiosk cabinetry. Furnish and install the required wiring harness between the Kiosk PA Control Panel and the Kiosk Cable Termination Rack in the Kiosk.
- D. Install the wireless microphone receiver in the appropriate bay of the Kiosk cabinetry and mount the antenna on top of the Kiosk in a location approved by the Engineer. Furnish and

install the required wiring harness between the wireless microphone receiver and the Kiosk Cable Termination Rack in the Kiosk.

- E. Install individually-shielded, twisted, pair cables between the Kiosk Cable Termination Rack and the appropriate PA equipment in the Communications Equipment Room. The Contractor shall use these cables to connect the Kiosk PA Control Panel and wireless microphone receiver to the appropriate PA System equipment within the Communications Equipment Room.

### **3.05 KIOSK-ATTENDANT/PASSENGER INTERPHONE SUBSYSTEM INSTALLATION**

- A. Install a complete operational Kiosk-Attendant/Passenger Interphone Subsystem in the Kiosk of the passenger station(s).
- B. Surface-mount two Interphone Loudspeaker Enclosures to the exterior of the Kiosk structure at each passenger station. One Interphone Loudspeaker Enclosure shall be installed on the Kiosk door. The second Interphone Loudspeaker Enclosure shall be installed on the Kiosk structure associated with Bay Four of the Kiosk cabinetry. Exact locations shall be approved by the Engineer.

### **3.06 TERMINAL SUPERVISOR'S PUBLIC ADDRESS FACILITY INSTALLATION**

- A. Install a complete operational Dispatcher's Public Address Facility in the new end-of-line Passenger Station (if applicable).
- B. Install a Public Address System Control Panel (same as the Kiosk PA System Control Panel), with microphone and a Loudspeaker Zone Selection Panel in a Tabletop Instrument Cabinet. The Contractor shall install the Tabletop Instrument Cabinet on top of the table/desk within the End-of-Line Terminal Supervisor's Room.
- C. Install a junction box with terminals within the Terminal Supervisor's Room in a location approved by the Engineer.
- D. Install a Terminal Supervisor's PA Zone Selection System for the Dispatcher's Facility.
- E. Provide all components needed to implement the Terminal Supervisor's PA Zone Selection System, and install the following components as stated below:
  - 1. Install the Terminal Supervisor's PA Zone Selection Panel in the Terminal Supervisor's Room.
  - 2. Install the Terminal Supervisor's PA Zone Control Unit in the Station PA System Equipment Rack in the Communications Equipment Room.
- F. Install individually shielded, twisted, three-pair audio cables, as needed, from the PA equipment in the Terminal Supervisor's Room to the Station PA Equipment Rack in the Communications Equipment Room, via the junction box with terminals. Install the necessary connections and cross-connections between the cables and the Kiosk PA Control Panel, Terminal Supervisor's PA Control Panel, Terminal Supervisor's PA Zone Selection Panel, Terminal Supervisor's PA Zone Control Unit; and the Station PA Control Unit. Connect the Terminal Supervisor's PA Control Panel to the Station PA Control Unit and the Terminal Supervisor's Zone Control Unit via the audio and control circuit connections assigned for Kiosk No. 3.

### **3.07 TERMINAL SUPERVISOR'S/TRAIN CONTROL ROOM/OPERATIONS ROOM INTERCOM**

- A. Install the Intercom Sub Station and the Surface-Mounted Enclosure in the Train Control Room and the Operations Room of the new Passenger Station in a location approved by the Engineer.
- B. Install a junction box with terminals within the Train Control Room and the Operations Room in a location approved by the Engineer.
- C. Install a two (2)-conductor cable from the Intercom Master to the Intercom Sub Stations in the Train Control Room, and the Operations Room, via the junction box installed at each location. The Contractor shall install the necessary connections and cross-connections to connect the Intercom Sub Station to the Intercom Master.

### **3.08 INTERFACE**

- A. Install the hardware and wiring required to connect the Automatic Public Address Announcement System equipment to the Passenger Station Public Address System equipment.
- B. Install the required hardware and wiring to connect the alarm output of the Station PA Control Unit to the Main Distribution Frame.
- C. Install the required cabling, hardware and material to connect the Carrier Transmission System to the Station PA Control Unit to provide for the Rail Operations Control Center announcements. Included in the installation is the wiring of -48 Vdc from the Carrier Transmission System Power Supply to the Station PA Control Unit to provide "M" lead signaling.

### **3.09 MANUFACTURER'S FIELD SERVICES**

- A. Prepare and start systems under provisions of Section 16707.
- B. Supervise final wiring connections and system adjustments.

### **3.10 ADJUSTING**

- A. Adjust operating Products and equipment to ensure smooth and unhindered operation.
- B. Adjust levels for proper sound levels in the services areas.

### **3.11 DEMONSTRATION**

- A. Demonstrate operation and maintenance of Products to WMATA personnel two weeks prior to date of Substantial Completion.
- B. Demonstrate Project equipment by a qualified person who is knowledgeable about the Project.
- C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with WMATA personnel in detail to explain all aspects of operation and maintenance.
- D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at equipment location.

- E. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.
- F. Demonstrate system operation.
- G. Conduct walking tour of Project and briefly describe function, operation, and maintenance of each component.

**END OF SECTION**

**SECTION 16820**  
**COMMUNICATIONS - PUBLIC ADDRESS SYSTEM**

**PART 1: GENERAL**

**1.01 SUMMARY**

- A. Public Address Systems are used to provide information to the public in passenger stations. Public Address Systems are also used to communicate with personnel in station service rooms. Separate public address systems shall be provided at each operational yard, facilities, and in shops.
- B. Access to each Public Address System shall be provided to a local control station on an individual basis and to Jackson Graham Building and Carmen Turner Facility on an individual select, group select, or "all call" select condition control.
- C. The Rail Operations Control Center (OCC) in the Jackson Graham Building and Carmen Turner Facility uses the PENTA PA Control Equipment to select and broadcast in the following ways:
  - 1. System wide announcements to all Metro Rail Stations.
  - 2. Announcements to selected Lines (i.e., Red Line, Green Line, Yellow line, Silver Line, or Blue/Orange lines).
  - 3. Individual passenger stations.
- D. Each passenger station in the WMATA Rail System shall be designed to have an independent Public Address (PA) system. The passenger station PA system provides for general purpose and emergency evacuation announcements throughout the passenger station. PA announcements originate from the kiosk, the Rail Operations Control Center (ROCC) in the Jackson Graham Building and Carmen Turner Facility, and end-of-line station's dispatcher's room.
- E. A line Priority mixer shall be used to control the level of these individual inputs.
- F. The PA system shall provide noise compensated circuits to the platform and mezzanine areas, where train noise must be overcome by automatically adjusting the PA volume.
- G. Non-noise compensated circuits shall be provided for service rooms and non-revenue passageways, these areas normally do not require noise compensation.
- H. The PA system design shall be such that announcements that are made over the PA system will be managed in accordance with the following access priority:
  - 1. Fire Emergency Evacuation Announcements.
  - 2. Wireless Microphone
  - 3. Rail Operations Control Center (ROCC) in the Jackson Graham Building and Carmen Turner Facility.
  - 4. Kiosk Microphone.
  - 5. End-of-line Dispatcher

When an announcement of a higher priority is initiated, the lower priority announcement is removed from the amplifier's input until the high priority announcement is completed.

- I. The operation of the passenger station PA system from the kiosk is accomplished by simultaneously depressing the push-to-talk pushbutton on the kiosk PA Control Panel, then speaking into the Goose Neck microphone. The diversity wireless receiver is connected to the PA system so as to by-pass and takes the place of the normal kiosk microphone when the wireless microphone is keyed. This feature is used to allow the kiosk attendant freedom of movement beyond the kiosk for various reasons including crowd control.
- J. When a selection is made by a Passenger Operations Supervisor in the Rail OCC, the audio path of the console is connected to the PA system channel of the selected passenger station's Carrier Transmission System terminal for transmission to the selected passenger station(s). At the passenger station, the audio path from the assigned PA system channel of the Carrier Transmission System is connected to the station PA Control Unit.
- K. The Dispatcher's PA Control Panel shall function in an identical manner as the kiosk Public Address Control Panel. (Loudspeaker zone selection is not available at the kiosk).
- L. The PA system's design shall have redundant power amplifiers. The power amplifiers shall be connected to the Amplifier Supervisory Control Unit. One power amplifier shall be connected to the "MAIN CHANNEL" of the Amplifier Supervisory Control Unit, and the second power amplifier shall be connected to the "auxiliary channel" of the Amplifier Supervisory Control Unit. Each Amplifier Supervisory Control Unit shall monitor the associated power amplifiers and, upon sensing a malfunction of the "main channel" power amplifier, shall automatically transfer the audio path to the "auxiliary channel" power amplifier.
- M. The passenger station PA speakers shall be designed to be wired in either noise-compensated or non-noise compensated circuits. Noise-compensated circuits shall be used in areas where train noise must be overcome by automatically adjusting the PA volume. The station mezzanine area and platform areas are of noise compensated circuits, which use Automatic Level Control. For areas where noise compensation is required, circuits shall be wired to the Loudspeaker Distribution Panel designated for noise-compensated circuits. Non-noise compensated circuits shall be used in all other areas. In areas where noise-compensated circuits are not required, circuits shall be wired to the Loudspeaker Distribution Panel designated for non-noise compensated circuits. Passenger station service rooms and non-revenue passageways are examples of areas that require non-noise compensated speaker circuits.
- N. Each kiosk in the WMATA Rail System shall be designed to have an Attendant/Passenger Interphone System. The Attendant/Passenger Interphone System

shall provide for communication between passengers and the kiosk attendant at the kiosk. The Attendant/Passenger Interphone System shall serve both the "PAID" and the "UNPAID" side of each kiosk.

- O. A sufficient quantity of speakers shall be placed in passenger stations to give even volume distribution without objectionable loudness from any one speaker location.
- P. The PA amplifiers shall have a constant voltage output of 70.7 volts. Each loudspeaker shall be equipped with an audio transformer to match the 70.7-volt line with the loudspeaker. The transformers shall have various taps to allow for adjustment of the sound level in a particular area. Each transformer shall have a minimum of four taps. The power rating for each of the taps shall be determined during installation.
- Q. Design of public address systems in stations shall be coordinated with architectural design.
- R. The Contractor shall have full responsibility to survey station, communication room, and services rooms and coordinate all work with WMATA's engineers.

#### **1.02 SECTION INCLUDES**

- A. Loudspeakers in the passenger station, passenger walkway, and services areas.
- B. Control hardware in the Kiosks and End-Of-Line dispatcher office.
- C. Control and amplification equipment in the Communication Equipment Room.
- D. Wireless Microphone System in the Kiosk.
- E. End-Of-Line dispatcher office.
- F. Fire Alarm System

#### **1.03 UNIT PRICES**

- A. Unit Prices include all equipment racks, terminals, hardware, protector blocks, enclosures, connecting blocks, wiring and cabling, conduits and fittings, all the connections and cross-connections required for a complete operational installation of the Public Address System and incidental items, not specifically mentioned, but required for complete and proper system operation.

#### **1.04 RELATED SECTIONS**

- A. Section 16705 - Communications Standard Specifications - Equipment & Materials.
- B. Section 16707 - Communications Systems Quality Assurance & Testing
- C. Section 16710 - Communications Grounding.
- D. Section 16715 - Communications Electrical Power Distribution.

- E. Section 16733 - Communications - Kiosk Systems
- F. Section 16820-2 – Communications Public Address System Facilities
- G. Section 16732 Communications Fire Alarm System

#### **1.05 REFERENCES**

- A. National Electric Code (NEC).
- B. National Fire Alarm Code (NFPA 72)
- C. UL Standard (*for the intend use*) 1480, Speakers for Fire Protective Signaling Systems.

#### **1.06 SYSTEM DESCRIPTION**

- A. Description: Provides for general purpose and emergency evacuation announcements throughout the passenger station. PA announcements originate from the Fire Alarm Equipment Panel, Kiosk Manager, End-of-line Dispatcher, the Rail OCC in the Jackson Graham Building and Carmen Turner Facility.
- B. The dispatcher PA system, in end-of-line stations, shall provide access to the passenger station PA system to make announcements to the station platform and mezzanine at any time that the PA system is not already in use.
- C. Capacity:
  - 1. The Contractor shall design the placement of Type 1 loudspeakers using sound coverage calculations and typical drawings from the communications drawing package.
  - 2. The Contractor shall design the placement of Type 2 loudspeakers using sound coverage calculations and typical drawings from the communications drawing package.
  - 3. The Contractor shall design the placement of Type 3 loudspeakers using sound coverage calculations and typical drawings from the communications drawing package.
  - 4. The Contractor shall furnish and install a kiosk PA Control Panel(s) constructed in accordance with contract specifications and drawings.
  - 5. The Contractor shall furnish and install a station PA Control Unit(s) constructed in accordance with contract specifications and drawings.
  - 6. The contractor shall furnish, and install gooseneck public address microphone and cables accordance with contract specifications and drawings.
  - 7. The contractor shall furnish, and install an audio voice processor in accordance with contract specifications and drawings.
  - 8. The contractor shall furnish, and install an audio priority mixer in accordance with contract specifications and drawings.
  - 9. The Contractor shall furnish, and install a DSP engine audio compressor/limiter in accordance with contract specifications and drawings.
  - 10. The Contractor shall furnish, and install an audio distribution amplifier in accordance with contract specifications and drawings.

11. The Contractor shall furnish, and install an ambient noise sensor in accordance with contract specifications and drawings.
12. The Contractor shall furnish, and install a digital equalizer in accordance with contract specifications and drawings.
13. The Contractor shall furnish, and install a 60-watt power amplifier in accordance with contract specifications and drawings.
14. The Contractor shall furnish, and install a 120-Watt Power Amplifier in accordance with contract specifications and drawings.
15. The Contractor shall furnish, and install wireless microphone transmitter equipment, wireless receiver equipment, antennas, and cables in accordance with contract specifications and drawings.
16. The Contractor shall furnish, and install a 24-Vdc power supply in accordance with contract specifications and drawings.
17. The Contractor shall design, furnish, and install a custom loudspeaker distribution panel in accordance with contract specifications and drawings.
18. The Contractor shall design, furnish, and install a custom Audio and control distribution panel in accordance with contract specifications and drawings.
19. The Contractor shall design, furnish, and install a custom Loudspeaker Zone Attenuator Assembly in accordance with contract specifications and drawings.
20. The Contractor shall furnish, and install a PA Patch Panel Assembly in accordance with contract specifications and drawings.
21. The Contractor shall furnish, and install end-of-line dispatcher PA equipment.
22. The Contractor shall design, furnish, and install Loudspeaker in accordance with contract specifications and drawings.
23. The contractor will take full responsibility for total design of the public address system with WMATA's engineer's approval.
24. The Contractor shall design, furnish, and install Wireless PA equipment in accordance with contract specifications and drawings.

#### **1.07 SYSTEM PERFORMANCE REQUIREMENTS**

- A. The contractor shall be responsible for the overall performance of the PA system. The following overall system performance requirements are designed to ensure that the PA system, delivered under these specifications, meets the performance requirements of the Washington Metropolitan Area Transit Authority.
  1. PA Overall Frequency Response:  $\pm 5$ db or better 200-Hz to 8,000-Hz
  2. PA Sound Pressure Levels: 85 dB minimum measured 3 meter from front of each canopy, pylon, ceiling, and passageway speaker.
  3. PA Overall Harmonic Distortion: Less than 1% 200-Hz to 8,000-Hz.

#### **1.08 SUBMITTALS**

- A. Submit under provisions of Section 16706.
  1. Shop Drawings: Indicate electrical characteristics and connection requirements, including system wiring diagram.

2. Product Data: Provide showing electrical characteristics and connection requirements for each component.
3. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.
4. Final As-Built drawings.
5. Operation and Maintenance manuals, preventative maintenance recommendations, and product data sheets.

#### **1.09 QUALIFICATIONS**

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Supplier: Authorized distributor of specified manufacturer with minimum three years documented experience.
- C. Installer: Service facilities within 50 miles of Project.

#### **1.10 MAINTENANCE SERVICE**

- A. Furnish service and maintenance of Public Address System until Final Completion.

### **PART 2: PRODUCTS**

#### **2.01 SPEAKERS ASSEMBLY PYLON, PARAPET, and CEILING**

- A. Manufacturers:
  1. Atlas- Sound loud speaker assembly Pylon Square or Round Horn Speaker (or approved equal)
  2. Atlas- Sound loud speaker assembly Pylon Vandal Resistant Square Speaker Grill (or approved equal)
  3. Atlas- Sound loud speaker assembly Pylon Weather Proof Square Surface Speakers Enclosure (or approved equal)
    - Weight: 10-ounces.
    - Material: Ceramic.
    - Flux Density: 9K gauss.
    - DC Resistance: 7.4 ohms.
    - Diameter: One inch.
    - Power Handling: 15-Watts.
    - Transformer: 70-volt multi-tap at 4, 2, 1, and .5watts.
    - Frequency Response: 80-Hz to 8-KHz.
    - Sensitivity: 95db.
    - Depth: 3-1/4 inches.

- Transformer Mounting: Min 2 inches – Max 2-13/16 inches.
  - Mounting Hole Circle: 7-5/8 inches.
  - Baffle Opening: Seven inches.
  - Cone: 8-inch full range moisture proof.
  - Grill: Custom finish color to match current WMATA pylon color.
4. Quam-Nichols loudspeaker assembly replacement (or approved equal)
  5. Quam-Nichols loudspeaker assembly parapet kit includes: speaker, TBLU transform, grill, and enclosure (or approved equal)

## **2.02 SPEAKERS ASSEMBLY STAFF SERVICE AREAS**

### **A. Manufacturers:**

1. Atlas- Sound loud speaker Loudspeaker assembly (VT 157U-C-N) Description: Speakers for use in service. (or approved equal)
  - Transformer: 70.7-Volts.
  - Power Taps: 1 and 2 Watts
  - Frequency Response: 600-Hz to 5500-Hz (± 5db).
  - Sensitivity: 96.9dB (1-watt at 1-meter).
  - Dimensions: 4-1/2 inches, square.
  - Color: Neutral Gray.
  - Construction: Die-cast zinc, water/moisture sealed.

## **2.03 KIOSK PA CONTROL PANEL**

### **A. Manufacturers:**

1. Custom Item.

### **B. Description: Station Manager's Public Address System Control Panel.**

## **2.04 STATION PA CONTROL UNIT**

### **A. Manufacturers:**

1. Custom Item.

### **B. Description: Control and interface unit for the PA system**

## **2.05 DUAL ZONE PRIORITY MIXER**

### **A. Manufacturers:**

1. Symetrix, Inc. Jupiter 8 (or approved equal).

### **B. Description: Mixer with eight (8) levels of priority.**

### **C. Ratings:**

1. Microphone inputs: Two, low impedance, balanced.
2. Microphone Common Mode Rejection: >85dB @ 1KHz, 1 Volt RMS.
3. Line Inputs: eight, stereo.
4. Line Input Impedance: > 10K ohms, balanced.
5. Line Common Mode Rejection: >40dB @ 1KHz, 1 Volt RMS.
6. Line Input Level: +24dBu balanced, +18dBu unbalanced maximum.
7. Frequency Response:  $\pm 1$  dB, 20-Hz to 20-KHz any input to any output.
8. Mounting: 19-inch rack.
9. Power Input: 120-Vac.

## **2.06 COMPRESSOR/LIMITER**

### **A. Manufacturers:**

1. Symetrix, Inc. Model 322 (or approved equal).

### **B. Description: DSP Engine Audio Leveler (Compressor/Limiter) Mounting: 19-inch rack**

## **2.07 AUDIO DISTRIBUTION AMPLIFIER**

### **A. Manufacturers:**

1. Symetrix, Inc. Model 581E (or approved equal).

### **B. Description: 4 input/ 16 output audio distribution amplifier.**

1. Maximum Output Level: +26dBu Balanced (20k ohm load), +22dBm (600 ohm load).
2. Input Impedance: 20k ohms balanced, 10k ohms unbalanced.
3. Output Impedance: 200 ohms balanced, 100 ohms unbalanced.
4. Frequency Response:  $\pm 0.5$ dBm, 20-Hz to 20-KHz.
5. Input Gain Range:  $\pm 15$ dB.
6. Output Gain Range: 0 to -20dB.

## **2.08 AMBIENT NOISE SENSOR MICROPHONE (ANSM)**

### **A. Manufacturers:**

1. Crown Model No PZM-11 (or approved equal)

## **2.09 AMBIENT NOISE COMPENSATION PROCESSOR (ANCP)**

### **A. Manufacturers:**

1. Symetrix Model No 371 (or approved equal)

### **B. Description: Ambient sensing automatic level controlling device to regulate the operating level of a sound system in proportion to changing noise levels in the sound system's operating area.**

C. Ratings:

1. Inputs: Two sensing mic (-40dBu nominal) CMRR => 60dB at 1-KHz, one paging mic (-40dBu nominal) CMRR => 60dB at 1-KHz, one line (0dBu nominal) CMRR=< 40dB at 1-KHz, one music (-10dBu nominal) CMRR =< 40dB at 1-KHz
2. Maximum Input Level: -30dBu (mic inputs), +18 (line inputs).
3. Input Impedance: Mic: electronically balanced bridging 200 ohms, nominal (not phantom powered). Line: electronically balanced bridging 20 kilo ohms nominal.
4. Phantom Power (on all mic inputs): 15-Vdc.
5. Output: Balanced, transformer.
6. Output Impedance: 100 ohms.
7. Maximum Control Range: 40dB.
8. Ambient noise to Gain Ratio: Variable, 2:1 to 1:2.
9. Averaging Time: 1.2 sec. to 5 min.
10. Page-Over Music (ducking): Variable, 0 to 14 dB
11. Frequency Response: 20-Hz to 20-KHZ (+ 1 dB,-0 dB).
12. Power Input: 120-Vac 60-Hz.
13. Mounting: 19-inch rack.

## 2.10 DIGITAL AUDIO EQUALIZER

A. Manufacturers:

1. Shure Model No. DFR-11EQ (or approved equal).

B. Description: Digital 1/3 Octave graphic equalizer, automatic and manual acoustic feedback suppression for 10 frequencies, digital delay compressor/limiter.

C. Ratings:

1. Remote Programming: RS232C serial port, USB, Category 6 .
2. Frequency Response: 20-Hz to 20-KHz  $\pm$  1.0dB reference 1 KHz.
3. Dynamic Range: 104db minimum, A-weighted, 20-Hz to 20-KHz.
4. Sampling Rate: 48-KHz.
5. Digital-to-Analog, Analog-to-digital Conversion: 20-bit resolution.
6. Voltage Gain:
7. LED Signal Indicators: Clip: 6dB down from input clipping.
8. Feedback Filters:
9. Graphic Equalizer:
10. Parametric Equalizer:
11. Delay: Up to 1300ms.
12. Limiter:
13. Mounting: 19-inch rack.
14. Power Input: 120-Vac 60-Hz.

## **2.11 60-WATTS POWER AMPLIFIER**

### **A. Manufacturers:**

1. Crown Model No. 180 A with rack mount kit (or approved equal).

### **B. Description: Audio power amplifier.**

### **C. Ratings:**

1. Output Power: 80-watts RMS.
2. Frequency Response: 20-20,000 Hz, +1dB/-3 dB
3. Inputs: One input port, one direct.
4. Input Sensitivity/Impedance:
5. Output:
  - a. Main (Transformer): 8 ohms, 25 and 70 volts, balanced.
  - b. Main (Direct): 4 ohms, unbalanced.
6. Indicators: One power LED, one protect LED, one signal LED, one normal LED, one peak LED.
7. Power Input: 120-Vac 60-Hz, 100-watts.
8. Mounting: 19-inch rack.
9. Input Module: balanced line input, 10k ohms.

## **2.12 120-WATTS POWER AMPLIFIER**

### **A. Manufacturers:**

1. Crown Model No. 1160A rack mounting kit (or approved equal)

### **B. Description: Audio power amplifier.**

### **C. Ratings:**

1. Output Power: 120-watts RMS
2. Frequency Response: 20-20,000 Hz, +1dB/-3dB.
3. Inputs: One input port, one direct.
4. Input Sensitivity/Impedance:
  - a. Input Port: 100 mV or 1000 mV (switchable)/10 K ohms.
  - b. Direct Input: 100 mV or 1000 mV (switchable)/10 K ohms.
5. Outputs:
  - a. Main (Transformer): 8 ohms, 25 and 70 volts, balanced.
  - b. Main (Direct): 4 ohms, unbalanced.
6. Indicators: One power LED, one protect LED, one signal LED, one normal LED, one peak LED.
7. Power Input: 120-Vac 60-Hz, 180-watts.
8. Mounting: 19-inch rack.
9. Input Module: line input, 10k ohms.

## **2.13 OCC AUDIO INPUT STATION CONTROLLERS**

### **A. Manufacturers:**

1. Barix Corporation (Annunicom100)
2. Penta Corporation (Firmware)

### **B. Description: Self-contained streaming VoIP with serial interface and digital I/O**

### **C. Features:**

1. Operates on 9 to 30 VDC / 12 to 24 VDC
2. 1 or 2 unit rack mounts kit (1RU)
3. 300 to 115.2K Baud RS-232 port
4. Web-based configuration
5. 10/100 Mbit Ethernet, TCP/IP UDP, SNMP
6. G7.11 and PCM Audio Compression
7. Mic In, Line In, Line Out, Speaker Out
8. Support Penta VoIP control protocol

### **D. Provide a Barix Rack Mount and install on the equipment racks in the Communication Equipment Room at each passenger station.**

## **2.14 WIRELESS MICROPHONE TRANSMITTER AND RECEIVER**

### **A. Manufacturers:**

1. Shure Model No. ULXP4: microphone receiver system (or approved equal).
2. Shure Model No. ULX2/58: microphone (or approved equal).
3. Shure Model No. UA505: remote antenna mounting brackets and BNC connectors.
4. Shure Model No. UA820: ½ wave dipole antenna UXL receiver.
5. Shure Model No. UA830: UHF in-line amplifier.
6. Shure Model No. A13HDB: mounting flange, heavy duty in amplifier.
7. Shure Model No. UA2212: passive antenna combiner/splitter.

### **B. Description: The wireless microphone receiver system equipment shall be mounted in the kiosk. The wireless antenna shall be placed on top on the kiosk. The wireless system shall cover 95% on the station.**

### **C. Ratings:**

1. RF Carrier Frequency Range: 554-590 MHz
2. Working Range 700 ft. minimum under typical conditions.
3. Audio Frequency response: 45 to 15,000 Hz ±2dB.
4. Gain Adjustment Range: -6 to 26 dB.

5. Receiver Audio Output Level (Maximum):
  - a. Unbalanced: + 5dBu typical.
  - b. Balanced: + 14dBu typical.
6. RF Sensitivity: -108dBm at 12dB SINAD.
7. Image Rejection 90dB typical.
8. Spurious Rejection 70dB typical.
9. Power Requirements:
10. Microphone 9V alkaline battery.

## **2.14 24-VDC POWER SUPPLY**

### **A. Manufacturers:**

1. ADC

## **2.15 LOUDSPEAKER DISTRIBUTION PANEL**

### **A. Manufacturers:**

1. Custom assembly by contractor.

## **2.16 LOUDSPEAKER ZONE ATTENUATOR ASSEMBLY**

### **A. Manufacturers:**

1. Atlas-Soundolier Model No. AT-10: Loudspeakers Attenuator 70 volts( or approved equal).

## **2.17 PA PATCH PANEL ASSEMBLY**

### **A. Manufacturers:**

1. ADC Model No.PPA3-14MKIVNS (or approved equal). Patch panel assembly for the audio power amplifiers and audio signal.

### **B. Ratings:**

1. Number of Jacks: Two rows of 24
2. Insertion Loss: Less than 0.1dB
3. Jack Circuits Configuration: Top-to-bottom row jack circuits.
4. Punch Block: Rear mounted proprietary 66-terminal punch block for solid and stranded wire (Flexi-block)
5. Chassis and Brackets: Aluminum
6. Mounting: 19-inch rack.
7. Compatibility: Standard ¼ inch 3-conductor phone shielded audio patch cords.  
Provide printed designation labeling for each jack.

## **2.18 PATCH PANEL PUNCH TOOL**

### A. Manufacturers:

1. ADC Model No. QB-4 (or approved equal). Compatible with wiring punch blocks included with patch panel.

## **2.19 MICROPHONE WITH 18" GOOSENECK**

### A. Manufacturers:

1. Shure SM57 (microphone) with Shure A12 (mounting flange), with Shure G18-CN (18" Gooseneck), with Shure A2WS (windscreen) (or approved equal).

## **2.20 AC POWER LINE CONDITIONER-20 AMP**

### A. Manufacturers:

1. New Frontier Electronics Surge-X SX2120 (or approved equal). B. Description: Electrical power line surge suppressor and line conditioner.

### B. Ratings:

1. Mounting: 19-inch rack.
2. Current: 20 amps at 120-Vac.
3. Rear Outlets: 12 switched, two un-switched.
4. Front Panel Indications: Electrical service and surge fault.
5. Front Panel Switches: One for switched outlets.

- C. UL Listed. Meeting or exceeding UL grade A-1-1 for power line surge suppression and EMI/RFI line conditioning.

## **2.21 AC POWER LINE CONDITIONER, 15-AMP**

### A. Manufacturers:

1. New Frontier Electronics Surge-X SX115R (or approved equal). B. Description: Electrical power line surge suppressor and line conditioner.

### B. Ratings:

1. Mounting: 19-inch rack.
2. Current: 15-amps at 120-Vac.
3. Rear Outlets: Six switched two un-switched.
4. Front Panel Indications: Electrical service and surge fault.
5. Front Panel Switches: One for switched outlets.

- C. UL Listed. Meeting or exceeding UL grade A-1-1 for power line surge suppression and EMI/RFI line conditioning.

## **2.22 SHIELDED TWISTED-PAIR CABLE (16-AWG)**

- A. Description: loudspeaker cable type, for loudspeaker zones not exceeding 60 watts. UL rated. NEC Type CMR with low smoke NON-PVC jacket.
- B. Ratings:
  - 1. Conductors: 16-AWG stranded twisted pair ASTM tinned copper with overall 100% foil shield.

## **2.23 SHIELDED TWISTED-PAIR CABLE (14-AWG)**

- A. Description: loudspeaker cable type, for loudspeaker zones not exceeding 120 watts. UL rated. NEC Type CMR with low smoke NON-PVC jacket.
- B. Ratings:
  - 1. Conductors: 14-AWG stranded twisted pair ASTM tinned copper with overall 100% foil shield.

## **2.24 SHIELDED MULTI-TWISTED-PAIR CABLE (20-AWG)**

- A. Description: Audio cable for all audio wiring and ambient noise and paging microphones. UL rated. NEC Type CMR with low smoke NON-PVC jacket.
- B. Ratings:
  - 1. Conductors: 20-AWG stranded twisted pair ASTM tinned copper with overall 100% foil shield.

## **2.25 SHIELDED MULTI-TWISTED-PAIR CONTROL SIGNALING/AUDIO CABLE**

- A. Description: control signaling multi-pair cable type, for all control and DC voltage wiring.
- B. UL rated. NEC Type CMR with low smoke NON-PVC jacket.
- C. Ratings:
  - 1. Conductors: 18-AWG stranded twisted pairs ASTM tinned copper with overall 100% foil shield.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION REQUIREMENTS**

- A. Install a complete and operational passenger station Public Address System, as described herein, in the passenger station(s). This includes installations in the Kiosk(s), Communications Equipment Room(s) and Dispatcher's Facility.

- B. Install all terminals, hardware, wiring and cabling, conduits, and fittings. The Contractor shall install the required connectors, attenuators, baluns, audio isolation transformers, and inter-rack wiring between the various equipment, and make all necessary connections and cross-connections required for complete installations. All inter-rack wiring between various equipment shall be shielded, twisted-pair cable.
- C. The Contractor shall have full responsibility to survey station, communication room, services rooms before any work is completed.

### **3.02 PA SPEAKER INSTALLATION**

- A. In those locations where a PA Speaker enclosure is not imbedded, the Contractor shall install the appropriate type PA speaker enclosure. PA speaker enclosures are imbedded in the ceiling of the mezzanine areas, under the mezzanine structure, and in entrance passageways of the passenger station. No speaker enclosures are imbedded in service rooms and non-revenue passageways. Install surface mounted speaker enclosures or suspended ceiling mounted enclosures as appropriate.
- B. Submit a proposed PA speaker layout for the passenger station to the Communication Engineer for approval. This layout shall show each PA speaker, the matching transformer tap to be used and the total power per circuit.
- C. Install the PA speaker, with matching transformer and associated speaker baffles, in the PA speaker enclosures.
- D. Install the PA speaker, with matching transformer and associated speaker baffles, in the Pylon on the station platform.
- E. Install the required cabling, hardware and material to connect the speakers (via matching transformers) to the appropriate Loudspeaker Distribution Panels. Furnish and install conduit between PA speakers.

### **3.03 COMMUNICATIONS EQUIPMENT ROOM INSTALLATION**

- A. Install the equipment on a 19-inch equipment rack in the Communications Equipment Room of the passenger station(s).
- B. Distribute the 70.7-volt amplified audio to all speakers in the passenger station(s) using a Loudspeaker Distribution Panel for each zone.
- C. All PA amplifiers shall be adjusted, internally or externally, via audio attenuators, to provide the full rated audio output for a 0 dBm input signal level.
- D. Install the required cabling, connectors and plugs to provide 120-Vac, 60-Hz to the various PA equipment from the ac power receptacle strip on the PA equipment rack.

### **3.04 KIOSK INSTALLATION**

- A. Install a Kiosk Public Address Control Panel in the designated bay of the Kiosk cabinetry.
- B. Install the voice pre-amp/processor in the appropriate bay of the Kiosk cabinetry.
- C. Install a hand-held Gooseneck microphone on the appropriate bay of the Kiosk cabinetry. Furnish and install the required wiring harness between the Kiosk PA Control Panel and the Kiosk Cable Termination Rack in the Kiosk.
- D. Install the wireless microphone receiver in the appropriate bay of the Kiosk cabinetry and mount the antenna on top of the Kiosk in a location approved by the Engineer. Furnish and install the required wiring harness between the wireless microphone receiver and the Kiosk Cable Termination Rack in the Kiosk.
- E. Install individually-shielded, twisted, pair cables between the Kiosk Cable Termination Rack and the appropriate PA equipment in the Communications Equipment Room. The Contractor shall use these cables to connect the Kiosk PA Control Panel and wireless microphone receiver to the appropriate PA system equipment within the Communications Equipment Room.

**3.05 TERMINAL SUPERVISOR'S PUBLIC ADDRESS FACILITY INSTALLATION (End of line)**

- A. Install a complete operational Dispatcher's Public Address Facility in the new end-of-line Passenger Station (if applicable).
- B. Install a Public Address System Control Panel (same as the Kiosk PA System Control Panel), with microphone and a Loudspeaker Zone Selection Panel in a Tabletop Instrument Cabinet. The Contractor shall install the Tabletop Instrument Cabinet on top of the table/desk within the End-of-Line Terminal Supervisor's Room.
- C. Install a junction box with terminals within the Terminal Supervisor's Room in a location approved by the Engineer.
- D. Install a Terminal Supervisor's PA Zone Selection System for the Dispatcher's Facility.
- E. Provide all components needed to implement the Terminal Supervisor's PA Zone Selection System, and install the following components as stated below:
  - 1. Install the Terminal Supervisor's PA Zone Selection Panel in the Terminal Supervisor's Room.
  - 2. Install the Terminal Supervisor's PA Zone Control Unit in the Station PA System Equipment Rack in the Communications Equipment Room.
- F. Install individually shielded, twisted, three-pair audio cables, as needed, from the PA equipment in the Terminal Supervisor's Room to the Station PA Equipment Rack in the Communications Equipment Room, via the junction box with terminals. Install the

necessary connections and cross-connections between the cables and the Kiosk PA Control Panel, Terminal Supervisor's PA Control Panel, Terminal Supervisor's PA Zone Selection Panel, Terminal Supervisor's PA Zone Control Unit; and the Station PA Control Unit. Connect the Terminal Supervisor's PA Control Panel to the Station PA Control Unit and the Terminal Supervisor's Zone Control Unit via the audio and control circuit connections assigned for Kiosk No. 3.

### **3.06 INTERFACE**

- A. Install the hardware and wiring required to connect the Fire Alarm System "Emergency Evacuation Announcements" to the Passenger Station Public Address System equipment.
- B. Install the required hardware and wiring to connect the alarm output of the Station PA Control Unit to the Priority Mixer.
- C. Install the required cabling, hardware and material to connect WMATA'S WAN/LAN system.

### **3.07 MANUFACTURER'S FIELD SERVICES**

- A. Prepare and start systems under provisions of Section 16707.

### **3.09 DEMONSTRATION**

- A. Demonstrate operation and maintenance of Products to WMATA personnel two weeks prior to date of Substantial Completion.
- B. Demonstrate Project equipment by a qualified person who is knowledgeable about the Project.
- C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with WMATA personnel in detail to explain all aspects of operation and maintenance.
- D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at equipment location.
- E. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.
- F. Demonstrate system operation.
- G. Conduct walking tour of Project and briefly describe function, operation, and maintenance of each component.

**END OF SECTION**

## SECTION 16821

### COMMUNICATIONS - AUTOMATIC PUBLIC ADDRESS ANNOUNCEMENT SYSTEM

#### PART 1 - GENERAL

##### 1.01 SECTION DESCRIPTION AND BASIC REQUIREMENTS

- A. The Automatic Public Address Announcement System (APAAS) shall promote a safe and expeditious evacuation of WMATA Rail System patrons from a passenger station upon detection of a fire within that passenger station.
- B. The Automatic Public Address Announcement System shall provide a pre-programmed emergency announcement to be automatically broadcast within a passenger station upon detection of a fire within the limits of that particular passenger station. The announcement shall be activated (triggered) upon receipt of a fire alarm indication from the Fire and Intrusion Alarm System. A control panel located in the Kiosk within the passenger station shall provide the capabilities to initiate (activate) the announcement manually, to preempt the announcement and to cancel the announcement while in progress. The control panel allows specific functions of the Passenger Emergency Reporting System (PERS), the Automatic Public Address Announcement System and the Passenger Station Fire and Intrusion Alarm System (FIA) to be disabled.
- C. The Automatic Public Address Announcement System shall include the following equipment, which shall be located in the Communications Equipment Room of the station, except as noted:
  - 1. Kiosk APAAS Control Panel (located in the Kiosk).
  - 2. APAAS Control Unit.
  - 3. Life Safety Tape Playback Unit.
  - 4. Public Address Interface Unit.
  - 5. APAAS Patch Panel, complete with patch cords and holder.
  - 6. PERS/APAAS Dual Power Supply Assembly.
- D. The Kiosk APAAS Control Panel shall provide the interface point between the Station Manager and the Automatic Public Address Announcement System. The Kiosk APAAS Control Panel provides the following controls and indications necessary for the attendant to operate the Automatic Public Address Announcement System:
  - 1. Depressing the "MANUAL" pushbutton switch, which has an integral light emitting diode (LED) indicator, shall trigger the Life Safety Tape Playback Unit.
  - 2. Depressing the "CANCEL" pushbutton switch, which has an integral light emitting diode (LED) indicator, shall prohibit/inhibit the emergency announcement from being broadcast.
  - 3. The "AUTO" indicator, which is a light emitting diode (LED), shall indicate that the emergency announcement process has been initiated.
  - 4. Placing the "INTRUSION-APAAS-PERS" keyswitch in the "UNATTEND" position shall:
    - a. Inhibit the emergency announcement upon detection of a fire within the passenger station limits.
    - b. Cause previously disabled intrusion zones within the passenger station limits to be reactivated.
  - 5. Placing the "INTRUSION-APAAS-PERS" keyswitch in the "ATTEND" position shall cause selected intrusion zones within the passenger station limits to be disabled.
  - 6. Depressing the "LAMP TEST" pushbutton switch shall test all of the illuminating indicators on the panel except for the "POWER" indicator.
  - 7. The "POWER" indicator illuminates when power is being supplied to the panel.

- E. The APAAS Control Unit shall provide the required interfaces between the Kiosk APAAS Control Panel, the Life Safety Tape Playback Unit, the Public Address Interface Unit, the Passenger Station Fire and Intrusion Alarm System, the Passenger Station Public Address System, and the Passenger Emergency Reporting System. The APAAS Control Unit shall be able to:
1. Detect a fire alarm indication (STATION FIRE DTS-INPUT) from the Passenger Station Fire and Intrusion Alarm System.
  2. Provide the appropriate timing circuits for the activation of the emergency announcement and the automatic reset of the Passenger Station Fire and Intrusion Alarm System.
  3. Provide a fire alarm indication (STATION FIRE DTS-OUTPUT) for the fire zones within the passenger station limits to the Data Transmission System.
  4. Automatically reset the Passenger Station Fire and Intrusion Alarm System. A separate normally open contact and a separate normally closed contact shall be provided for the interface of the features to the Passenger Station Fire and Intrusion Alarm System.
  5. Provide the appropriate controls to the PERS Control Unit for the activation and termination of the external chime/tone to the speaker horn that is external to the Kiosk.
  6. Activate the Life Safety Tape Playback Unit for the broadcasting of the emergency announcement (automatically and manually).
  7. Connect the Life Safety Tape Playback Unit audio output (emergency announcement) to the audio path of the Public Address System.
  8. Provide the appropriate output controls to the PA Interface Unit to reroute the emergency announcement audio to the music input of the ambient noise compensation amplifier of the Passenger Station Public Address System.
  9. Accept the appropriate controls from the Kiosk APAAS Control Panel.
  10. Provide the appropriate indications to the Kiosk APAAS Control Panel.
  11. Disable the Life Safety Tape Playback Unit upon activation of the cancel feature.
  12. Provide the appropriate output contacts for the key-switch features.
- F. The Life Safety Tape Playback Unit shall function as the emergency announcement broadcasting device.
- G. The Public Address Interface Unit shall provide the required interfaces between the Passenger Station Automatic Public Address Announcement System and the Passenger Station Public Address System. The Public Address Interface Unit shall be able to:
1. Establish an audio path for a normal public address announcement to the normal input of the ambient noise compensation amplifier of the Passenger Station Public Address System. The audio path of the Passenger Station Public Address System shall be routed through the APAAS Patch Panel and the APAAS Control Unit.
  2. Reroute the emergency announcement audio of the APAAS to the music input of the ambient noise compensation amplifier of the Passenger Station Public Address System.
  3. Detect the appropriate output controls of the APAAS Control Unit to reroute the emergency announcement.
  4. Provide the appropriate output controls to the Station Control Unit of the Passenger Station Public Address System when the emergency announcement is being broadcast, to prevent a trouble alarm from being activated.
  5. Terminate the music input audio path of the ambient noise compensation amplifier of the Passenger Station Public Address System during the (idle) normal state.
- H. The APAAS Patch Panel shall enable audio connections and cross-connections to be easily made between the APAAS Control Unit and other equipment items of the Automatic Public Address Announcement System and the Public Address System.

- I. The PERS/APAAS Dual Power Supply Assembly shall provide redundant diode-coupled direct current power to operate the Automatic Public Address Announcement System and the Passenger Emergency Reporting System.
- J. Upon receipt of a fire alarm indication (STATION FIRE DTS) from the Passenger Station Fire and Intrusion Alarm System, the following actions shall occur:
  - 1. The "AUTO" indicator of the Kiosk APAAS Control Panel shall illuminate (flash).
  - 2. A chime/tone external to the Kiosk shall sound every five seconds. This external chime/tone is to alert the Station Manager (when the attendant is outside the Kiosk) that the Automatic Public Address Announcement System has been activated.
- K. Once 1.5 minutes have elapsed from the time the fire alarm indication was received, the Automatic Public Address Announcement System shall automatically reset the Passenger Station Fire and Intrusion Alarm System. The reset shall be for a duration of three (3) seconds and shall occur only one (1) time.
- L. If the reset restores all the fire zone circuits within the passenger station limits to a non-alarm state, then:
  - 1. The "AUTO" indicator of the Kiosk APAAS Control Panel shall be extinguished.
  - 2. The broadcasting of the external chime/tone shall cease.
  - 3. The Automatic Public Address Announcement System circuitry shall be restored to an idle (normal) condition.
- M. If the automatic reset does not restore all the fire zone circuits within the passenger station limits to a non-alarm state, then:
  - 1. The "AUTO" indicator on the Kiosk APAAS Control Panel shall remain illuminated.
  - 2. The external chime/tone shall continue to sound
  - 3. The Automatic Public Address Announcement System circuitry shall remain in the alarm receive mode.
- N. After a two (2) minute interval from the initial receipt of the fire alarm indication, if the automatic reset does not restore all fire zones to a non-alarm state, then:
  - 1. The broadcasting of the external chime/tone shall cease.
  - 2. The Life Safety Tape Playback Unit shall be activated.
  - 3. The pre-programmed emergency announcement shall be broadcast via the Passenger Station Public Address System. The emergency announcement shall be repeated and the "AUTO" indicator shall remain illuminated until these functions are canceled.
- O. Note that an audible tone shall not be provided in the Kiosk when the Automatic Public Address Announcement System is activated. This is because the Kiosk FIA Annunciator Panel will provide an audible alarm upon the detection of a fire alarm within the passenger station Fire and Intrusion Alarm System.
- P. The pre-programmed emergency announcement can be manually activated by depressing the "MANUAL" pushbutton switch on a Kiosk APAAS Control Panel, which shall:
  - 1. Cause the "MANUAL" pushbutton integral LED indicator on the Kiosk APAAS Control Panel to be illuminated (flash).
  - 2. Cause the "AUTO" indicator on the Kiosk APAAS Control Panel to be extinguished if previously illuminated.
  - 3. Activate the Life Safety Tape Playback Unit and cause the pre-programmed emergency announcement to be broadcast via the passenger station Public Address System. The emergency announcement shall be repeated until canceled.
- Q. The pre-programmed emergency announcement can be manually activated only when the Automatic Public Address Announcement System is not in the "CANCEL" mode.

- R. During a period of up to two (2) minutes after the fire alarm indication has been received by the Automatic Public Address Announcement System, the automatic broadcast of the emergency announcement can be prevented by depressing the "CANCEL" pushbutton on a Kiosk APAAS Control Panel to its locked position. Such action shall:
  1. Silence the external chime/tone.
  2. Extinguish the illuminated "AUTO" indicator on the Kiosk APAAS Control Panel.
  3. Cause the "CANCEL" pushbutton switch integral indicator on the Kiosk APAAS Control Panel to be illuminated (flash).
  4. Prohibit the Life Safety Tape Playback Unit from being activated.
- S. The "CANCEL" feature allows time for the Station Manager to investigate the location and magnitude of a fire before causing the emergency announcement to be broadcast.
- T. Depressing the "CANCEL" pushbutton switch to its locked position, while the pre-programmed emergency announcement is being broadcast, shall:
  1. Cause the "CANCEL" pushbutton switch integral indicator to be illuminated (flash).
  2. Extinguish any other indicators that were illuminated.
  3. Deactivate the Life Safety Tape Playback Unit and stop the emergency announcement broadcast.
- U. Activation of the "CANCEL" pushbutton shall cancel an automatic announcement or a manual announcement.
- V. Depressing the "CANCEL" pushbutton switch on a Kiosk APAAS Control Panel to its locked position to intentionally disable the APAAS System, while the Passenger Station Fire and Intrusion Alarm System is being serviced shall:
  1. Cause the "CANCEL" pushbutton switch integral indicator to be illuminated (flash).
  2. Cause the automatic and manual emergency announcement circuitry to be disabled to prevent the activation of the Life Safety Tape Playback Unit.
- W. The pre-programmed emergency announcement must be canceled before the Automatic Public Address Announcement System can be reset. Depressing the "CANCEL" pushbutton switch on a Kiosk APAAS Control Panel a second time shall:
  1. Release the pushbutton switch from its locked position.
  2. Extinguish the "CANCEL" pushbutton switch integral indicator.
  3. Restore the Automatic Public Address Announcement System circuitry to its normal (idle) condition.
- X. The passenger station Fire and Intrusion Alarm System must be reset, and all fire zone circuits associated with areas within the passenger station limits must be restored to a non-alarm state before the APAAS is reset. Failure to restore the fire zone circuits to a non-alarm state while resetting the APAAS will cause the passenger station Fire and Intrusion Alarm System to immediately initiate another automatic announcement.

**1.02 SECTION INCLUDES**

- A. Kiosk Automatic Public Address Announcement Control Panel.
- B. Automatic Public Address Announcement Control Unit
- C. Life Safety Tape Playback Unit.
- D. Public Address Interface Unit.
- E. Automatic Public Address Announcement Patch Panel.
- F. PERS/APAAS Dual Power Supply Assembly.

## **1.02 UNIT PRICES**

- A. Unit Prices include incidental items, not specifically mentioned, but required for complete and proper system operation.

## **1.03 RELATED SECTIONS**

- A. Section 16705 - Communications Standard Specifications - Equipment & Materials.
- B. Section 16706 - Communications System Submittals & Services.
- C. Section 16707 - Communications Systems Quality Assurance & Testing.
- D. Section 16710 - Communications Grounding.
- E. Section 16715 - Communication Electrical Power Distribution.
- F. Section 16727 - Communications - Passenger Emergency Reporting System
- G. Section 16731 - Communications - Fire and Intrusion Alarm System.
- H. Section 16733 - Communications - Kiosk Systems.
- I. Section 16820 - Communications - Public Address System.

## **1.05 REFERENCES**

- A. National Electric Code (NEC).

## **1.06 SYSTEM DESCRIPTION**

- A. Description: The Automatic Public Address Announcement (APAAS) provides a pre-programmed emergency announcement to be automatically broadcast within a passenger station upon detection of a fire within the limits of that particular passenger station.
- B. Operation: The announcement is activated (triggered) upon receipt of a fire alarm indication from the Fire and Intrusion Alarm System. A control panel located in the Kiosk within the passenger station provides the capabilities to initiate (activate) the announcement manually, to preempt the announcement and to cancel the announcement while in progress. The control panel allows specific functions of the Passenger Emergency Reporting System (PERS), the Automatic Public Address Announcement System and the Passenger Station Fire and Intrusion Alarm System (FIA) to be disabled.
- C. Capacity:
  - 1. The Authority (WMATA) will furnish Kiosk Automatic Public Address Announcement Control Panels, as required to support the required APAAS systems.
  - 2. The Authority (WMATA) will furnish Automatic Public Address Announcement Control Units, as required to support the required APAAS systems.
  - 3. The Contractor shall furnish and install the Life Safety Tape Playback Unit(s) in accordance with Contract Specifications and Drawings.
  - 4. The Contractor shall design, furnish, and install the Public Address Interface Unit(s) in accordance with Contract Specifications and Drawings.
  - 5. The Contractor shall furnish and install the Automatic Public Address Announcement Patch Panel(s) in accordance with Contract Specifications and Drawings.

6. The Contractor shall design, furnish, and install the Passenger Emergency Reporting System/Automatic Public Address Announcement Dual Power Supply Assembly(s) in accordance with Contract Specifications and Drawings.

**1.07 SYSTEM PERFORMANCE REQUIREMENTS**

- A. The Contractor shall be responsible for the overall performance and interface of the Automatic Public Address Announcement System, as specified herein. The following overall system performance requirements are designed to ensure that the Automatic Public Address Announcement System, delivered under these Specifications, meets the performance requirements of the Washington Metropolitan Area Transit Authority.

<u>SYSTEM PARAMETER</u>	<u>REQUIRED PERFORMANCE</u>
1. APAAS Audio Output @ the APAAS/PAS Interface Point	Clearly and continuously understood audio when monitored using a test box containing audio amplifier and loudspeaker (with a flat frequency response Hz $\pm 3$ dB or better) by any person that is not significantly hearing impaired within the 300 to 3,600 Hz range. Interfering signals, hum or objectionable noise shall not be discernible to any listener during or between speech messages.
2. Measured Frequency Response (terminated lines @ the APAAS/PAS interface point with normal operating levels)	Flat from 100 to 5,000 Hz, $\pm 3$ dB or better during the playback of a prerecorded test message.
3. Measured Wow and Flutter (terminated lines @ the APAAS/PAS interface point with normal operating levels)	Maximum 0.4% (weighted during the playback of a prerecorded test message).
4. Measured Total Harmonic Distortion (terminated lines @ the APAAS/PAS message. interface point with normal operating levels)	Maximum 1% during a prerecorded test.
5. Measured Signal to Noise Ratio the APAAS/PAS (terminated lines @ interface point with normal operating levels)	45dB or greater during the playback of a prerecorded message.
<u>SYSTEM PARAMETER</u>	<u>REQUIRED PERFORMANCE</u>
6. Measured System Noise (@ the APAAS/ PAS interface point)	Maximum of -45dB below 1kHz test tone level, when all APAAS system and equipment controls are operated to any possible combination of positions. Momentary switching transients, however may peak to -30dB below 1kHz test tone level, for a duration that does not exceed 10 milliseconds.

1. **NOTE:** Persons not significantly hearing impaired within the 300 to 3,600 Hz range are defined, for the purpose of these performance specifications, as males or females with hearing capabilities that are normal, or slightly impaired to the extent that their response to audio tones in the 300 to 3,600 Hz frequency range is within -15 dB at all test frequencies and averages within -10 dB of "NORMAL" standard values for their classification (sex, age, etc.) as defined by American National Standards Institute (ANSI) standards.

## **1.08 SUBMITTALS**

- A. Submit under provisions of Section 16706.
- B. Shop Drawings: Indicate electrical characteristics and connection requirements, including system wiring diagram.
- C. Product Data: Provide showing electrical characteristics and connection requirements for each component.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

## **1.09 QUALIFICATIONS**

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Supplier: Authorized distributor of specified manufacturer with minimum three years documented experience.
- C. Installer: Authorized installer of specified manufacturer with service facilities within 50 miles of Project.

## **1.10 MAINTENANCE SERVICE**

- A. Furnish service and maintenance of Automatic Public Address Announcement System until Final Completion.

## **1.11 AUTHORITY FURNISHED EQUIPMENT**

- A. Design data, copies of required shop drawings and other technical documentation for Authority Furnished Equipment, being provided from "Additional Equipment" stocks may be obtained from the Engineer. This will allow the Contractor to develop the required system design, installation drawings and other technical documentation prior to the actual receipt of the Authority Furnished Equipment.

## **PART 2 - PRODUCTS**

### **2.01 LIFE SAFETY TAPE PLAYBACK UNIT**

- A. Manufacturers:
  - 1. Wheelock, Inc, Model No. DV-100 (or approved equal)
- B. Ratings:
  - 1. Playback
    - a. Memory Type: EPROM.
    - b. Memory Time: One to eight minutes.
    - c. Bandwidth: 70-Hz to 4,000-Hz.
    - d. Signal to Noise Ratio: 51dB.
    - e. THD 1 KHz (full scale): 5.5%.
  - 2. Inputs:
    - a. Programming: With DV-200 through serial port.

- b. Message File Activation:
- c. File Input Terminals: Input terminals for 8 message files. Activate files for 300 millisecond minimum with a short across input )to sink up to 10 mA current with maximum 2 Vdc drop).
- d. Digital Command: Through serial port, RS232.
- 3. Outputs:
  - a. Audio Output: One to four output channels optionally provided; each through 600-ohm isolation transformer. Output level adjustable from 0.5 to 2.0 Vrms. Minimum load impedance 600 ohm.
  - b. Status Contact: Form C contacts normally energized. Contacts transfer during trouble. Rated 0.5 amps at 30 Vdc max, resistive load.
  - c. Channel Playing Contact: One for each channel. Normal open contacts closed when channel is playing. Rated 0.5 amps at 30 Vdc max, resistive load.
- 4. Input Voltage:
  - a. Operating: 11-29 Vdc.
  - b. Programming: 15 Vdc minimum.
  - c. Ripple: 500 mV.

## **2.02 APAAS PATCH PANEL**

- A. Manufacturers:
  - 1. Trompeter Electronics Model No. JSI-32S/MT-389 (or approved equal).
- B. Ratings:
  - 1. Accommodate sixteen (16) normal through telephone patch jacks. Constructed of black plastic with steel mounting brackets and reinforcing strips. Contains two (2) marking designation strips with clear plastic covers mounted at the top and bottom of the front side for identification of the patch jacks, and suitable for mounting in a standard 19-inch width equipment rack.

## **2.03 PATCH CORD HOLDER**

- A. Manufacturers:
  - 1. Trompeter, Model No. CH50 (or approved equal).
- B. Ratings:
  - 1. mounted to a blank panel on the APAAS/PERS equipment rack.

## **2.04 PERS/APAAS DUAL POWER SUPPLY ASSEMBLY**

- A. Manufacturers:
  - 1. Acopian Corp., Model No. R24M13H (or approved equal).
- B. Ratings:
  - 1. Input Power: 115-120 Vac, 60 Hz, fused.
  - 2. Outputs (each supply): 24 Vdc, 5.0 amps diode coupled for redundancy.
  - 3. Total loading of each discrete power supply shall not be more than 50% of its rated output. Failure of one power supply shall not result in failure of the other power supply.
  - 4. Suitable for mounting in the standard 19-inch equipment rack.

## **2.05 12-PAIR CABLE**

- A. Manufacturers:
  - 1. Okonite Model No. 261-40-2212 (or approved equal).
- B. Ratings:
  - 1. Pairs: 12 individually shielded, twisted pairs.
  - 2. Conductors: Stranded, 20 AWG, copper.
  - 3. Outer Jacket: Okozel.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. KIOSK
  - 1. Install a Kiosk APAAS Control Panel in Bay #5 of the Kiosk cabinetry of the Kiosk in each passenger station.
  - 2. Install the required cable harnesses, and connectors and make the necessary connections to connect the Kiosk APAAS Control Panel to the Emergency Communications Kiosk Terminal Panel in the Kiosk of each passenger station.
  - 3. Install a 12-pair cable from the Emergency Communications Kiosk Terminal Panel in the Kiosk to the MDF/Protector Cabinet in the Communications Equipment Room of the passenger station. Terminate the 12-pair cable to the Emergency Communications Kiosk Terminal Panel and to the appropriate Line Terminal Block in the MDF/Protector Cabinet in each passenger station.
- B. COMMUNICATIONS EQUIPMENT ROOM
  - 1. Install an APAAS Control Unit, an APAAS Patch Panel, a Life Safety Tape Playback Unit, a Public Address Interface Unit and a PERS/APAAS Dual Power Supply Assembly in the Communications Equipment Room of each passenger station. Install the equipment for the Automatic Public Address Announcement System in the same equipment rack as the Passenger Emergency Reporting System. Install the required intra-rack wiring and connectors, and make the necessary connections and cross-connections for a complete installation in the Communications Equipment Room of each passenger station.
  - 2. Install the required cabling, connectors and plugs and make the necessary connections and cross-connections to provide 120-Vac, 60-Hz power to the various equipment from the ac power receptacle strip on the equipment rack.
  - 3. Install the required cabling and connectors, and make the necessary connections and cross-connections to extend the 12-pair cable from the Kiosk terminated on the Line Terminal Block in the MDF/Protector Cabinet to the APAAS Control Unit.
  - 4. Install the required cables, wires and connectors, and make the necessary connections and cross-connections between the APAAS Control Unit and the PERS Control Unit for the APAAS Kiosk external tone activation/termination feature.
  - 5. Install the required cabling and connectors, and make the necessary connections and cross-connections between the PERS/APAAS Dual Power Supply Assembly, and the APAAS and PERS Control Units.
  - 6. Install the required cables, wires and connectors, and make the necessary connections and cross-connections between the appropriate equipment in the Automatic Public Address Announcement System and the appropriate equipment in the passenger station Public Address System.
  - 7. Install the required cabling and connectors, and make the necessary connections and cross-connections between the APAAS Control Unit and the various equipment in the passenger station Fire and Intrusion Alarm System for the Automatic FIA System reset feature, the fire indication APAAS activation feature and the station fire zones contact closure to the Data Transmission System.

8. Install the required cables, wires and connectors, and make the necessary connections and cross-connections from the APAAS Control Unit to the line terminal block in the MDF/Protector Cabinet for the intrusion zones disable feature associated with the INTRUSION-APAAS-PERS keyswitch.

C. **SYSTEM MODIFICATION**

1. Upon completing the engineering, installation and complete testing of the APAAS, deactivate the "Automatic Activation of Emergency Announcement" feature of the APAAS, via an external method, which can be reactivated at the option of the Authority for future use.
2. Disable the "Automatic Activation of Emergency Announcement" feature of the APAAS by Wiring Option "D".
3. Provide the necessary equipment and material and make the necessary connections and cross-connections for Wiring Option "D." The utilization of this option will result in the following modifications to System Operation:
  - a. The "Manual Activation of Emergency Announcement" feature shall still be operational by depressing the "Manual" pushbutton on a Kiosk APAAS Control Panel.
  - b. An active station fire alarm shall not cause the APAAS System to be activated.
  - c. An active station fire alarm shall report to the OCC via the Data Transmission System.
  - d. All modifications shall be made via external connections routed to or from the APAAS Control Unit.

**3.02 MANUFACTURER'S FIELD SERVICES**

- A. Prepare and start systems under provisions of Section 16707.
- B. Supervise final wiring connections and system adjustments.

**3.03 ADJUSTING**

- A. Adjust operating Products and equipment to ensure smooth and unhindered operation.

**3.04 DEMONSTRATION**

- A. Demonstrate operation and maintenance of Products to WMATA personnel two weeks prior to date of Substantial Completion.
- B. Demonstrate Project equipment by a qualified person who is knowledgeable about the Project.
- C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with WMATA personnel in detail to explain all aspects of operation and maintenance.
- D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at equipment location.
- E. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.
- F. Demonstrate system operation.

- G. Conduct walking tour of Project and briefly describe function, operation, and maintenance of each component.

**END OF SECTION**

## **SECTION 16851**

### **COMMUNICATIONS – CLOSED-CIRCUIT TELEVISION SYSTEM**

#### **PART 1 - GENERAL**

##### **1.01 SUMMARY**

- A. This section specifies a complete and operational CCTV system for Authority-wide monitoring of WMATA's rail system, parking garages, bus divisions and support facilities.
- B. Related Sections:
  - 1. Section 16703 – Communications Standard Specifications-Engineering Services
  - 2. Section 16704 – Communications Standard Specifications-Installation
  - 3. Section 16705 – Communications Standard Specifications-Equipment & Material
  - 4. Section 16706 – Communications System Submittals & Services
  - 5. Section 16707 – Communications Quality Assurance & Testing
  - 6. Section 16710 – Communications Grounding
  - 7. Section 16715 – Communications Electrical Power Distribution
  - 8. Section 16733 – Communications – Kiosk Systems

##### **1.02 REFERENCES**

- A. Code, Regulations, Reference Standards and Specifications:
  - 1. National Electrical Code (NEC)
  - 2. Electronics Industries Alliance (EIA) Standard RS 170
  - 3. Federal Standard 595B, Colors Used in Government Procurement

##### **1.03 QUALITY ASSURANCE**

- A. Qualifications:
  - 1. Equipment manufacturer: Select a manufacturer who is engaged in production of similar CCTV products and accessories.
  - 2. Equipment supplier: An authorized distributor of specified manufacturer with minimum three years documented experience.
  - 3. Equipment installer: A manufacturer authorized installer of specified products with service facilities within 100 miles of WMATA.
- B. Coordination
  - 1. Installer shall coordinate CCTV installation with all other concurrently running work at the location specified under this task.
- C. For Code, Regulations, Reference Standards and Specifications, refer to Article 1.02 above.
- D. The Contractor shall develop test procedures and obtain Engineer approval prior to final acceptance testing.
- E. The Contractor shall perform progressive tests in accordance with an approved test procedure to verify compliance with specified system performance requirements, including but not limited to proper component operation and input/output signal operations.
  - 1. The Contractor's Quality Assurance Engineer shall witness all progressive testing.

2. All discrepancies found during testing shall be corrected and test reports submitted prior to scheduling end-to-end testing.
  3. The Contractor shall notify the Engineer prior to commencing progressive testing and shall offer the Engineer the opportunity to witness the testing. Witnessing of any portion of the progressive testing by the Engineer shall not relieve the contractor from responsibility for any portion of follow-on testing.
- F. End-to-End Test:
1. The Contractor shall demonstrate the proper functioning of the completed CCTV system.
  2. Each camera shall be viewable from all points of monitoring as specified in the design drawings.
  3. The Contractor shall submit certified test reports within 10 working days after completion of field tests.

#### **1.04 SUBMITTALS**

- A. Submit the following for approval in accordance with Section 16706 and with the additional requirements as specified for each:
1. Design Drawings
    - a. Proposed changes and revised equipment layouts
    - b. System riser diagrams to include source of power.
    - c. CCTV equipment mounting details.
    - d. Completed camera and equipment schedules
  2. Product Data: Provide product data sheets for each item of equipment and resubmittal for equipment which changes as a result of required modification.
  3. Manufacturer's Installation Instructions
    - a. Indicate application conditions and limitations of use, stipulated by Product testing agency.
    - b. Include instructions for storage, handling, protection, examination, preparation, installation and start-up of Product.
- B. As-Built Documents: Prior to Substantial Completion, develop As-Built documents as follows:
1. As-Built Drawings of the CCTV system installation to include, but not be limited to camera layouts, communication and power cable pathways and wiring, equipment details and equipment schedules.
  2. Approved copies of each submittal
- C. Operation and maintenance (O & M) manuals
1. Complete printed operating instructions in manual or handbook form, completely and clearly indexed for ready reference during actual operation and for use as text during instruction of personnel.
  2. Include descriptions of systems, background information and complete procedures for adjustment, calibration, replacement and repair of components in system.
  3. Make data contained specific for and exclusive to the systems and equipment for the work of this Contract.
  4. Field test data and reports.

D. Certification

1. Certificates from manufacturers verifying that equipment conforms to the specified requirements.

**1.05 OPERATION AND MAINTENANCE TRAINING**

- A. In accordance with the General Requirements.

**PART 2 - PRODUCTS**

**2.01 SECTION INCLUDES:**

- A. Network-Based IP Cameras
- B. Networking Devices
- C. Mounting Hardware

**2.02 PTZ DOME NETWORK CAMERA**

- A. Make and Model: Axis Q6045-E or approved equal
- B. Environmental Factors:
  1. Operating temperature: -50°C to 50°C (-58°F to 122°F)
  2. Humidity: 10-100% RH (condensing)
  3. Storage conditions: -50°C to 50°C (-58°F to 122°F)
  4. IP-66, NEMA 4X and 1K10-rated
- C. Power Requirements:
  1. High Power over Ethernet (High PoE), max. 60W
  2. AXIS T8124 High PoE 60W Midspan 1-port: 100-240VAC, max 74W
- D. Mounting:
  1. Wall: Axis T91A61 Wall Mount
  2. Parapet: Pelco PP-Series Parapet Mount
  3. Ceiling: Axis T91A63 Ceiling Mount
  4. Pole: Axis T91A67 Pole Mount
- E. Interface: RJ-45 for 10BASE-T/100BASE-TX PoE interface
- F. Salient Characteristics:
  1. Camera:
    - a. Image sensor: 1/2.8 progressive scan CMOS
  2. Lens:
    - a. F=4.7-94mm, F1.6-3.5 autofocus
    - b. Automatic day/night
  3. Horizontal angle of view: 54.1° - 2.9° in HDTV 1080p
  4. Horizontal angle of view: 37.6° - 2° in HDTV 720p
  5. Min. Illumination:
    - a. Color: 0.8 lux @ 30 IRE F1.6
    - b. B&W: 0.04 lux @ 30 IRE F1.6

6. Pan/tilt/zoom:
  - a. 20x optical zoom and 12x digital zoom, total 240x zoom
  - b. Pan: 360° endless, 0.05°-450/s
  - c. Tilt: 220°, 0.05° - 450/s
7. Video:
  - a. Compression:
    - i. H.246 (MPEG-4 Part 10/AVC)
    - ii. Motion JPEG
  - b. Resolution:
    - i. HDTV 1080p 1920x1080 to 320x180
    - ii. HDTV 720p 1280x720 to 320x180
  - c. Frame Rate:
    - i. H.264: up to 30/25 fps (60/50 Hz) in HDTV 1080p
    - ii. H.264: up to 60/50 fps (60/50 Hz) in HDTV 720p
    - iii. Motion JPEG: up to 25 fps (60/50 Hz) in HDTV 1080p
    - iv. Motion JPEG: up to 50 fps (60/50 Hz) in HDTV 720p
  - d. Video Streaming:
    - i. Multiple, individual configurable streams in H.264 and Motion JPEG
    - ii. Controllable frame rate and bandwidth
8. Network:
  - a. Security:
    - i. Password protection
    - ii. IP address filtering
    - iii. HTTPS encryption
    - iv. IEEE 802.1X network access control
    - v. Digest authentication
    - vi. User access log
9. System integration:
  - a. Application Programming Interface:
    - i. Open API for software integration, including VAPIX and AXIS Camera Application Platform
    - ii. ONVIF specified
  - b. Intelligent video:
    - i. Video motion detection
    - ii. Auto-tracking
    - iii. Active Gatekeeper
    - iv. Enabled for installation of additional applications

- c. Alarm triggers:
  - i. Video motion detection
  - ii. Auto-tracking
  - iii. AXIS Camera Application Platform
  - iv. PTZ preset
  - v. Temperature
  - vi. Memory card full
- d. Alarm events:
  - i. File upload via FTP, HTTP and e-mail
  - ii. Notification via e-mail, HTTP and TCP
  - iii. PTZ preset, guard tour, local storage, auto-tracking
  - iv. Pre- and post-alarm video buffering

10. General

- a. Processors and memory: ARTPEC-3, 256 MB RAM, 128 MB flash
- b. Local storage: SD/SDHC memory card slot
- c. Included accessories:
  - i. Clear dome cover
  - ii. Installation guide
  - iii. User's manual (CD)
  - iv. Recording software
  - v. Installation and management tools
  - vi. Windows decoder 1-user license
  - vii. Sunshield
  - viii. IP-66 rated RJ-45 connector kit
  - ix. Axis T8124 High PoE Midspan, 1-port

G. Warranty: 3-year warranty

**2.03 MINI PTZ**

- A. Make and Model: Axis M5014 PTZ Dome Network Camera or approved equal
- B. Environmental Factors:
  - 1. Operating temperature: 0°C to 45°C (32°F to 113°F)
  - 2. Humidity: 10-85% RH (non-condensing)
  - 3. IP-51-rated
- C. Power Requirements: Power over Ethernet 802.3af/802.3at Type 1 Class 3
- D. Mounting:
  - 1. Wall: direct to wall
  - 2. Ceiling: direct to ceiling or AXIS ceiling mount
- E. Interface: RJ-45 for 10BASE-T/100BASE-TX PoE interface

- F. Salient Characteristics:
1. Camera:
    - a. Image sensor: 1/4" progressive scan RGB CMOS
    - b. Lens:
      - i. 3.6mm, F1.8
      - ii. 60° Horizontal angle of view
    - c. Min. Illumination: 1.4 lux, F1.8
    - d. Pan/tilt/zoom:
      - i. Pan: + 180°, 100°-450/s
      - ii. Tilt: 90°, 100°/s
      - iii. Zoom: 3x digital zoom
  2. Video:
    - a. Compression:
      - i. H.246 (MPEG-4 Part 10/AVC)
      - ii. Motion JPEG
    - b. Resolution: HDTV 720p 1280x720 to 320x180
    - c. Frame Rate:
      - i. H.264: 30 fps in all resolutions
      - ii. Motion JPEG: 30 fps in all resolutions
    - d. Video Streaming:
      - i. Multiple, individually configurable streams in H.264 and Motion JPEG
      - ii. Controllable frame rate and bandwidth, VBR/CBR H.264
  3. Audio:
    - a. Audio Streaming: one-way
    - b. Audio input: built-in microphone
  4. Network:
    - a. Security:
      - i. Password protection
      - ii. IP address filtering
      - iii. HTTPS encryption
      - iv. IEEE 802.1X network access control
      - v. Digest authentication
      - vi. User access log
    - b. Supported protocols: IPv4/v6, HTTP, HTTPS, SSL/TLS, QoS Layer 3 DiffServ, FTP, CIFS/SMB, SMTP, Bonjour, UPnP, SNMPv1/v2c/v3 (MIB-II), DNS, DynDNS, NTP, RTSP, RTP, TCP, UDP, IGMP, RTCP, ICMP, DHCP, ARP, SOCKS
  5. System integration:

- a. Application Programming Interface:
  - i. Open API for software integration, including VAPIX and AXIS Camera Application Platform
  - ii. ONVIF Profile S specified
- 6. Intelligent video:
  - a. Video motion detection
  - b. Audio detection
  - c. Enabled for installation of additional applications
- 7. Event triggers:
  - a. Video motion detection
  - b. Audio detection
  - c. AXIS Camera Application Platform
  - d. PTZ preset
  - e. Memory card full
- 8. Event actions:
  - a. File upload via FTP, HTTP, network share and e-mail
  - b. Notification via e-mail, HTTP and TCP
  - c. PTZ preset, video recording to edge storage
  - d. Pre- and post-alarm video buffering
- 9. General:
  - a. Processors and memory: 256 MB RAM, 128 MB flash
  - b. Local edge storage: SD/SDHC memory card slot
- 10. Included accessories:
  - a. Drill template
  - b. Mounting brackets for hard and soft ceiling
  - c. Installation guide
  - d. Installation and management software CD
  - e. Windows decoder 1-user license
  - f. Sunshield
- G. Warranty: 1-year

**2.04 EXTERIOR FIXED DOME NETWORK CAMERA**

- A. Make and Model: Axis P3367-VE, 5 MP, multi-stream viewing (or approved equal)
- B. Environmental Factors:
  - 1. Operating temperatures: -40°C to 55°C (-40°F to 131°F)
  - 2. Humidity: 0-100% RH (condensing)
  - 3. IP-66, NEMA 4X and 1K10-rated
- C. Power Requirements:

1. Power over Ethernet IEEE 802.3af
  2. Class 3; max 12.1W
- D. Mounting:
1. Wall: Axis T91A61 Wall Mount
  2. Parapet: Pelco PP-Series Parapet Mount
  3. Ceiling: Axis T91A63 Ceiling Mount
  4. Pole: Axis T91A67 Pole Mount
- E. Interface:
1. RJ-45 10 BASE-T/100BASE-TX PoE
  2. Terminal block for 1 alarm input and 1 output
  3. 3.5 mm/mic/line in, 3.5 mm line out
- F. Salient Characteristics:
1. Camera:
    - a. Image sensor: 1/3.2" progressive scan CMOS
    - b. Lens:
      - i. Varifocal
      - ii. Remote focus and zoom
      - iii. IR corrected
      - iv. P-Iris control
      - v. Megapixel resolution
      - vi. 3-9mm
    - c. Horizontal angle of view: 84° - 30°, F1.2
    - d. Day & Night: Automatically removable infrared-cut filter
    - e. Min. Illumination:
      - i. Color: 0.2 lux F1.2
      - ii. B&W: 0.04 lux F1.2
    - f. Shutter time: 1/28000 s to 2 s
    - g. Camera angle adjustment:
      - i. Pan: 360°
      - ii. Tilt: 160
      - iii. Rotation: 340°
  2. Video:
    - a. Compression:
      - i. H.246 Baseline and Main Profile (MPEG-4 Part 10/AVC)
      - ii. Motion JPEG
      - iii. Resolution: 2592 x 1944 (5MP) to 160 x 90
    - b. Frame Rate: 5 MP capture mode: 12 fps in all resolutions

- c. Video Streaming:
    - i. Multiple, individual configurable streams in H.264 and Motion JPEG
    - ii. Controllable frame rate and bandwidth
    - iii. VBR/CBR H.264
  - d. Multi-view streaming:
    - i. 5 MP capture mode: When streaming 4 view areas and 1 overview in VGA resolution, the frame rate is 12 fps per stream
    - ii. 3 MP capture mode: When streaming 4 view areas and 1 overview in VGA resolution, the frame rate is 20 fps per stream
  - e. Pan-tilt-zoom: Digital
3. Network:
- a. Security:
    - i. Password protection
    - ii. IP address filtering
    - iii. HTTPS encryption
    - iv. IEEE 802.1X network access control
    - v. Digest authentication
    - vi. User access log
  - b. Supported protocols: IPv4/v6, HTTP, HTTPS, SSL/TLS, QoS Layer 3 DiffServ, FTP, CIFS/SMB, SMTP, Bonjour, UPnP, SNMPv1/v2c/v3 (MIB-II), DNS, DynDNS, NTP, RTSP, RTP, TCP, UDP, IGMP, RTCP, ICMP, DHCP, ARP, SOCKS
4. System integration:
- a. Application Programming Interface:
    - i. Open API for software integration, including VAPIX and AXIS Camera Application Platform
    - ii. ONVIF specified
  - b. Intelligent video
    - i. Video motion detection
    - ii. Active tampering alarm
    - iii. Audio detection
    - iv. Enabled for installation of additional applications
  - c. Event triggers
    - i. Intelligent video
    - ii. External input
    - iii. Edge storage events
  - d. Event actions
    - i. File upload via FTP, HTTP, network share and e-mail
    - ii. Notification via e-mail, HTTP and TCP

- iii. External output activation
  - iv. Video and audio recording to edge storage
  - v. PTZ preset, guard tour
  - vi. Play audio clip
  - vii. Pre- and post-alarm video buffering
- 5. General
  - a. Processors and memory: ARTPEC-3, 256 MB RAM, 128 MB flash
  - b. Local edge storage: SD/SDHC memory card slot
- 6. Included accessories
  - a. Installation guide
  - b. Installation and management software CD
  - c. Windows decoder 1-user license
  - d. Sunshield
  - e. IP-66 rated RJ-45 connector kit
  - f. Mounting bracket
  - g. 5 m (16 ft.) network cable
  - h. Smoked transparent cover
- 7. Casing
  - a. IP-66 and NEMA 4X-rated, 1K10 impact-resistant casing with aluminum base and dehumidifying membrane.
  - b. Color: White NCS S 1002-B
- G. Warranty: 3-years

## **2.05 INTERIOR FIXED DOME NETWORK CAMERA**

- A. Make and Model: Axis P3367-V, 5 MP, multi-stream viewing, vandal resistant (or approved equal)
- B. Environmental Factors:
  - 1. Operating temperatures: 0°C to 50°C (-32°F to 122°F)
  - 2. Humidity: 0-85% RH (non-condensing)
- C. Power Requirements:
  - 1. Power over Ethernet IEEE 802.3af/802.3at Type 1
  - 2. Class 2; max 6.2 W
- D. Mounting:
  - 1. Wall: Axis T91A61 Wall Mount
  - 2. Parapet: Pelco PP-Series Parapet Mount
  - 3. Ceiling: Axis T91A63 Ceiling Mount
  - 4. Pole: Axis T91A67 Pole Mount
- E. Interface:
  - 1. RJ-45 10 BASE-T/100BASE-TX PoE

2. Terminal block for 1 alarm input and 1 output
  3. 3.5 mm/mic/line in, 3.5 mm line out
- F. Salient Characteristics
1. Camera:
    - a. Image sensor: 1/3.2" CMOS, progressive scan
    - b. Lens:
      - i. Varifocal
      - ii. Remote focus and zoom
      - iii. IR corrected
      - iv. P-Iris control
      - v. Megapixel resolution
      - vi. 3-9mm
    - c. Horizontal angle of view: 100° - 35°, F1.3
    - d. Day & Night: Automatically removable infrared-cut filter
    - e. Min. Illumination:
      - i. Color: 0.2 lux F1.2
      - ii. B&W: 0.04 lux F1.2
    - f. Shutter time: 1/28000 s to 2 s
    - g. Camera angle adjustment:
      - i. Pan: 360°
      - ii. Tilt: 160
      - iii. Rotation: 340°
  2. Video
    - a. Compression:
      - i. H.246 Baseline and Main Profile (MPEG-4 Part 10/AVC)
      - ii. Motion JPEG
    - b. Resolution: 2592 x 1944 (5MP) to 160 x 90
    - c. Frame Rate: 5 MP capture mode: 12 fps in all resolutions
    - d. Video Streaming:
      - i. Multiple, individual configurable streams in H.264 and Motion JPEG
      - ii. Controllable frame rate and bandwidth
      - iii. VBR/CBR H.264
      - iv. Multi-view streaming
      - v. 5 MP capture mode: When streaming 4 view areas and 1 overview in VGA resolution, the frame rate is 12 fps per stream
      - vi. 3 MP capture mode: When streaming 4 view areas and 1 overview in VGA resolution, the frame rate is 20 fps per stream
    - e. Pan-tilt-zoom: Digital

3. Audio:
  - a. Audio streaming: two-way audio
  - b. Audio input/output: External mic input or line input, Line output
4. Network:
  - a. Security:
    - i. Password protection
    - ii. IP address filtering
    - iii. HTTPS encryption
    - iv. IEEE 802.1X network access control
    - v. Digest authentication
    - vi. User access log
    - vii. Supported protocols: IPv4/v6, HTTP, HTTPS, SSL/TLS, QoS Layer 3 DiffServ, FTP, CIFS/SMB, SMTP, Bonjour, UPnP, SNMPv1/v2c/v3 (MIB-II), DNS, DynDNS, NTP, RTSP, RTP, TCP, UDP, IGMP, RTCP, ICMP, DHCP, ARP, SOCKS
5. System integration:
  - a. Application Programming Interface
  - b. Open API for software integration, including VAPIX and AXIS Camera Application Platform
  - c. ONVIF Profile S specified
6. Intelligent video:
  - a. Video motion detection
  - b. Active tampering alarm
  - c. Audio detection
  - d. Enabled for installation of additional applications
7. Event triggers:
  - a. Intelligent video
  - b. External input
  - c. Edge storage events
8. Event actions:
  - a. File upload via FTP, HTTP, network share and e-mail
  - b. Notification via e-mail, HTTP and TCP
  - c. External output activation
  - d. Video and audio recording to edge storage
  - e. PTZ preset, guard tour
  - f. Play audio clip
  - g. Pre- and post-alarm video buffering
9. General:

- a. Processors and memory: ARTPEC-3, 256 MB RAM, 128 MB flash
- b. Local edge storage: SD/SDHC/SDXC memory card slot
- 10. Included accessories:
  - a. Installation guide
  - b. Installation and management software CD
  - c. Windows decoder 1-user license
  - d. Drill hole template
- 11. Casing:
  - a. 1K10 impact-resistant casing with aluminum base and dehumidifying membrane.
  - b. Color: White NCS S 1002-B
- G. Warranty: 3-years

**2.06 360° CAMERA**

- A. Make and Model: Mobotix MX-Q24M-SEC-DN, 3.1 megapixel or approved equal
- B. Environmental Factors: Operating temperatures: -30°C to 60°C (-22°F to 140°F)
- C. Power Requirements:
  - 1. Power over Ethernet IEEE 802.3af
  - 2. PoE class varies with operation
  - 3. Power consumption: approx. 4.5W
- D. Mounting:
  - 1. Wall
  - 2. Ceiling
  - 3. Elevator cab ceiling mount MX-OPT-IC
- E. Interface:
  - 1. RJ-45 10 BASE-T/100BASE-TX PoE
  - 2. USB
- F. Salient Characteristics
  - 1. Camera:
    - a. Image sensor: 1/2" CMOS, progressive scan
    - b. Lens: L11 (hemispherical), L22 (90° x 67°)
    - c. Min. Illumination: Color: 1 lux (t=1/60 sec.), 0.05 lux (t=1/1 sec)
    - d. Video:
      - i. Compression
      - ii. MxPEG
      - iii. Motion JPEG
      - iv. JPG
      - v. H.263 (video – VoIP - telephony)

- e. Resolution: 2048 x 1536 (3MP)
  - f. Frame Rate:
    - i. VGA: 22 fps
    - ii. TV-PAL: 18 fps
    - iii. Mega: 8 fps
    - iv. 3MP: 4 fps
  - g. Video Streaming:
    - i. VGA: 30 fps
    - ii. TV-PAL: 30 fps
    - iii. Mega: 30 fps
    - iv. 3MP: 20 fps
  - h. Pan-tilt-zoom: Digital, continuous 8x zoom
2. Network:
- a. Security:
    - i. User-/Group management
    - ii. IP address filtering
    - iii. HTTPS/SSL
    - iv. IEEE 802.1X network access control
    - v. Intrusion detection
    - vi. Digital image signature
  - b. System integration:
    - i. Application Programming Interface
    - ii. Inclusive video management software MxEasy
  - c. Alarm/Events
    - i. Integrated multiple-window motion detection
    - ii. Temperature sensor
    - iii. Notification via e-mail, FTP, IP-Telephony (VoIP, SIP)
    - iv. Visual/acoustic alarm
    - v. Pre- and post-alarm images
3. General
- a. Memory: Internal 64 MB image memory
  - b. Local edge storage: MicroSD slot
  - c. Included accessories
    - i. Installation manual
    - ii. Software
    - iii. 4 GB MicroSD
    - iv. Mounting parts

- v. Patch cable
    - d. Casing
      - i. High-resistant composites – PBT-PC
      - ii. Color: White
    - e. Edge Storage: Micro SD memory card slot
  - G. Warranty: 1-year
- 2.07 THERMAL CAMERAS**
- A. Make/Model: Axis Q1922-E or approved equal
  - B. Environmental Factors:
    - 1. Operating temperatures: -40°C to 60°C (-40°F to 140°F)
    - 2. Humidity: 10-85% RH
    - 3. IP66-rated aluminum casing
  - C. Power Requirements:
    - 1. Power over Ethernet IEEE 802.3af Class 3
    - 2. 8-20 VDC, max 13W or 20-24 VAC 50-60 Hz, max 20 VA
  - D. Mounting:
    - 1. Wall: Axis T91A61 Wall Mount
    - 2. Parapet: Pelco PP-Series Parapet Mount
    - 3. Pole: Axis T91A67 Pole Mount
  - E. Interface:
    - 1. RJ-45 10 BASE-T/100BASE-TX PoE
    - 2. Terminal block for power
    - 3. Terminal block for 2 configurable inputs/outputs
    - 4. 3.5 mm/mic/line in, 3.5 mm line out
    - 5. RS-422/RS-485
    - 6. Terminal block for heater
  - F. Salient Characteristics:
    - 1. Camera:
      - a. Image sensor: Uncooled Micro bolometer 640x480, pixel size: 17µm, spectral range: 8-14 µm
      - b. Lens: 10 mm, 19 mm, 35 mm and 60 mm
      - c. Sensitivity: NETD < 100 mK
    - 2. Video:
      - a. Compression:
        - i. H.246 (MPEG-4 Part 10/AVC)
        - ii. Motion JPEG
        - iii. Resolution: Sensor is 640 x 480. Image can be scaled up to 800 x 600 (D1)

- iv. Frame Rate: Up to 30 fps
  - v. Video Streaming
  - vi. At least 3 H.264 and Motion JPEG streams using the same palette, simultaneous and individually configured in max. resolution at 30 fps.
  - vii. Controllable frame rate and bandwidth
  - viii. VBR/CBR H.264
3. Audio:
- a. Audio streaming: two-way audio, full duplex
  - b. Audio input/output: External mic input or line input, line output
4. Network
- a. Security:
    - i. Password protection
    - ii. IP address filtering
    - iii. HTTPS encryption
    - iv. IEEE 802.1X network access control
    - v. Digest authentication
    - vi. User access log
    - vii. Supported protocols: IPv4/v6, HTTP, HTTPS, SSL/TLS, QoS Layer 3 DiffServ, FTP, CIFS/SMB, SMTP, Bonjour, UPnP, SNMPv1/v2c/v3 (MIB-II), DNS, DynDNS, NTP, RTSP, RTP, TCP, UDP, IGMP, RTCP, ICMP, DHCP, ARP, SOCKS
5. System integration:
- a. Application Programming Interface
  - b. Open API for software integration, including VAPIX and AXIS Camera Application Platform
  - c. ONVIF specified
6. Intelligent video:
- a. Video motion detection
  - b. Active tampering alarm
  - c. Audio detection
  - d. Enabled for installation of additional applications
7. Event triggers:
- a. Intelligent video
  - b. External input
  - c. Event actions
  - d. File upload via FTP, HTTP, network share and e-mail
  - e. Notification via e-mail, HTTP and TCP
  - f. External output activation
  - g. Pre- and post-alarm video buffering

8. General:
  - a. Processors and memory: 128 MB RAM, 128 MB flash
  - b. Local edge storage: SD/SDHC memory card slot
  - c. Included accessories:
    - i. Installation guide
    - ii. Installation and management software CD
    - iii. Windows decoder 1-user license
    - iv. Wall-mount bracket

G. Warranty: 3-years

## **2.08 PERIPHERAL PoE NETWORK SWITCHES, SMALL FORM FACTOR**

- A. Make and Model: COMNET, CNGE2FE8MS Series Ethernet Managed Switch or approved equal
- B. Environmental Factors:
  1. MTBF: >100,000 Hours
  2. Operating Temp: -40° C to 75° C
  3. Storage Temp: -40° C to 85° C
  4. Relative Humidity: 0% to 95% (non-condensing).
- C. Power Requirements:
  1. Power: 12VDC to 24VDC @ 1A maximum
  2. Current Protection: Automatic re-settable solid-state current limiters
  3. Voltage Regulation: Solid-state, Independent on each board
  4. Circuit Board: UL 94 flame-rated and meets all IPC standards.
  5. Mounting: DIN Rail or wall-mount
- D. Interface:
  1. 8 (eight) 10-100TX RJ-45 ports
  2. 2 (two) 10-100/1000TX RJ-45 ports
  3. 2 (two) Gigabit SFP ports
- E. Salient Characteristics:
  1. General:
    - a. IEEE Networking Standards:
      - i. IEEE 802.3 10Base-T Ethernet
      - ii. IEEE 802.3u 100Base-TX Fast Ethernet
      - iii. IEEE 802.3ab 1000Base-TX
      - iv. IEEE 802.3z Gigabit Ethernet Fiber
      - v. IEEE 802.3x Flow Control and Back-pressure
      - vi. IEEE 802.1p class of service
      - vii. IEEE 802.1Q VLAN and GVRP

- viii. IEEE 802.1D-2004 Rapid Spanning Tree Protocol (RSTP)
  - ix. IEEE802.3ad LACP
  - x. IEEE802.1X Port-based Network Access Control
2. Switching Performance:
- a. Switch Technology: Store and Forward Technology with 32Gbps Switch Fabric
  - b. System Throughput: 14,880pps for 10M Ethernet; 148,800pps for 100M Fast Ethernet; 1,488,100 for Gigabit Ethernet
  - c. Transfer Packet Size: 64 bytes to 1522 bytes (with VLAN Tag)
  - d. MAC Address: 8K MAC
  - e. Packet Buffer: 1Mbits
  - f. Relay Alarm: Dry Relay output with 1A@24V ability
3. Management:
- a. Configuration: Web, HTTPS, SSH, TFTP/Web Update for firmware and configuration backup/restore, DHCP Client, Warm reboot, Reset to default, Admin password, Port Speed/Duplex control, status, statistic, MAC address table display, Static MAC, Aging time, SNMP v1, v2c, v3, Traps and RMON1. SNMP MIB: MIB-II, Bridge MIB, VLAN MIB, SNMP MIB, RMON and Private MIB
  - b. Port Trunk: Up to 5 Static Trunk and 802.3ad LACP
  - c. VLAN: IEEE802.1Q VLAN, GVRP. Up to 64 VLAN groups
  - d. Quality of Service: Four priority queues per port, IEEE802.1p COS and Layer 3 TOS/DiffServ
  - e. IGMP Snooping: IGMP Snooping V1/V2 for multicast filtering and IGMP Query
  - f. Rate Control: Ingress filtering for Broadcast, Multicast, Unknown DA or all packets, and Egress filtering for all packets
  - g. NTP: Network Time Protocol to synchronize time from Internet
  - h. Embedded Watchdog: Embedded hardware watchdog timer to auto reset system when switch system failure
  - i. Port Mirroring: Online traffic monitoring on multiple selected ports
  - j. Port Security: Assign authorized MAC to specific port
  - k. IP Security: IP security to prevent unauthorized access
  - l. 802.1x: Port-based Network Access Control
  - m. DHCP Server: Can assign 255 IP address, support IP and MAC binding
  - n. System Log: Supports both Local mode and Server mode
4. Network Redundancy:
- a. Rapid Spanning Tree Protocol: IEEE802.1D-2004 Rapid Spanning Tree Protocol. Compatible with Legacy STP and IEEE802.1w.
  - b. Rapid Super Ring (RSR): Ring Redundancy Technology. Failure recovery within 5ms.
  - c. Dual Homing II: Multiple uplink paths to upper switches

- d. Multiple Ring: Couple or multiple Rapid Super Rings
  - e. Legacy Super Ring: Backward compatible in client mode
  - f. Any Ring: Inter-operate with other vendors' ring Interface
5. Data Specifications:
    - a. Data Interface: Ethernet IEEE802.3
    - b. Data Rate: up to 1000 Mbps
    - c. Data Inputs/Outputs: up to 10
    - d. Operation Mode: Half or Full Duplex
    - e. Optical Specifications
  6. Number of Optical ports: up to 2 SFP-based
  7. Number of Fibers Required: 1 or 2, SFP-dependent
  8. Optical Wavelength: 1310 or 1550 nm, SFP-dependent
  9. Optical Power Budget: SFP-dependent
  10. Maximum Distance: up to 120 km (70 mi) single mode, SFP-dependent
  11. Status Indicators:
    - a. Power: Proper Power = Green
    - b. RJ-45 Link/Data: Green, No Link/No Data: Off
    - c. SFP Link/Data: Green, No Link/No Data: Off
  12. Connectors:
    - a. Optical: LC or SC, SFP-dependent
    - b. Power: Screw Clamp Terminal Strip.
    - c. Data: RJ-45
    - d. Console: RJ-45 serial communication
  13. Included Accessories:
    - a. Wall mount bracket automatically included
    - b. DIN Rail back mount automatically included
    - c. Warranty: Lifetime

## **2.09 PERIPHERAL PoE NETWORK SWITCHES, RACK MOUNT**

- A. Make and Model: COMNET, CNGE2FE24MS Series Ethernet Managed Switch or approved equal
- B. Environmental Factors:
  1. MTBF: >100,000 Hours
  2. Operating Temp: -40° C to 75° C
  3. Storage Temp: -40° C to 85° C
  4. Relative Humidity: 0% to 95% (non-condensing).
- C. Power Requirements:
  1. Power: 12VDC to 24VDC @ 1A maximum

2. Current Protection: Automatic re-settable solid-state current limiters
  3. Voltage Regulation: Solid-state, Independent on each board
  4. Circuit Board: UL 94 flame-rated and meets all IPC standards.
  5. Mounting: Rack
- D. Interface:
1. 8 (eight) 10-100TX RJ-45 ports
  2. 2 (two) 10-100/1000TX RJ-45 ports
  3. 2 (two) Gigabit SFP ports
- E. Salient Characteristics:
1. General:
    - a. IEEE Networking Standards:
      - i. IEEE 802.3 10Base-T Ethernet
      - ii. IEEE 802.3u 100Base-TX Fast Ethernet
      - iii. IEEE 802.3ab 1000Base-TX
      - iv. IEEE 802.3z Gigabit Ethernet Fiber
      - v. IEEE 802.3x Flow Control and Back-pressure
      - vi. IEEE 802.1p class of service
      - vii. IEEE 802.1Q VLAN and GVRP
      - viii. IEEE 802.1D-2004 Rapid Spanning Tree Protocol (RSTP)
      - ix. IEEE802.3ad LACP
      - x. IEEE802.1X Port-based Network Access Control
  2. Switching Performance:
    - a. Switch Technology: Store and Forward Technology with 32Gbps Switch Fabric
    - b. System Throughput: 14,880pps for 10M Ethernet; 148,800pps for 100M Fast Ethernet; 1,488,100 for Gigabit Ethernet
    - c. Transfer Packet Size: 64 bytes to 1522 bytes (with VLAN Tag)
    - d. MAC Address: 8K MAC
    - e. Packet Buffer: 1Mbits
    - f. Relay Alarm: Dry Relay output with 1A@24V ability
  3. Management:
    - a. Configuration: Web, HTTPS, SSH, TFTP/Web Update for firmware and configuration backup/restore, DHCP Client, Warm reboot, Reset to default, Admin password, Port Speed/Duplex control, status, statistic, MAC address table display, Static MAC, Aging time, SNMP v1, v2c, v3, Traps and RMON1. SNMP MIB: MIB-II, Bridge MIB, VLAN MIB, SNMP MIB, RMON and Private MIB
    - b. Port Trunk: Up to 5 Static Trunk and 802.3ad LACP
    - c. VLAN: IEEE802.1Q VLAN, GVRP. Up to 64 VLAN groups

- d. Quality of Service: Four priority queues per port, IEEE802.1p COS and Layer 3 TOS/DiffServ
  - e. IGMP Snooping: IGMP Snooping V1/V2 for multicast filtering and IGMP Query
  - f. Rate Control: Ingress filtering for Broadcast, Multicast, Unknown DA or all packets, and Egress filtering for all packets
  - g. NTP: Network Time Protocol to synchronize time from Internet
  - h. Embedded Watchdog: Embedded hardware watchdog timer to auto reset system when switch system failure
  - i. Port Mirroring: Online traffic monitoring on multiple selected ports
  - j. Port Security: Assign authorized MAC to specific port
  - k. IP Security: IP security to prevent unauthorized access
  - l. 802.1x: Port-based Network Access Control
  - m. DHCP Server: Can assign 255 IP address, support IP and MAC binding
  - n. System Log: Supports both Local mode and Server mode
4. Network Redundancy:
- a. Rapid Spanning Tree Protocol: IEEE802.1D-2004 Rapid Spanning Tree Protocol. Compatible with Legacy STP and IEEE802.1w.
  - b. Rapid Super Ring (RSR): Ring Redundancy Technology. Failure recovery within 5ms.
  - c. Dual Homing II: Multiple uplink paths to upper switches
  - d. Multiple Ring: Couple or multiple Rapid Super Rings
  - e. Legacy Super Ring: Backward compatible in client mode
  - f. Any Ring: Inter-operate with other vendors' ring Interface
5. Data Specifications:
- a. Data Interface: Ethernet IEEE802.3
  - b. Data Rate: up to 1000 Mbps
  - c. Data Inputs/Outputs: up to 10
  - d. Operation Mode: Half or Full Duplex
  - e. Optical Specifications
6. Number of Optical ports: up to 2 SFP-based
7. Number of Fibers Required: 1 or 2, SFP-dependent
8. Optical Wavelength: 1310 or 1550 nm, SFP-dependent
9. Optical Power Budget: SFP-dependent
10. Maximum Distance: up to 120 km (70 mi) single mode, SFP-dependent
11. Status Indicators:
- a. Power: Proper Power = Green
  - b. RJ-45 Link/Data: Green, No Link/No Data: Off
  - c. SFP Link/Data: Green, No Link/No Data: Off
12. Connectors:

- a. Optical: LC or SC, SFP-dependent
- b. Power: Screw Clamp Terminal Strip.
- c. Data: RJ-45
- d. Console: RJ-45 serial communication

**13. Included Accessories:**

- a. Wall mount bracket automatically included
- b. DIN Rail back mount automatically included
- c. Warranty: Lifetime

**2.010 MEDIA CONVERTERS**

- A. Make/Model: Axis T8604 Media Converter Switch
- B. Environmental Factors:
- C. Operating and Storage Temperatures: -40°C to 75°C (-40°F to 167°F)
- D. Operating and Storage Humidity: 10-85% RH (non-condensing)
- E. Power Requirements: 12.0-13.2 V DC max. 3.5 W
- F. Mounting: DIN Rail
- G. Interface:
  - 1. 2 (two) RJ45 connectors (10/100 Mbps)
  - 2. 2 (two) SFP connectors (100/1000 Mbps) for SFP fiber optic modules or SFP to copper modules
  - 3. 1x power
- H. Salient Characteristics:
  - 1. Display and Indicators: Power LED indicator; Network LED indicator (4x)
  - 2. Compliance: RoHS, REACH, WEEE, CE, EN 50022, IEC 60715, AS 2756
  - 3. Approvals: EN 55022 Class A, EN 61000-3-2, EN 61000-3-3, EN 61000-6-1, EN 61000-6-2, EN 55024, FCC Part 15 Subpart B Class A, ICES-003 Class A, VCCI Class A, C-tick AS/NZS CISPR 22, KCC KN22 Class A, KN24, IEC/EN 60950-1
  - 4. Included Accessories: Bracket Mount DIN Clip, Installation Guide
  - 5. Warranty: 3-year

**PART 3 - EXECUTION**

**3.01 DESIGN**

- A. Submit the optimum design layout of the cameras and camera specifications prior to installing any equipment. The Contractor will use the layout to determine the adequacy of the design and, in conjunction with a field survey, determine the exact location of each CCTV camera.

**3.02 INSTALLATION**

- A. Installation of the camera system shall be performed in a neat and professional manner and retain all elements of the rail system's architectural excellence.
- B. Installation of the camera system shall be coordinated with work of other trades.
- C. CCTV equipment shall be installed in accordance with manufacturer's instructions.

- D. Within rail station passenger areas, CCTV cameras shall be installed a minimum of 9'-0" above finished floor (AFF).
- E. CCTV cameras shall not be installed over tracks or extend beyond the inside of the platform edge granite unless otherwise specified or approved.
- F. Cameras mounted to suspended ceiling panels shall be installed flush with the ceiling panel and all wiring shall be concealed within the suspended ceiling.
- G. Enclosures shall be weather-proof, NEMA4X Stainless Steel enclosures with a padlock hasp.
- H. Enclosures shall be mounted no more than 5'-6" above finished floor.
- I. All cables shall be installed and tested in accordance with the most current WMATA Design and Wiring Standards.
- J. Grounding and/or bonding of the CCTV system shall be completed in accordance with
- K. For conduit, raceways and cabinet installation see Section 16130.
- L. For wire cable and busways installation, see Section 16120.

### **3.03 CONFIGURATION AND ADJUSTMENT**

- A. Configure and document all parameters required for optimized camera operation.
- B. Adjust cameras and document as required to capture the view as shown on approved drawings.
- C. Focus cameras using Rotakin focusing tool.

### **3.04 FIELD QUALITY CONTROL**

- A. Design and Performance Testing: Perform tests and submit results in accordance with the General Provisions, certified test results for the CCTV system installed under this contract.
- B. Acceptance Testing:
  - 1. Furnish equipment required to perform tests.
  - 2. Comply with WMATA approved system testing.
  - 3. Perform approved tests to verify that the CCTV systems comply with requirements shown and specified.
- C. The Contractor is responsible for testing all power and communications signals in accordance with

### **3.05 DEMONSTRATION**

- A. Conduct walking tour of Project and briefly describe function, operation and maintenance of the system components.
- B. Demonstrate operation and maintenance of the system to W MATA personnel two weeks prior to date of Substantial Completion.
- C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with W MATA personnel in detail to explain all aspects of operation and maintenance.
- D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance and shutdown of each item of equipment at equipment location.
- E. Prepare and insert additional data in operations and maintenance manuals as needed for additional data becomes apparent during instruction.

**3.06 SPARE PARTS**

A. In accordance with special conditions and the following:

1. Provide spare parts and/or equipment for no less than 10% of new items that are added to WMATA's inventory under this task.

**PART 4 - END OF SECTION**

## SECTION 16852

### COMMUNICATIONS - PARKING GARAGE CLOSED-CIRCUIT TELEVISION SYSTEM

#### PART 1 - GENERAL

##### 1.01 SECTION DESCRIPTION AND BASIC REQUIREMENTS

- A. The Parking Garage Closed-Circuit Television (CCTV) System Provides monitoring of the parking garage exit gates from the Parking Garage Communication Equipment Room.
- B. The Closed-Circuit Television System described herein includes, but is not limited to, the following components:
  - 1. In designated parking garage locations;
  - 2. Color CCTV Cameras.
  - 3. Fiber-Optic Video Transmitters
  - 4. Fiber-Optic Cable and Conduit from the camera location to the Communications Equipment Room.
- C. In Parking Garage Communications Equipment Rooms;
  - 1. 17-inch CCTV Monitors.
  - 2. VHS Time Lapse Recorder/Players.
  - 3. Video Equipment Security Cabinets.
  - 4. Quad Video Processors.
  - 5. Fiber-Optic Video Receivers
- D. Video outputs from all CCTV cameras shall be connected to the Quad Video Processors located the Communications Equipment Room via fiber-optic transmitters, fiber-optic cable and fiber-optic receivers.
- E. A 17-inch CCTV monitor shall be installed in the Garage Communications Equipment Room and interfaced with the Quad Video Processor.
- F. A VHS Time Lapse Recorder/Player shall be installed in the Garage Communications Equipment Room and interfaced with the Quad Video Processor.

##### 1.02 SECTION INCLUDES

- A. Cameras.
- B. 17-inch CCTV Monitors.
- C. VHS Time Lapse Recorder/Players.
- D. Video Equipment Security Cabinets.
- E. Quad Video Processors.

##### 1.03 UNIT PRICES

- A. Unit Prices include incidental items, not specifically mentioned, but required for complete and proper system operation.

##### 1.04 RELATED SECTIONS

- A. Section 16705 -Communications Standard Specifications - Equipment & Materials.
- B. Section 16706 - Communications System Submittals & Services.
- C. Section 16707 - Communications Systems Quality Assurance & Testing.
- D. Section 16710 -Communications Grounding.
- E. Section 16715 - Communications Electrical Power Distribution.

#### **1.05 REFERENCES**

- A. National Electrical Code (NEC).
- B. Electronics Industries Alliance (EIA) Standard RS 170
- C. Federal Standard 595B, Colors Used in Government Procurement

#### **1.06 SYSTEM DESCRIPTION**

- A. Description: Provides monitoring of the exit gates from the Parking Garage Communication Equipment Room.
- B. Capacity:
  1. The Contractor shall design, furnish, and install Color CCTV Cameras to monitor all garage exit gates from each Parking Garage Communication Equipment Room.
  2. The Contractor shall furnish and install a 17-inch video monitor in each Parking Garage Communications Equipment Room.
  3. The Contractor shall furnish and install a Video Equipment Security Cabinet in each Garage Communications Equipment Room to house the following video equipment: 17-inch CCTV Monitors, VHS Time Lapse Recorder/Players, Video Equipment Security Cabinets, Quad Video Processors, and Fiber-Optic Video Receivers
  4. The Contractor shall furnish and install Quad Video Processors in each Parking Garage Communications Equipment Room.
- C. Configuration: RS-170 with 1 volt peak-to-peak across 75-ohms.

#### **1.07 SYSTEM PERFORMANCE REQUIREMENTS**

- A. The Contractor shall be responsible for the overall performance of the Closed-Circuit Television System. The following overall system performance requirements are designed to ensure that the Closed-Circuit Television System delivered under these Specifications meets the performance requirements of the Washington Metropolitan Area Transit Authority.
  1. Gray Scale Reproduction: Ten shades of gray shall be distinguishable when viewing a standard EIA Resolution Chart on each CCTV camera.
  2. Sensitivity: A faceplate illumination of 0.25 foot-candles (or less) using an Infrared (IR) filter and with the Automatic Gain Control (AGC) off shall cause a full video output from the CCTV camera.
  3. Minimum Scene Illumination: Each television camera shall provide a usable video output using an IR filter and with the AGC on with a faceplate illumination of 0.04 foot-candles (or less).
  4. Resolution: The vertical resolution as determined by viewing each CCTV monitor, as produced by a signal originating from each associated CCTV camera and

passing through the installed cable and distribution equipment in the CCTV System, shall not be less than 350 lines in the center of the picture, when all system equipment is operated to any combination of the previously stated system design capabilities. The horizontal resolution measured under these conditions shall not be less than 550 TV lines in the center of the picture on any Kiosk CCTV monitor.

5. Video Signal Level: Video signal levels shall conform to level requirements of EIA Standard RS-170 when measured at the signal input of the installed Kiosk monitors.
6. Scanning Lines: 525 lines per frame, interlaced 2:1 Standard RS-170 with no discernible interlace jitter or pairing on the monitor.
7. Frame Frequency: 30 frames per second.
8. Aspect Ratio: Height to width ratio of three (3) to four (4).
9. Environmental Standards: All equipment mounted outdoors shall be fully operational without damage or functional degradation under any combination of the following environmental/working conditions:
  - a. Ambient temperature  $-40^{\circ}\text{C}$  to  $+50^{\circ}\text{C}$ .
  - b. Relative humidity 0% to 100%.
  - c. Operation to  $+60^{\circ}\text{C}$  shall not reduce the horizontal resolution of the CCTV camera by more than 100 lines.
  - d. Rain, salt, dust, oil, and other pollutants.
  - e. Winds up to and including 90 MPH with rime icing.
  - f. Vigorous and normal use.
  - g. Train-related vibrations.
10. Noise: Operation of any aspect of the system shall not produce any discernible noise on the CCTV monitor. The signal-to-noise ratio under all transit system operating conditions shall be degraded by no more than 3-dB.

#### **1.08 SUBMITTALS**

- A. Submit under provisions of Section 16706.
- B. Shop Drawings: Indicate electrical characteristics and connection requirements, including system wiring diagram.
- C. Product Data: Provide showing electrical characteristics and connection requirements for each component.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

#### **1.09 QUALIFICATIONS**

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Supplier: Authorized distributor of specified manufacturer with minimum three years documented experience.
- C. Installer: Authorized installer of specified manufacturer with service facilities within 50 miles of Project.

#### **1.10 REGULATORY REQUIREMENTS**

- A. Conform to requirements of NFPA 130.
- B. Furnish Products listed and classified by Underwriters Laboratories, Inc. or testing firm acceptable to authority having jurisdiction as suitable for purpose specified and indicated.

### **1.11 MAINTENANCE SERVICE**

- A. Furnish service and maintenance of Closed-Circuit Television system until Final Completion.

## **PART 2 - PRODUCTS**

### **2.01 COLOR CCTV CAMERA**

- A. Manufacturers:
  - 1. Philips Model LTC 0600/60, (or approved equal).
- B. Description: High-resolution color video camera.
- C. Imager: ½-inch image format.
- D. AGC: 18 dB, (24 dB selectable)
- E. Lens Mount: C and CS
- F. Ratings:
  - 1. Input Power: 120-Vac, 60-Hz.
  - 2. Scene Illumination: 0.04 fc for usable picture, 0.15 fc for full video.
  - 3. Active Picture Elements: 768 (H) x 492 (V).
  - 4. Horizontal Resolution: 480 TVL.
- G. Features:
  - 1. Digital Signal Processor
  - 2. Backlight Compensation
  - 3. Automatic Picture Enhancement
- H. Power Supply: Integral 120-volts, 60-Hz.

### **2.02 3.7-MM FIXED LENS**

- A. Manufacturer:
  - 1. Philips Model LTC 3214/20, (or approved equal).
- B. Description: Fixed focal-length, auto-iris lens.
- C. Mount Style: CS
- D. Iris Range, max. to min. (f-stop): 1.6 to 300
- E. Focal Length: 3.7-mm.

### **2.03 8-MM FIXED LENS**

- A. Manufacturer:

1. Philips Model LTC 3123/40, (or approved equal).
- B. Description: Fixed focal-length, auto-iris lens.
- C. Mount Style: C
- D. Iris Range, max. to min. (f-stop): 1.4 to 360
- E. Focal Length: 8-mm.

#### **2.04 SEVENTEEN-INCH MONITORS**

- A. Manufacturers:
  1. Philips Model 9617C/R with LTC 9017/00 rack kit (or approved equal).
- B. Description: Rack-mounted monochrome television monitor.
- C. Viewable Picture Area: 17-inches.
- D. Ratings:
  1. Horizontal Resolution: 700 lines.
  2. Linearity: 2% Horizontal and Vertical measured diagonally.
  3. Video Input: EIA RS-170.
  4. Input Power: 120-Vac, 60-Hz.

#### **2.05 VHS TIME LAPSE RECORDER/PLAYER**

- A. Manufacturers:
  1. Philips Model LTC 3991/60 (or approved equal).
- B. S-VHS format.
- C. Selectable Speeds (recording & Playback) 2, 12, 24, 48, 72, 120, 168, 240, 360, 480, 600, and 720 hours with ST-120 tape.
- D. High Speed Video Scan: 5 x 2 hour speed.
- E. Rewind/Fast Forward Time: 4.5 minutes average.
- F. Video Signal Format: EIA Standard, 525 lines, 60 fields/second. National Television System Committee (NTSC) color/monochrome Auto-selection.
- G. Video Input: 1 V p-p, 75-ohms, unbalanced.
- H. Video Output: 1 V p-p, 75-ohms, unbalanced.
- I. Horizontal resolution 400 lines (monochrome and color).
- J. Date/Time/Recording Data Generator with Time/Memory Power-Loss Backup of one month minimum
- K. Connectors: BCN - Video In and Out
  1. Radio Corporation of America (RCA) Phono Jack - Audio in, audio out
  2. 15-Pin D-Connector
    - a. Alarm Commands in

- b. Alarm On signal out
- c. Alarm Record Reset
- d. Tape End Out
- e. Tape End Reset
- f. Switcher Control Pulse
- g. Record Start In
- h. Record Output
- i. Low Tape Out.
- j. Record Check In
- k. One-Shot Command In
- 3. S Connectors
  - a. S(Y/C)\_in
  - b. S(Y/C) out
- L. Rated Voltage: 120-Vac, 60-Hz.
- M. Power Record/Play: 26-watts
- N. Operating Temperature: 5 to 40 EC

## **2.06 VIDEO EQUIPMENT SECURITY CABINET**

- A. Manufacturers:
  - 1. Bud Model No. DC-8002-BT (or approved equal).
- B. 19-inch rack mounting.
- C. Locking Plexiglas Front Door.

## **2.07 QUAD VIDEO PROCESSOR**

- A. Manufacturers:
  - 1. Philips Model LTC 2272 (or approved equal).
- B. Digital Memory: 8-bit, 256 gray steps.
- C. Video Inputs: four BNC, 75-ohms, 0.5 to 2.0 V p-p composite video, sysnc negative, 2:1 interlaced
- D. Video Outputs: one BNC, 75 ohms, continuous quad presentation of the four inputs.
- E. Supply Voltage: 120-Vac, 60-Hz.
- F. Power at Rated Voltage: 8 watts
- G. Operating Temperature: +0 EC to +40 EC

## **2.08 FIBER OPTIC VIDEO TRANSMITTERS**

- A. Manufacturers:
- B. Philips Model LTC4641(or approved equal).
- C. Lascomm Model 145/195, (or approved equal).

- D. Force, Incorporated Model 2792, (or approved equal).
- E. American Fibertek Inc. Model 20 Series, (or approved equal).
- F. Description: Fiber optic video transmitter, multi-mode.
- G. Format: NTSC video format.
- H. Ratings:
  - 1. Bandwidth: 6-MHz.
  - 2. Optical mode: Multi-mode.
  - 3. Input: 1 volts peak-to-peak at 75 ohms.

## **2.09 FIBER OPTIC VIDEO RECEIVERS**

- A. Manufacturers:
  - 1. Philips Model LTC4642, (or approved equal).
  - 2. Lascomm Model 145/195, (or approved equal).
  - 3. Force, Incorporated Model 2792, (or approved equal).
  - 4. American Fibertek Inc. Model 20 Series, (or approved equal).
- B. Description: Fiber optic video receiver, multi-mode.
- C. Format: NTSC video format.
- D. Ratings:
  - 1. Bandwidth: 6-MHz.
  - 2. Optical mode: Multi-mode.
  - 3. Input: 1-volt peak-to-peak at 75-ohms.

## **2.10 CAMERA ENVIRONMENTAL HOUSING**

- A. Manufacturers:
  - 1. Philips Model LTC 9488/61, (or approved equal).
- B. Ratings:
  - 1. Environmental: Thermostatically-controlled heater/blower designed to minimize window fogging.
  - 2. Material: Aluminum and Advanced Polymer
- C. \*Finish: Metro Bronze, Federal Standard 595B, Color No. 20040.

## **2.11 CAMERA WALL MOUNTS**

- A. Manufacturers:
  - 1. Pelco Model EM22, (or approved equal).
  - 2. Philips Model LTC9216, (or approved equal).
- B. Ratings:

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\*The required Metro Bronze finish may require a special manufacturer's part number or, if not available through the manufacturer, shall require the Contractor to provide the Metro Bronze finishing.

1. Load rating: 40 pounds.
2. Material: Aluminum.

C. \*Finish: Metro Bronze, Federal Standard 595B, Color No. 20040.

## **2.12 CAMERA CEILING MOUNTS**

A. Manufacturers:

1. Pelco Model MM22, (or approved equal).
2. Philips Model LTC9214, (or approved equal).

B. Ratings:

1. Load rating: 40 pounds.
2. Material: Aluminum.

C. \*Finish: Metro Bronze, Federal Standard 595B, Color No. 20040.

## **2.13 FIBER OPTIC CABLE (Riser)**

A. Manufacturers:

1. International Fiber Systems Model A-1-6-TB, (or approved equal).

B. Ratings:

1. Multi-mode, 850-nanometers
2. NEC Riser rated
3. Service Temperature: -20 EC to +80 EC.
4. Tensile Load (install/service): 112/25 lbs.
5. Fiber Core Diameter: 62.5 microns
6. Overall Diameter: .112

## **2.14 FIBER OPTIC CABLE (Plenum)**

A. Manufacturers:

1. International Fiber Systems Model A-1-6-PL, (or approved equal).

B. Ratings:

1. Multi-mode, 850-nanometers
2. NEC Riser rated
3. Service Temperature: 0C. to +80C.
4. Tensile Load (install/service): 112/25 lbs.
5. Fiber Core Diameter: 62.5 microns
6. Overall Diameter: .098

## **2.15 TWO-CONDUCTOR SHIELDED POWER CABLE**

A. Manufacturers:

1. Belden Type 83321, (or approved equal).

B. Ratings:

1. Type: 18-AWG, two-conductor stranded silver plated copper.
2. Conductor Insulation: Extruded TFE Teflon
3. Shielding: Silver-plated copper braid.
4. Rating: 600-Volt UL Class-1.
5. Jacket: TFE Teflon tape-wrapped (No PVC)

6. Vertical Wire Flame Test: Passes VW-1

## **2.16 POWER ISOLATION TRANSFORMER**

- A. Manufacturers:
  1. Acme Model T-3-53043-S, (or approved equal).
- B. Ratings:
  1. Primary: 120/240 Vac, single phase.
  2. Secondary: 120/240 Vac, single phase.

## **2.17 COAXIAL VIDEO CABLE**

- A. Manufactures:
  1. Belden Type 89120 (or approved equal).
- B. Description: Provides connection between equipment and fiber optic transmission equipment.
- C. Ratings:
  1. Type: RG-6/U.
  2. Shielding: Aluminum Foil-Polyester Tape-Aluminum Foil/Braid.
  3. Attenuation: 0.66 dB/100 Ft. (nominal at 10 MHz).
  4. Jacket: Fluorinated Ethylene-Propylene (FEP) (No PVC)
  5. Insulation: Foam Teflon.
  6. Rating: Meets NEC\_CMP.
  7. Impedance: 75-ohm.

## **2.18 POWER CABLES**

- A. Manufactures:
  1. Belden Type 83321 (or approved equal).
- B. Description: Provides connection between power between equipment at the camera location and the power distribution panel in the Communication Room.
- C. Ratings:
  1. Type: 18-AWG, two-conductor stranded silver plated copper.
  2. Conductor Insulation: Extruded TFE Teflon, color-coded.
  3. Shielding: Silver-plated copper braid.
  4. Rating: 600-Volt UL Class-1.
  5. Jacket: TFE Teflon tape-wrapped (No PVC).
  6. Vertical Wire Flame Test: Passes VW-1

## **PART 3 - EXECUTIONS**

### **3.01 INSTALLATION**

- A. Submit the optimum design layout of the cameras and lens types to the Engineer prior to installing any equipment. The Engineer shall use the design to determine the adequacy of the design and, in conjunction with a field survey, determine the exact location of each CCTV camera.

- B. Furnish and install all terminals, hardware, wiring and cabling, connectors and adapters, conduits and fittings; and make all the necessary connections and cross-connections required for a complete operational CCTV System for each parking garage required by these specifications.

### **3.02 CAMERA EQUIPMENT**

- A. Install the Color CCTV cameras in the parking garages with the appropriate type mounting brackets. Install conduit from the parking garage Communication Equipment Room to the camera location shown on the Contract Drawings. The Engineering Definition Review shall be used to assist the Engineer in determining the adequacy of the design and, in conjunction with a field survey, determining the exact location of each CCTV camera. The bottom of installed CCTV cameras shall, ideally, be nine feet or greater above the finished floor. The conduit routing shall be approved by the Engineer.
- B. Install conduit from the CCTV cameras to the nearest Parking Attendant Booth for power in the parking garage and/or to the Communications Equipment Room in the parking garage.
- C. The Contractor shall install a power isolation transformer and connect it to the 120-Vac power source.
- D. The Contractor shall install a 2-conductor 18-AWG shielded power cable from the isolation transformer to each CCTV camera.
- E. All installed video connectors and adapters shall be covered with shrink sleeving to electrically isolate the connectors from building and power ground.
- F. All equipment mounted outside of the Communication Room or Parking Attendant Booth, which is not weatherproof, shall be mounted in weatherproof boxes.
- G. Terminate all unused video inputs and outputs in 75 ohms using appropriate termination plugs/jacks.

### **3.03 PARKING GARAGE COMMUNICATIONS EQUIPMENT ROOM CCTV INSTALLATION**

- A. Install and connect the following equipment in a 19-inch equipment cabinet in the Communications Equipment Rooms of the parking garages:
  - 1. 17-inch CCTV Monitors.
  - 2. VHS Time Lapse Recorder/Players.
  - 3. Video Equipment Security Cabinets.
  - 4. Quad Video Processors.

### **3.04 VIDEO CABLE**

- A. Install coaxial video cable from the CCTV monitor to VHS Time Lapse Recorder/Player in the parking garage Communications Equipment Room. The Contractor shall use coaxial video cable for all video connections within the parking garage Communications Equipment Room.
- B. Install coaxial video cable from the Time Lapse Recorder/Player to the Quad Video Processors in the parking garage Communications Equipment Room

- C. Install coaxial video cable from each CCTV camera to the fiber optic transmitters and from the fiber optic receivers to the Quad Video Processors in the parking garage Communications Equipment Room.
- D. Install fiber optic video cable from each CCTV camera location to the parking garage Communications Equipment Room and install the required connectors.
- E. Install the required video connectors and adapters, and connect the video cables to the CCTV equipment. At each CCTV camera location, the Contractor shall install the appropriate mating connector on the coaxial cable. Video connectors shall be crimp type with weatherproof gaskets. Shrink sleeving (approved for outdoor use and installed per manufacturer's directions) shall be installed on connectors that are exposed in the parking garage, including splices. All splices shall be TDR tested and approved by the Engineer.

### **3.05 MANUFACTURER'S FIELD SERVICES**

- A. Prepare and start systems under provisions of Section 16707.
- B. Supervise final wiring connections and system adjustments.

### **3.06 ADJUSTING**

- A. Adjust operating Products and equipment to ensure smooth and unhindered operation.
- B. Adjust cameras for best view of required areas.

### **3.07 DEMONSTRATION**

- A. Demonstrate operation and maintenance of Products to Owner's personnel two weeks prior to date of Substantial Completion.
- B. Demonstrate Project equipment by a qualified person who is knowledgeable about the Project.
- C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with Owners' personnel in detail to explain all aspects of operation and maintenance.
- D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at equipment location.
- E. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.
- F. Demonstrate system operation.
- G. Conduct walking tour of Project and briefly describe function, operation, and maintenance of each component.

### **3.08 SCHEDULES**

- A. Camera GTVC-1
  - 1. Lens: 3.7-mm, f/1.6 lens, with automatic iris.

- B. Camera GTVC-2
  - 1. Lens: 8-mm, f/1.4 lens, with automatic iris

**END OF SECTION**

## SECTION 16866

### INTERFACE CRITERIA AND RESPONSIBILITIES

#### PART 1 - GENERAL DESCRIPTION

##### 1.01 SECTION DESCRIPTION AND BASIC REQUIREMENTS

- A. The Contractor shall identify all electrical, mechanical and physical interfaces associated with these Specifications. These shall include, but not be limited to, the following interfaces:
  - 1. Between the various communications systems, subsystems, equipment and materials included in these Specifications.
  - 2. Between the communications systems, subsystems, equipment and materials included in these Specifications, and existing WMATA systems, subsystems, and equipment.
  - 3. Between the Contractor-provided systems, subsystems, equipment and materials and those furnished by the Authority or other contractors (including structures, equipment, etc.).
- B. The Contractor-provided systems, subsystems, equipment and materials shall be designed to have the characteristics required to ensure that electrical, mechanical and physical interfaces achieve the specified grade of service and performance levels on a non-interfering basis with existing system and equipment functions (except as otherwise specified).
- C. The Contractor shall be fully responsible for the correct interfacing of the systems, facilities and equipment that are provided under this Contract with the existing WMATA communications systems, subsystems, facilities, and with the facilities and equipment furnished by the Authority. If any incompatibility is discovered, the Contractor shall correct the incompatibility by modifying the equipment provided and/or by providing additional required equipment and material at no additional cost to the Authority. Unless otherwise specified, modifications to the equipment of existing WMATA systems, subsystems and facilities and to equipment provided by the Authority will not be permitted.
- D. The Contractor shall be responsible for verifying product compatibility and system performance of all equipment, including equipment specified under the Major Items sections of this Contract.
- E. The Contractor shall ensure that continuing coordination is accomplished as defined. The Contractor shall submit an interface procedure which shall include the following:
  - 1. A detailed list specifically identifying each interface associated with this Contract.
  - 2. A description of the work involving interfaces to be performed by the Contractor under this Contract.
  - 3. Sketches or drawings showing details of interface points, where applicable.

##### 1.02 DEFINITION

- A. Interface Point
  - 1. An interface point is defined as the line(s) of demarcation between the various Contractor-furnished and/or installed systems, subsystems, equipment and materials, and those existing facilities including WMATA communications systems and equipment.
- B. Electrical/Mechanical Interface Compatibility

1. Electrical and mechanical interface compatibility is defined as the electrical and mechanical characteristics required to: Ensure that separate systems, subsystems, equipment and materials, and existing systems, subsystems, equipment and materials are compatible, retain their specified function, and perform a specified service in the specified manner, in conjunction with facilities to which they are connected; and that they do not impair, or have any adverse effect on, the specified operation of any system, subsystem or equipment to which they are directly or indirectly connected, or that may be influenced by them or their electromagnetic field(s).
- C. Physical Interface Compatibility
1. Physical interface compatibility is defined as the physical form and fit required to ensure that all items of equipment and materials are fully compatible with all other equipment, materials, facilities and structures with which they interface, including: Those furnished in accordance with these Specifications; and those owned or occupied by the Authority.
- D. Schedule Compatibility
1. Schedule compatibility is defined as the scheduling of contract work on the essentially non-interfering basis to WMATA. The Engineer's determination of what constitutes an "essentially non-interfering basis" shall be required whenever any degree of interference to WMATA is anticipated.

### **1.03 COMMUNICATIONS SYSTEMS/SUBSYSTEMS/FACILITIES INTERFACE**

- A. General
1. Some of the communications systems, subsystems and facilities to be furnished and installed in accordance with these Specifications are expansions and extensions of systems, subsystems and facilities furnished and installed by WMATA or local jurisdiction contracts.
  2. All systems, subsystems, equipment and materials furnished in accordance with the provisions of this Contract shall be fully compatible and operable to full specifications on an essentially non-interfering basis with all systems, subsystems, equipment and materials that are to be utilized by WMATA (including the electromagnetic compatibility of electrical, magnetic and radio frequency emissions of all types). The existing systems and facilities, and the extensions and expansions furnished in accordance with these Specifications, shall be fully compatible with each other, and each shall function as a single integrated system/facility.

### **1.04 PUBLIC ADDRESS SYSTEM**

- A. Passenger Station Public Address System interfaces shall include, but are not limited to, the Carrier Transmission System, the Technical Control Facility, the Automatic Public Address Announcement System, the Electrical Power Distribution System, the passenger station Kiosk, and the existing Public Address System equipment in the Jackson Graham Building. Points of interface include the passenger station's Communications Equipment Room, the Jackson Graham Building, the Kiosk, and locations within the passenger stations where loudspeakers are required.

### **1.05 CLOSED CIRCUIT TELEVISION SYSTEM**

- A. The Closed Circuit Television System interfaces include, but are not limited to, the passenger station's Kiosk and the Electrical Power Distribution System. Points of interface

include the passenger station's Communications Equipment Room, the Kiosk, and locations within the passenger stations where CCTV cameras are required.

#### **1.06 FIRE AND INTRUSION ALARM SYSTEM**

- A. Passenger Station Fire and Intrusion Alarm System interfaces include, but are not limited to, the existing partial Station Fire and Intrusion System, the Technical Control Facility, the passenger station Public Address System, the Data Transmission System, the Automatic Fare Collection equipment, the elevators, and the Electrical Power Distribution System.
- B. Points of interface in the passenger stations and ancillary buildings associated with this Contract include the Communications Equipment Room, the Kiosk, elevators and the Elevator Machine Room, selected air handling equipment, escalators and areas that contain deluge valves and water flow valves, and all locations where detectors are required.

#### **1.07 CARRIER TRANSMISSION SYSTEM**

- A. .Carrier Transmission System interfaces include, but are not limited to, the Fiber Optics System, the Telephone System, the Public Address System, the Passenger Emergency Reporting System, the Data Transmission System, the Technical Control Facility, the Mobile Radio System, and the Electrical Power Distribution System. Each system/facility shall be compatible with the channel(s) of the Carrier Transmission System which it utilizes.
- B. Points of interface exist in the Communications Equipment Rooms in the passenger stations, the Jackson Graham Building, and in the Communications Equipment Rooms and designated intermediate locations along the right-of-way.
- C. Carrier Transmission Systems, in addition to interfacing with each of the systems/facilities that use it as a transmission means, shall be compatible and operable with Carrier Transmission System equipment located at the Jackson Graham Building, in Communications Equipment Rooms along the right-of-way, and/or other specified locations. Space has been allocated in the Jackson Graham Building for Carrier Transmission System equipment to be furnished and installed in accordance with these Specifications.

#### **1.08 FIBER OPTICS SYSTEM**

- A. The Fiber Optics System interfaces include, but are not limited to, the Carrier Transmission System and the Electrical Power Distribution System for the passenger stations.
- B. Points of interface exist at the passenger station Communications Equipment Room, the Jackson Graham Building, and along the right-of-way.

#### **1.09 TELEPHONE SYSTEM**

- A. Passenger Station Telephone System interfaces include, but are not limited to, the Carrier Transmission System, the existing Computerized Branch Exchange (CBX) in the Jackson Graham Building, and the Electrical Power Distribution System. Points of interface include the passenger station's Communications Equipment Room, the Jackson Graham Building, the Kiosk; and in the passenger stations, ancillary buildings, and at Emergency Trip Station (ETS) enclosures along the right-of-way where telephone instruments are required.

#### **1.10 PASSENGER EMERGENCY REPORTING SYSTEM**

- A. Passenger Emergency Reporting System interfaces include, but are not limited to, the

passenger station Kiosk, the Electrical Power Distribution System and on the passenger station's platform. Points of interface exist in the Communications Equipment Room of the passenger stations, the Kiosk, and at locations within the passenger stations where Call Station Panels are required.

#### **1.11 AUTOMATIC PUBLIC ADDRESS ANNOUNCEMENT SYSTEM**

- A. Automatic Public Address Announcement System interfaces include, but are not limited to, the Public Address System, the Fire and Intrusion Alarm System, the passenger station Kiosk, and the Electrical Power Distribution System. Points of interface exist in the Communications Equipment Room of the passenger stations and the Kiosk within the passenger stations.

#### **1.12 PASSENGER STATION KIOSKS**

- A. Passenger Station Kiosk interfaces include, but are not limited to, the passenger station Public Address System, the passenger station Telephone System, the passenger station Closed Circuit Television System, the Passenger Station Fire and Intrusion Alarm System, the Technical Control Facility, the Passenger Emergency Reporting System, the Automatic Public Address Announcement System, the Electrical Power Distribution System, the Kiosk structures, the Data Transmission System, and the escalators and elevators. Points of interface exist within the Kiosk, in the passenger station Communications Equipment Room, in the AC Switchboard Room, and at the elevators and escalators.

#### **1.13 ELECTRICAL POWER DISTRIBUTION SYSTEM**

- A. Electrical Power Distribution System interfaces for the provision of uninterruptible 120 Vac power include, but are not limited to, the passenger station Public Address System, the passenger station Closed Circuit Television System, the passenger station Fire and Intrusion Alarm System, the Carrier Transmission System, the passenger station Telephone System, the Passenger Emergency Reporting System, the Automatic Public Address Announcement System, the passenger station Kiosk and the passenger station Mobile Radio System. Points of interface include the passenger station Communications Equipment Room, the Kiosk, and the AC Switchboard Room.
- B. For the provision of -48 Vdc power, Electrical Power Distribution System interfaces include, but are not limited to, the Carrier Transmission System, the Fiber Optics System and the passenger station Telephone System. Points of interface include the passenger station Communications Equipment Room.

#### **1.14 MOBILE RADIO SYSTEM**

- A. Mobile Radio System interfaces include, but are not limited to, the existing slotted coaxial cable antenna along the right-of-way and in other areas. Points of interface may exist within the tunnel areas where the existing slotted coaxial cable antenna is terminated, at the remote ancillary building(s) and passenger station(s) where UHF Two-Way Line Driver Units may be installed, and the passenger station Communications Equipment Room where a base station shall be installed.

#### **1.15 FARE COLLECTION SYSTEM**

- A. The Contractor shall interface with the Fare Collection System to determine the availability of the Kiosk fare collection console and fare collection equipment, and to coordinate work schedules and related details.

#### **1.16 INTERFACE WITH THE AUTHORITY**

- A. WMATA is an operating rapid transit system. The Contractor shall interface with the Authority to coordinate schedules and access to areas of the system where work is to be performed. Coordination is required for physical access to Communications Equipment Rooms, tunnel areas, the Jackson Graham Building, operations rooms, Kiosks, and platform areas (other than areas within the passenger stations in this Contract).
- B. Equipment installed in the Communications Equipment Rooms and Kiosks in operational passenger stations and in the Jackson Graham Building, contain working circuits supporting transit operations. Certain work in those areas may require special coordination, in accordance with instructions furnished by the Engineer, to ensure that work can be performed on an essentially non-interfering basis.
- C. Within Communications Equipment Rooms and Kiosks in operational passenger stations and yards, Contractors' work shall be performed with a representative of the Authority present. Connections to working circuits shall be made only by the Authority or with the permission of the Authority. The Contractor shall coordinate with the Authority all other work in operational passenger stations and yards to be performed in Communications Equipment Rooms and Kiosks. The Contractor shall advise the Authority of the work to be accomplished, including wiring and cross-connections, and the scheduled beginning and completion of each task.

#### **1.17 LOCAL FIRE AUTHORITY**

- A. The Contractor shall interface with the local fire authority having jurisdiction over the various areas within the limits of the Contract work area to obtain advisory opinions concerning compliance with proprietary "Fire Protection Equipment and Life Safety Agreements" and applicable provisions of the local fire codes, and to coordinate related details when so directed by the Engineer.

**PART 2 PRODUCTS (SECTION NOT USED)**

**PART 3 EXECUTION (SECTION NOT USED)**

**END OF SECTION**

## **SECTION 16900**

### **BASIC ATC DEFINITIONS, CHARACTERISTICS and BACKGROUND INFORMATION**

#### **PART 1 - GENERAL**

##### **1.01 SECTION INCLUDES**

- A. This SECTION lists all of the various 16900-series SECTIONS and sub-Sections comprising the Wayside Automatic Train Control System Specifications.
  
- B. BASIC ATC DEFINITIONS, CHARACTERISTICS and BACKGROUND INFORMATION
  - 1. Definition of ATC Terms (Section 16901)
  - 2. ATC Abbreviations (Section 16902)
  - 3. Initial Metrorail System (Section 16903)
  - 4. Current Automatic Train Control System (Section 16904)
  - 5. Transit Vehicle Characteristics (Section 16905)
  - 6. Determination of Payment for ATC Work (Section 16906)

**END OF SECTION**

## SECTION 16901

### DEFINITIONS OF ATC TERMS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section contains a Glossary of ATC Terms used in these Automatic Train Control Specifications which defines their meaning as used in these ATC Specifications, and provides references for the definition of standard terms used in these ATC Specifications.
- B. Standard Definitions
  - 1. Definitions pertaining to the train control design and equipment description shall conform to the standard definitions promulgated by the following organizations unless otherwise specified in the GLOSSARY of ATC Terms contained in Part 1.04 of this Section:
    - a. Part 1.1.1 of the American Railway Engineering and Maintenance of Way Association (AREMA) (formerly AAR) Signal Manual (of Recommended Practice).
    - b. Electronic Industries Association (EIA)
    - c. The Institute of Electrical and Electronics Engineers, Inc. (IEEE).
- C. Order of Priority
  - 1. Where definitions conflict, the order of priority shall be:
  - 2. Section 16901.1.04, Glossary of ATC Terms;
  - 3. AREMA Signal Manual;
  - 4. EIA;
  - 5. IEEE.

##### 1.02 RELATED SECTIONS

- A. All Sections in the 16900 Series.

##### 1.03 REFERENCES

- A. Part 1.1.1 of the American Railway Engineering and Maintenance of Way Association (AREMA) Signal Manual of Recommended Practice
- B. Electronic Industries Association (EIA)
- C. The Institute of Electrical and Electronics Engineers, Inc. (IEEE)

##### 1.04 GLOSSARY OF ATC TERMS

- A. Words, terms, and phrases, as used in these Wayside ATC System Specifications, are defined as follows:
  - 1. **Abnormal Condition** (as referred to in ATS description)
    - a. An event of unusual nature (i.e., associated with a low probability) exceeding the capabilities of Strategy Selection and Rescheduling.
  - 2. **Active Component**
    - a. An electronic component, such as a transistor, which requires power supply energy in addition to the input signal to function and produces current or voltage gain.
  - 3. Active Element
    - a. An electronic component which converts or controls energy (e.g., a single

- integrated circuit, transistor, diode, relay, or operational amplifier).
4. Active Element Group
    - a. A network of piece-part components functioning with an active element.
  5. Address
    - a. The bits of a message used to identify the destination or origin of the message.
  6. Aerial Structure
    - a. Track support structure that carries the track above the local surrounding ground level.
  7. Alarm Condition
    - a. Any off-normal condition which requires the attention of an operator, supervisor or maintainer.
  8. Ambiguity Level
    - a. In the context of Test Program Sets, the number of components to which a fault can be diagnosed. These components may be individual electronic components on a Printed Wiring Board Assembly; Active Element Groups, on a Printed Wiring Board Assembly, or individual Printed Wiring Board Assemblies in a chassis. Ambiguity Level is usually expressed in a table that indicates the percentage of the time that it is required to resolve faults to various limiting numbers of components.
  9. Aspect, Signal
    - a. See "Signal Aspect".
  10. At-Grade
    - a. That portion of the Metrorail system which is constructed at the approximate elevation of the adjacent ground surface.
  11. "... at the appropriate time ..."
    - a. The appropriate time as determined by the designated Resident Engineer (Engineer).
  12. Audible Alarm
    - a. The sounding of a bell, buzzer, or other acoustic device to draw the attention of a Train Operator, ATC Maintainer, or Central Control Supervisor to an alarm condition.
  13. (The) Authority,
    - a. Washington Metropolitan Area Transit Authority (WMATA).
  14. Automatic Local Control
    - a. A mode of system operation in which functions such as route initiation and dispatching are performed automatically by local wayside equipment.
  15. Automatic Speed Regulator
    - a. That portion of the carborne ATO System which measures actual train speed and controls positive and negative tractive effort to maintain the desired speed.
  16. Automatic Train Control (ATC)
    - a. The system for automatically controlling train movement, enforcing train safety, and directing train operations. ATC includes subsystems for Automatic Train Operation, Automatic Train Protection, and Automatic Train Supervision.
  17. Automatic Train Operation (ATO)
    - a. The subsystem within Automatic Train Control which performs the on-train functions of speed regulation, program stopping, and performance adjustment. This subsystem, in conjunction with the Train-to-Wayside Communications (TWC) System, may also control train door operation and train starting.
  18. Automatic Train Protection (ATP)

- a. The subsystem within Automatic Train Control which maintains safe train operation. ATP subsystems include train detection, train separation, interlocking, and speed-limit enforcement.
- 19. Automatic Train Supervision (ATS)
  - a. The subsystem within Automatic Train Control which monitors and provides controls necessary to direct the operation of a system of trains in order to maintain intended traffic patterns and minimize the effects of train delays on the operating schedule.
- 20. Auxiliary Switch Operation
  - a. The operation of a switch-and-lock movement by means of an independent manual control without clearing a signal or calling for a signal to clear.
- 21. Availability
  - a. The portion of total elapsed time that a system is operating or ready for operation.
- 22. B Point
  - a. An intermediate, direct-track-rail connection point, located between two successive impedance bonds on a single track, at which train detection frequency signals are received by one or two terminating receivers.
- 23. Back-to-Back Signals
  - a. See "Signals, Back-to-Back."
- 24. Ballast Resistance
  - a. The total interrail resistance caused by electrical leakage paths of a given section of electrically isolated unoccupied track.
- 25. Ballasted Track
  - a. Track structure in which the running rails and the propulsion rail insulators are affixed to individual crossties which are in turn supported by loose ballast.
  - b. (See also, "Direct Fixation Track").
- 26. Berth
  - a. The portion of track occupied by a train when stopped for loading and discharging passengers at a station platform.
- 27. Berthing
  - a. The precise positioning and stopping of a train at a passenger station platform.
- 28. Bipolar Mode
  - a. The connection of two channels in a manner that requires, for a single operation, a positive polarity on one and a negative polarity on the other. For instance, two input channels which are connected together in a way that requires an input of one polarity on one channel and an input of the opposite polarity on the other channel to produce a single permissive input.
- 29. Bit
  - a. A binary digit, 0 or 1 in number representation, with the radix 2.
- 30. Blending
  - a. The simultaneous action and proportional effort of both dynamic and mechanical braking to achieve the required total braking effort during the transition from all dynamic to all mechanical.
- 31. Block
  - a. A contiguous section of track of defined limits on which the movement of trains is governed by Automatic Train Control or wayside signals or both.
- 32. Block, Absolute
  - a. A block into which no train is permitted to enter while it is occupied by another train.
- 33. Block, Interlocking
  - a. A contiguous section of track within an interlocking plant, the entrance to which is governed by interlocked signals and the use of which is governed

- by interlocking rules for automatic or manual train operation. An interlocking block will contain one or more track switches and/or crossing frogs and one or more track circuits.
34. Block, Traffic
- a. A contiguous section of track between opposing wayside interlocking signals on which the prescribed direction of running can be reversed only when the block is unoccupied and no routes are established (or are timing out) for entry into that block.
35. Block, Turnback
- a. See "Turnback Block."
36. Block Design
- a. The process of dividing the METRO trackage into sections having defined limits for the purpose of train detection and ATP speed command transmission, and the determination of the speed commands to be transmitted in each of the blocks so determined. The locations of the block boundaries and the speeds to be transmitted are determined by:
- 1) The location of fixed facilities such as substation negative-propulsion return points, crossbonding locations, insulated rail joints and station platforms.
  - 2) Civil restrictions due to grades, curves, and special trackwork.
  - 3) Safety considerations based upon the acceleration and braking characteristics of the transit vehicles.
  - 4) Passenger comfort considerations for both the people on the transit vehicles and on station platforms.
37. Bond, Clamped
- a. A type of electrical bond attached to the base of one or more running rails by means of a mechanical clamp.
38. Bond, Compression-Bolted
- a. A type of electrical bond attached to the web of one or more running rails by means of a metal collar swaged onto a ribbed metal "pin" passing through the rail web and the bond connecting lug(s).
39. Bond, Cross
- a. An electrical connection between the negative-propulsion-return rails of adjacent tracks, used to equalize negative propulsion return currents in the running rails. In audio-frequency track circuit territory, these bonds must be connected between the center taps of impedance bonds on the adjacent tracks.
40. Bond, Exothermic
- a. A type of electrical bond attached to the running rails by exothermic means.
41. Bond, Impedance
- a. A copper, single-turn, center-tapped coil unit of low resistance, wound with coils for inductively coupling train detection, speed command and TWC frequencies, as required. These units are installed between the running rails of WMATA mainline tracks for one or more of the following purposes:
- 1) To provide a path for negative propulsion return currents around insulated joints and/or from running rails to crossbonding or substation-return cables.
  - 2) To delineate the boundaries of audio frequency track circuits.
  - 3) To inductively connect AF train detection signals between the running rails and ATP transmitter and/or receiver modules.
  - 4) To inductively connect AF speed commands and/or door control signals between the running rails and ATP transmitter and/or receiver modules.

- 5) To inductively connect TWC signals between the running rails and wayside TWC modules via the ATP modules.
42. Bond, Negative Return (or Propulsion Return)  
a. A type of electrical rail bond designed to carry heavy negative propulsion return current at impedance bonds, rail joints, frogs, and switch point rails.
43. Bond, Pin Type  
a. A type of electrical rail bond designed to be attached to the running rails by means of metal pins driven into holes in the web or head of the rails.
44. Bond, Railhead  
a. A type of rail bond consisting of a length of electrical conductor having a device on one or both ends to facilitate connection to the head portion of the rail(s) to be bonded.
45. Bond, Rail Web  
a. A type of rail bond consisting of a length of electrical conductor having a device on each end to facilitate connection to the web portion of the rails to be bonded together.  
b. A type of rail bond consisting of length of electrical conductor welded, bolted or otherwise connected to the web portion of a rail.
46. Bond, Signal  
a. A type of electrical rail bond designed to carry the relatively light current of a power frequency (60 Hz) track circuit.
47. Bond, Substation Return  
a. An electrical connection between the center tap of an impedance bond and a negative propulsion return bus from a substation.  
b. An impedance bond having its center tap used for the negative propulsion return connection to a substation.
48. Bonding  
a. The permanent joining of metallic parts to form an electrically conductive path which will assure electrical continuity and the capacity to conduct safely any current likely to be imposed.
49. Brake Rate  
a. The rate of deceleration caused by the braking system.
50. Bridging Receiver  
a. (OBSOLETE; See "Terminating Receiver")
51. Bus (Electrical)  
a. A conductor, or group of conductors, that serve as a common connection for two or more circuits.
52. Cab Signal  
a. See "Signal, Cab."
53. Cable Jacket  
a. A protective outer covering over the insulation, core, or sheath of a cable.
54. Cable Sheath  
a. A conductive protective covering applied to cables. Note: A cable sheath may consist of multiple layers of which one or more is conductive.
55. Central Computer Control  
a. A mode of system operation in which functions such as route initiation and dispatching are performed by the Central Control Computer through the local equipment.
56. Central Control (Central)  
a. The area in the Jackson Graham Building (JGB) where the main train control console, display units, and central automatic train supervision equipment and personnel are located.
57. Central Control Supervisor  
a. The ATC system control console operator on duty at Central Control.
58. Central Manual Control

- a. A mode of system operation in which ATC functions such as route initiation and dispatching are performed manually from Central Control through the local equipment.
59. Circuit, Track (See also "Track Circuit, Audio Frequency", "Track Circuit, Power Frequency", and "Track Circuit Vital.")
- a. An electrical or electronic circuit in which defined portions of one or both running rails of a track constitute a portion of the conductors, and in which the shunting of the running rails is used to detect the presence of trains or equipment on the track.
  - b. Single-Rail Track Circuit;
    - 1) A track circuit in which one running rail is an isolated signal rail and the other running rail is a common, non-isolated rail.
  - c. Double-Rail Track Circuit;
    - 1) A track circuit in which both running rails are isolated signal rails, or in which both running rails serve as both signal rails and negative-propulsion common-return rails.
  - d. Series-Type Track Circuit;
    - 1) A non-vital, single-rail track circuit which is energized only when shunted to the opposite running rail.
60. Circuit, Traffic
- a. A vital circuit used to determine the permissible direction of train operation over a segment of track between two interlockings and/or set(s) of back-to-back signals. (See "Block, Traffic.")
61. Circuit, Vital
- a. Any circuit whose function directly affects the safety of train operation.
62. Civil Speed Limit
- a. See "Speed Limit, Civil."
63. Clearance Point
- a. The location between the diverging tracks emanating from a turnout at which the Authority's required clearance is achieved between the diverging tracks. This point is usually defined by the distances (along each of the diverging tracks) from the point-of-switch.
64. Closing-In
- a. Operating a following train toward a preceding train which is either stopped or running slower than the following train.
65. Code Rate
- a. The rate of on/off modulation. See "Rate Coding."
66. Command (noun)
- a. As used with respect to ATP or TWC messages from TCRs to trains
    - 1) An electronic signal to start, stop, cancel, change or continue an operation governed by ATP or ATO, respectively.
  - b. As used with respect to DTS messages from Central Control to TCRs
    - 1) See "Request" and "Control."
67. Computer
- a. Any device capable of accepting information, applying prescribed processes to it and supplying the results of these processes in a usable form.
68. Conduit
- a. A tube-like structure for electrical wires or cables. Conduit may be either rigid or flexible, metallic or non-metallic, as specified.
69. Consist (noun)
- a. The number and specific identity of cars which make up a train.
70. Contact Rail Assembly
- a. An assembly of a special, insulated, non-running rail and its supports and

coverboards, which is installed alongside a track and which carries high voltage electrical energy for the propulsion of trains on that track. See also "Rail, Third."

71. (The) Contractor  
a. The successful Bidder who is awarded a Contract for providing all facilities and equipment described in these Specifications for the Automatic Train Control System.
72. Control (noun)- As used with respect to DTS messages from Central Control to wayside Train Control Rooms  
a. A "Control" is actually only a non-vital supervisory "request" for certain action. If the applicable function is non-vital, the "Control" will be acted upon, but if the applicable function is a vital Train Control function, the "Control" will be treated as a "request" to the vital ATC wayside logic circuits and equipment, and will be granted only if it is safe to do so. See:  
1) "Command"  
2) "Request."  
3) "Indication."
73. Control Limits  
a. The boundaries limiting the area of trackage controlled from a Train Control Room (and its satellite TCER, if applicable). (See TCR and TCER).
74. Controlled Signal  
a. See "Signal, Controlled."
75. Converging Route  
a. See "Route, Converging."
76. Coupling (verb)  
a. The act of connecting one married-pair of transit vehicles to another by pushing their aligned automatic couplers together.
77. Cross Bond  
a. See "Bond, Cross."
78. Crossover  
a. Two turnouts, with track between the frogs, arranged to form a continuous passage between two tracks.
79. Crossover, Diamond  
a. A double crossover which has the trailing point and facing point crossovers installed at approximately the same civil stationing on the two running tracks, and in which the two crossover tracks between the running track frogs cross each other in a "diamond" configuration.
80. Crossover, Double  
a. A pair of crossovers, one of the facing point type and another of the trailing point type, located in close proximity between the same two tracks. These two crossovers may be located either successively (Universal Crossover), or concurrently (Diamond Crossover).
81. Crossover, Facing Point  
a. A crossover installed in such a manner that trains traveling in the normal direction of traffic on the main tracks will move from the points to the frog of the first turnout encountered, i.e., in which the crossover represents a potential diverging route to such trains.
82. Crossover, Trailing Point  
a. A crossover installed in such a manner that trains traveling in the normal direction of traffic on the main tracks will move from the turnout frog to the switch points, i.e., in which the crossover represents a converging route to such trains.
83. Crossover, Universal

- a. A double crossover that has the trailing point and facing point crossovers installed successively between the same two running tracks.
- 84. Crosstalk
  - a. Undesirable interference created by inductive coupling between one system and another system or from one portion of a system to another portion of the same system.
- 85. Current Schedule
  - a. The schedule residing in the Control Computer which is the set point for system control by the Traffic Regulation Program.
- 86. Current Revised Schedule
  - a. A revised schedule replacing the existing current schedule in the Control Computer.
- 87. Daily Safety Test (DST)
  - a. The speed command cycle test performed on a complete train before permitting the train to operate in the automatic mode.
- 88. Data Bit
  - a. One of the bits used to convey information in a message. (As opposed to a "housekeeping" bit.)
- 89. Data Transmission System (DTS)
  - a. The bi-directional, non-vital, digital communications system between Central Control and the Train Control Rooms.
- 90. Days
  - a. Unless otherwise stated, days that are listed as multiples of the number "15" shall be considered calendar days. Days that are listed as less than the number "15" shall be considered as working days.
- 91. Deceleration Rate
  - a. The rate of deceleration due to braking effort, train resistance, grade and curve resistance, or some combination of the above factors, as specified.
- 92. Decoder
  - a. A device which responds to valid incoming data and converts the incoming data format to the data format required by the device for which the data is intended.
- 93. Derail
  - a. A track structure for derailing rolling stock in case of an emergency.
- 94. Designated Resident Engineer (Engineer)
  - a. person designated by the Authority to oversee the Automatic Train Control portion of the Contract.
- 95. Destination Code
  - a. A code consisting of two decimal digits assigned to a train to indicate the desired destination and type of service for the train. The code is used to control the destination signs on the train, and to select automatic routing for the train.
- 96. Diamond Crossover
  - a. See "Crossover, Diamond."
- 97. Direct Fixation
  - a. A type of track structure in which the running rails and the propulsion rail insulators are affixed to a concrete support slab or to special grout pads on the slab rather than to individual cross-ties set in ballast.
- 98. Dispatching
  - a. The process of starting a train into revenue service from a terminal yard, or intermediate location.
- 99. Dispatching Machine (*No longer being installed or used.*)
  - a. A locally installed device used to store and reproduce in real time the current operating schedules and, when required, to use this information to dispatch trains automatically.

- 100. Dispatch Receiver
  - a. A Train-to-Wayside Communications System receiver which is used to accept Train Ready and Train Length data from trains leaving a dispatch point other than a station platform.
- 101. Diverging Route
  - a. See "Route, Diverging."
- 102. Double Crossover
  - a. See "Crossover, Double."
- 103. Downstream
  - a. Relative to a specified reference point and for a given direction of travel, the area which will be reached after passing the specified reference point. Used in the same sense as the AAR/AREMA term "in advance of." (See also, "Upstream.")
- 104. Drop (or Drop-Out)
  - a. A relay is said to "drop" or "drop-out" when the energization of its coil(s) is reduced to the point where its front contacts open.
- 105. Duct
  - a. A single enclosed runway for wires or cable.
- 106. Duct Bank
  - a. An arrangement of conduit or ducts providing two or more continuous ducts between two points.
- 107. Dwell (or Dwell Time)
  - a. The period of time measured from the instant a train stops in its berth at a station until the instant it resumes motion.
- 108. Dynamic Train Tests
  - a. The field tests conducted by the Contractor utilizing trains under electrical power: WTPs 2.17, 2.18, 2.19, 2.20, and 2.21 as well as the Level F (Systems) Field Tests.
- 109. Elevated
  - a. That portion of the system which is constructed above the adjacent ground surface. See "Aerial Structure."
- 110. Encoder
  - a. A device that adds security to and converts the data format produced by input devices to the data format required by associated data transmission links.
- 111. (The) Engineer
  - a. Wherever on the Contract ATC Drawings or in the ATC Specifications the term "the Engineer" is used, it shall mean the designated (ATC) Resident Engineer or other duly authorized representative of the Contracting Officer.
- 112. Entrance-Exit Type Route Control
  - a. Automatic route control implemented by defining first an entrance point and then an exit point.
- 113. Fail-Safe
  - a. An inherent characteristic of a system or circuit which ensures that any malfunction affecting safety will cause the system or controlled function of the circuit to revert to a state that is known to be safe.
- 114. Failure
  - a. An inability to perform an intended function.
- 115. Field Side (of a Running Rail)
  - a. The side of the rail away from the centerline of the applicable track. (See also; "Gauge Side.")
- 116. Fleeting
  - a. A method of route control in which a route request is not canceled by the

- passage of a train, thus permitting safe automatic following moves over the same route.
117. Flyby Receiver  
 a. A Train-to-Wayside Communications System receiver which is used to accept and store destination codes from moving trains in approach to junctions and terminals.
118. Flyby Transmitter  
 a. A Train-to-Wayside Communications System transmitter which is used to transmit performance level information to moving trains at locations between passenger stations.
119. Frog  
 a. A trackwork component used at the intersection of two running rails to provide support for wheels and passageways for their flanges, thus permitting wheels on either rail to cross the other.
120. Gauge Side (of a Running Rail)  
 a. The side of the rail closest to the centerline of the applicable track. (See also; "Field Side.")
121. Guard Rail  
 a. A rail or other structure fastened between and parallel with the running rails of a track and used to prevent wheels from being derailed, or to hold wheels in correct alignment to prevent their flanges from striking either crossing frogs or the points of switches, or to prevent a derailed train from leaving the track right-of-way. See also, "Restraining Rail."
122. Headway  
 a. The time separation between two trains both traveling in the same direction on the same track. It is measured from the time the head-end of the leading train passes a given reference point to the time the head-end of the following train passes the same reference point.
123. Home Signal  
 a. See "Signal, Home."
124. Impedance Bond  
 a. See "Bond, Impedance."
125. Indication (as used with respect to messages from local equipment and trains)  
 a. A DTS message from the Train Control Room to Central or  
 b. a Train-to-Wayside Communications System message from the train to the Train Control Room which carries information concerning the status of some device or system.  
 c. See "Control."
126. Indication, Signal  
 a. See "Signal Indication."
127. Insulated Joint (IJ)  
 a. See "Joint, Insulated."
128. Interface  
 a. The interconnection and/or inter-relationship between two or more systems, subsystems, circuits, persons or contracts, required to ensure continuity and proper operation.
129. Interlocking  
 a. An arrangement of signals and signal appliances so interconnected that their operations must succeed each other in proper sequence, thereby permitting train movements over controlled routes only if safe conditions exist.
130. Interlocking Control Panel (I.C.P.)  
 a. A panel displaying a line diagram of the trackage in and near a particular interlocking or group of interlockings, and equipped with various pushbuttons, electrical switches, indicator lights and audible

- alarms to allow the control and monitoring of that section of trackage.
131. Interlocking Limits
- a. The boundaries of an area of trackage controlled by an interlocking, as defined by the insulated joints at the extreme opposing home signals of that interlocking. The term "within interlocking limits" denotes the area of trackage over which routes are established and protected by the signals and signal appliances comprising that interlocking.
132. Jerk (or Jerk Rate)
- a. Rate of change of acceleration or deceleration equal to the second derivative of velocity. The normal unit is miles per hour per second per second (mphpsps).
133. Jet Fan Control (JFC)
- a. Having to do with special controls and indications for ventilation fans mounted axially in the METRORAIL Transit tunnels.
134. Joint, Insulated (IJ)
- a. A rail joint designed to prevent the flow of electric current from rail to rail by means of insulations placed so as to separate the rail ends and other metal parts connecting them.
135. Joint, Rail
- a. A fastening design to unite the abutting ends of contiguous rails.
136. Joint Electron Device Engineering Council (JEDEC)
- a. Cooperative effort of Electronic Industries Association (EIA) and National Electrical Manufacturers Association (NEMA).
137. Junction
- a. A location where train routes converge or diverge.
138. Junction Box
- a. An enclosure for equipment and/or wire terminations.
139. LED
- a. Light Emitting Diode
140. Left-Hand Running
- a. See "Running, Reverse".
141. Line
- a. As used with a color prefix, e.g., "Blue Line," "Red Line," one of the operational routings over which revenue service is regularly scheduled by the Authority. A "Line" may include all or parts of one or more geographical "Routes." See also "Route."
142. Load Weighing
- a. A function incorporated in the rail transit vehicles which measures gross car weight. Its purpose is to permit control of tractive effort in order to achieve a constant effort-to-weight ratio.
143. Locking
144. The electrical or mechanical establishment of a condition for a switch, interlocked route, speed limit, or automatic function which cannot be altered except by a prescribed and inviolate sequence of unlocking.
145. Locking, Approach
- a. Electric locking effective while a train is approaching, within a specified distance, a signal displaying an "INTERLOCKING CLEAR" aspect, and which prevents, until after the expiration of a predetermined time interval after such signal has been caused to display a "STOP" aspect, the movement of any interlocked switch or derail in the route governed by the signal, and which prevents an "INTERLOCKING CLEAR" aspect from being displayed for any conflicting route.
146. Locking, Detector
- a. Electric locking, effective while a train occupies a given section of a route, which prevents operation of switch-and-lock movements within

- that section.
147. Locking, Route
    - a. Electric locking, effective when a train passes a signal displaying an "INTERLOCKING CLEAR" aspect, which prevents the clearing of an interlocked signal for any conflicting route. It also prevents the movement of any switch or derail downstream of the train within the route entered. When required, it may be arranged so that as a train clears a track section of the route, the locking affecting that section is released. See "Sectional Release"
  148. Locking, Time
    - a. Electrical locking which, after an interlocked signal is cleared, prevents the operation of any switch or derail in the route governed by that signal until the expiration of a predetermined time interval after that signal has displayed a STOP aspect. It also prevents other interlocked signals from being cleared for any conflicting route during the same time interval.
  149. Locking, Traffic
    - a. Electrical locking which prevents the effective manipulation of devices for changing the direction of traffic on a section of track while that section of track is occupied or while a request which would permit entry into that section is being processed.
  150. Logic Code
    - a. A tabular or graphic representation of control lines representing the speed commands that shall be transmitted in each block (for a given direction of traffic and route alignment) and the track occupancy conditions under which each of the speed commands shall be transmitted.
  151. Maintenance, Preventative
    - a. Maintenance procedure carried out on a routine basis in order to reduce in-service equipment failure.
  152. Manual Local Control
    - a. A mode of system operation in which functions such as route initiation and dispatching are performed manually by personnel using local wayside equipment such as a local Interlocking Control Panel.
  153. Marker (as used in the Program Stop System)
    - a. A wayside device used to transfer data to trains at a precise location.
  154. Married Pair
    - a. Two transit cars, semi-permanently connected together (by a drawbar), which share certain common equipment.
  155. Maximum Authorized Speed (MAS) (or Maximum Allowable Speed)
    - a. The highest ATP speed command that can safely be transmitted to a train in a block for the purpose of enforcing civil speed limits. MAS is independent of block occupancy downstream from the given block. In blocks which lie in the approach to crossovers or diverging junctions, MAS can depend on which route is aligned.
  156. Mean Time Between Failures (MTBF)
    - a. The arithmetic mean of the time between successive failures.
  157. Mean Time to Restore (MTTR)
    - a. The arithmetic mean of time required to restore service after a failure has occurred. This time is measured from the time troubleshooting or repair work begins until restoration is complete. Time the equipment is out of service prior to the beginning of the repair work is not included in the "MTTR."
  158. Modem
    - a. A modulator and demodulator housed in a common assembly.

- 159. Mole
  - a. A device containing four or more sockets for multiple connection of 1000-kcmil negative return cables.
- 160. Necessary
  - a. Regarded by the designated Resident Engineer as needed.
- 161. Negative Return
  - a. Related to the return of 750 VDC train propulsion current to the substations.
- 162. Negative Return Bond
  - a. See "Bond, Negative Return."
- 163. Negative Return Rail
  - a. See "Rail, Negative Return."
- 164. Negative Testing
  - a. Testing conducted to ensure that applicable systems and/or equipment are not performing in any manner which could have an unsafe or undesirable effect upon METRORAIL operations, METRO riders, or the public in general. See "Positive Testing."
- 165. Noise
  - a. Interference brought about by undesirable voltages or currents.
- 166. Nonsynchronized (as used in a data transmission system)
  - a. A type of code format that does not use timing as the basis for bit separation.
- 167. Non-Vital
  - a. Not affecting the safety of train operations.
- 168. Normal Direction (of Traffic)
  - a. For a given track, the direction in which all regularly scheduled revenue service operations are conducted. For a terminal station and its associated terminal crossover, when the crossover is on the "revenue service" end of the terminal station, the normal direction of traffic on a given platform track shall be the same as the normal direction of traffic on the same track on the opposite end of the terminal crossover. For pocket tracks, the normal direction of traffic shall be in the outbound direction.
- 169. Normal Position (of a track switch or derail)
  - a. The position arbitrarily defined by the track plans and control circuits as being the "normal" alignment. The "Normal Position" for a derail is the derailing position. See "Reverse Position."
- 170. Normal Route
  - a. See "Route, Normal."
- 171. Normal Running
  - a. See "Running, Normal."
- 172. Off-Normal Operation
  - a. Operation at other than the normal schedule.
- 173. Operator
  - a. See "Train Operator."
- 174. Overcurrent Protection
  - a. A form of protection that operates when electrical current exceeds a predetermined value.
- 175. Overspeed Control
  - a. The portion of the carborne ATP equipment which enforces speed limits.
- 176. Parallel Format
  - a. A data format in which a group of data bits are input or output simultaneously. (See also, "Serial Format")
- 177. Performance Level (PL)
  - a. A designation for one of four relative levels of operating speeds

- between successive stations or Fly-by Transmitter control points, where:
- 1) PL1 = MAXIMUM Level; to achieve minimum attainable run time between stations (or control points);
  - 2) PL2 = NORMAL Level; to achieve normal scheduled run time between stations (approximately 10% slower than PL1);
  - 3) PL3 = REDUCED Level; to proceed approximately 10% slower than normal, i.e., 10% slower than PL2;
  - 4) PL4 = RETARDED Level; to proceed approximately 20% slower than normal, i.e., 20% slower than PL2.
- b. The desired Performance Level is implemented by the transmission of a locally predetermined maximum ATS speed limit to the train at each station and fly-by transmitter. PL1 (the MAXIMUM Level) is implemented by transmitting a Maximum Authorized Speed (MAS) ATS speed limit command to the trains, which permits the fastest achievable operating time between the applicable stations. A locally predetermined set of lower ATS speed limits for each consecutive station pair is used to implement the PL2, PL3, and PL4 levels of performance, all under control of the OCC. A second set of Performance Levels (PL5, PL6, PL7, & PL8) incorporates the same relative speed limits, but is implemented with a lower acceleration rate.
178. Pick (or Pick-Up)
- a. A relay is said to "pick" or "pick-up" when energization of its coil(s) causes its front contacts to close.
179. Point-of-Switch
- a. The location on a track switch layout where the tips of the tapered switch-point rails touch the stock rails. See "Switch Point."
180. Portable
- a. Having all of the following characteristics:
    - 1) Weighing no more than 50 pounds;
    - 2) having a volume of no more than two cubic feet;
    - 3) having one or more handles,
    - 4) easily carried by one person of average strength and dexterity.
181. Positive Testing
- a. Testing to ensure that applicable equipment circuits, systems and subsystems are performing the tasks which they are required to perform, in the manner specified. See "Negative Testing."
182. Preconditioning
- a. The storage of a control or panel manipulation which will cause the clearing of a route, or movement of a track switch at some later time as the result of a timer operation or train movement.
183. Program Stop
- a. See "Stop, Program."
184. Propulsion Rail
- a. See "Rail, Third."
185. Propulsion Return Rail
- a. See "Rail, Negative Return."
186. Provide
- a. As used in the "Technical Provisions" section of these Specifications, the word "provide" means "complete the final design, furnish, install, test, place in service, and document, in the manner specified, and to the greatest extent possible compatible with the intent and limits of the Specifications," unless otherwise indicated.
187. Rack
- a. A free standing, shock mounted, metal support frame or enclosure for the mounting of terminal boards, power supplies, equipment modules,

- relays or other train control devices.
188. Rack, Entrance  
a. A rack equipped primarily with terminal boards for the termination of cables coming from outside the room or housing in which the rack is located.
189. Rack, Equipment  
a. A rack equipped primarily with relays, equipment modules and/or other ATC devices, other than power supplies.
190. Rack, Power  
a. A rack equipped primarily with ATC Power Supply units.
191. Rail (Track)  
a. A rolled steel shape, commonly a T-section, designed to be laid and fastened end-to-end in two parallel lines on cross ties or other suitable supports to form a track for railway rolling stock. See "Rail, Running."
192. Rail, Closure  
a. Either of the two rails of a turnout which connect the frog to the heels of the two switch point rails.
193. Rail, Contact  
a. See "Rail, Third."
194. Rail, Guard  
a. See "Guard Rail."
195. Rail, Negative Return  
a. A running rail used also for the return of electrical propulsion energy to a substation. Also known as a Propulsion Return Rail.
196. Rail, Propulsion  
a. See "Rail, Third."
197. Rail, Propulsion Return  
a. See "Rail, Negative Return."
198. Rail, Restraining  
a. See "Restraining Rail."
199. Rail, Running  
a. One of the two rails of a track which carry and guide the wheels of the rolling stock.
200. Rail, Signal  
a. A running rail which carries low voltage electrical signals used for the detection, and possibly the control, of rolling stock carried thereon.
201. Rail, Stock  
a. Either of the two continuous outside running rails of a turnout, against which the switch point rails bear.
202. Rail, Third  
a. A non-running rail, fastened parallel to, and outside of the running rails of a track, but isolated electrically from the running rails, and used to carry high-voltage electrical energy to be used for the propulsion of certain rolling stock on the track. Also known as the Propulsion Rail or Contact Rail.
203. Rails, Adjacent, Non-Sequential  
a. Running rails of separate tracks located in close proximity to each other, as at the end of a crossing frog.
204. Rate Coding  
a. A method of applying intelligence to a carrier by means of On/Off modulation at fixed sub-audio frequencies.
205. Reaction Time  
a. For automatic control:  
1) Time from the occurrence of a step change of control command or request to the first attainment of the new steady-state value of

- the controlled variable, within a designated accuracy.
  - b. For human control:
    - 1) The interval between the beginning of a stimulus and the beginning of the response of an observer.
- 206. Redundancy
  - a. The existence in a system of more than one means of accomplishing a given function, for purpose of increasing security or reliability.
- 207. Relay (noun)
  - a. An electrically-controlled, electromagnetically-operated switching device for controlling electrical circuits.
- 208. Reliability
  - a. The probability of performing a specified function, without failure and within design parameters, for the period of time intended under actual operating conditions.
- 209. Remote Terminal Unit (RTU)
  - a. A modem installed at each ATC field control location (usually at passenger station TCRs) to act as the interface unit between the Data Transmission System (DTS) and the local ATC and support system functions.
- 210. Request (noun)
  - a. As used with respect to DTS messages from Central Control to wayside Train Control Rooms
    - 1) An electronic signal indicating a desire to start, stop, cancel, change or continue some ATC or support system function. See
    - 2) "Command"
    - 3) "Control."
- 211. Rescheduling
  - a. The development of a new schedule based on a corrective strategy.
- 212. Restraining Rail
  - a. A special type of guard rail fastened in close proximity to the gauge side of the inside running rail on sharp curves. The purpose of the restraining rail is to bear upon the back of the transit vehicle wheels on the inner running rail in order to prevent undue pressure and head wear on the inside (gauge side) of the outer running rail of the curve. See "Guard Rail."
- 213. Revenue Service
  - a. The transportation of passengers who have paid a fare.
- 214. Revenue System
  - a. The portion of the METRO System on which revenue service is conducted.
- 215. Reverse Direction (of Traffic)
  - a. The direction opposite to the normal direction of traffic on a given track.
- 216. Reverse Position (of a track switch or derail)
  - a. The position opposite to the position arbitrarily defined by the track plans and control circuits as being the "normal" alignment. The "Reverse Position" for a derail is the non-derailing position. See also, "Normal Position."
- 217. Reverse Running
  - a. See "Running, Reverse."
- 218. Reverse Terminal
  - a. A temporary terminal located at the inbound end of a "Line" segment. See "Terminal."
- 219. Revised Schedule
  - a. A new schedule generated and/or selected as described under Strategy Selection and Rescheduling.

- 220. Right-Hand Running
  - a. See "Running, Normal"
- 221. Right-of-Way
  - a. The land or structure surface occupied by the METRORAIL transit system, especially for its main line. Also, the land or structure surface used by another transportation facility such as a railroad or highway.
  - b. The right of traffic on a given route to take precedence.
- 222. Right-of-Way, Track
  - a. An area encompassing the track ties and rails and extending two feet beyond each end of each crosstie.
- 223. Right-of-Way Hazard
  - a. An abnormal condition on or near the tracks which could impair safe train movement.
- 224. Route
  - a. A block or specified succession of contiguous blocks in a given direction over which trains operate between two controlled signals.
  - b. A continuous track path in a given direction from one controlled signal to another.
  - c. A designation, e.g., "E" Route or "Greenbelt" Route, for a specific, contiguous geographical segment of the METRORAIL System. See also, "Line."
- 225. Route, Conflicting
  - a. One of two or more routes (converging, crossing, or opposing), within an interlocking, or between two consecutive interlockings, which cannot be safely traversed at the same time, i.e., one of two or more routes that are mutually exclusive. See also, "Route, Parallel".
- 226. Route, Converging
  - a. One route of two or more routes (through an interlocking) having different originating (entrance) points, but coming together in the same direction to share the same destination (exit) point.
  - b. A route over one or more trailing-point switches, having an exit point in common with one or more other routes originating at other entrance points. See also, "Route, Diverging."
- 227. Route, Diverging
  - a. One of two or more routes (through an interlocking) from a common entrance point, passing over one or more facing-point switches, and having an exit point different than another route from that same entrance point. See also, "Route, Converging."
  - b. A route differing from the arbitrarily defined NORMAL or "through" route, i.e., a route in which at least one facing-point switch is lined in its "REVERSE" position. This is usually a route departing from the tangent alignment of the switch (or switches). See also, "Route, Through" and "Route, Converging."
- 228. Route, Following
  - a. A route for movement of a successive train in the same direction into a given track block as allowed by the immediately preceding route into that track block.
- 229. Route, Interlocked
  - a. A route within interlocking limits, i.e., a route (over special trackwork) which is protected by a fail-safe system of controls and controlled signals interlocked in such a manner that all conflicting or potentially conflicting routes must first be prevented. (See also, "Routes, Conflicting").
- 230. Route, Normal

- a. With regard to traffic direction, a route established in the normal direction of train travel, i.e., a route which results in normal running.
  - b. A route (through an interlocking) in which all switches are lined in their defined "NORMAL" position.
231. Route, Opposing
- a. A route which has as its destination or exit point a signal which serves as the entrance point for another route (over the same track) in the opposite direction.
232. Route, Parallel
- a. One of two or more routes within an interlocking which can be safely traversed at the same time, i.e., one of two or more routes that are not mutually exclusive. See also, "Conflicting Route".
233. Route, Reverse
- a. With regard to traffic direction, a route in which trains run opposite to the normal direction of train travel, i.e., a route which results in reverse running.
234. Route, Through
- a. The most commonly used or "main" route through a track switch, usually the tangent (straight) alignment. Also usually the route through the NORMAL setting of the switch. See also, "Route, Diverging."
235. Route Designation
- a. The input to a train supervision device reflecting a desired routing by means of a two-digit destination code.
236. Route Locking
- a. See "Locking, Route."
237. Route Request
- a. A non-vital electrical or electronic message ("command") from Central or a local Interlocking Control Panel to a wayside interlocking operational control point, requesting the establishment of a desired interlocking route.
238. Route Segment
- a. A defined portion of route consisting of contiguous ATC blocks.
239. Routes, Conflicting
- a. Two or more routes, opposing, converging, or intersecting, over which movements cannot be made simultaneously without possibility of collision. See also, "Routes, Parallel."
240. Routes, Parallel
- a. Two or more routes (through an interlocking) over which movements can be made simultaneously without possibility of collision. See also, "Routes, Conflicting."
241. Running, Normal
- a. Train movement forward on the right hand track, which is in the normal direction of traffic. Right-hand running.
242. Running, Reverse
- a. Train movement forward on the left hand track, which is opposed to the normal direction of traffic. Left-hand running.
243. Running Rail
- a. See "Rail, Running."
244. Safety Speed Limit
- a. See "Speed Limit, Safety."
245. Scan Sheets
- a. Sheets listing the successive "control" and "status" (indication) data points required for a given Remote Terminal Unit.
246. Schedule

- a. A set of data providing the time/location information for all trains to be operated in a feasible manner on a system or in a specified area of a system, over a fixed period of time such as a 24-hour day or portion thereof.
- 247. Schedule Control
  - a. Traffic regulation, corrective strategy selection and rescheduling performed by the ATS system.
- 248. Schedule Error
  - a. The difference between actual time and current schedule time for a given event (e.g., the arrival of a train at a station).
- 249. Schedule Tolerance
  - a. Maximum permissible schedule error; for each schedule, direction, location and time, a different schedule tolerance may exist.
- 250. Sectional Release:
  - a. Route Locking
    - 1) The release of route locking in sections behind a train as the train proceeds past the clearance point(s) of one or more diverging switches through an interlocking. This is for the purpose of expediting the establishment of subsequent routes through the interlocking.
  - b. Switch Control
    - 1) The release of switch locking in sections behind a train as it first occupies, then vacates, detector tracks for one or more diverging switches as it proceeds through an interlocked route.
- 251. Security Bit
  - a. A bit inserted in a message to permit a validity check of that message after it is decoded.
- 252. Serial Format
  - a. A data format in which the data bits are input or output one at a time in sequence. (See also, "Parallel Format".)
- 253. Service Brake
  - a. The primary train brake system which is used to control train deceleration under normal operating conditions.
- 254. Sign (noun)
  - a. A wayside appliance which conveys information concerning train operation or location.
- 255. Sign, Advance Warning (AWS)
  - a. A sign which, when illuminated, warns a train operator of some possible hazardous condition ahead.
- 256. Sign, Station Stop (SS)
  - a. A sign which denotes the start of the ATO approach limits to a passenger station.
- 257. Sign, Turnback (TB)
  - a. A sign which denotes the limit of an Automatic Turnback block, and the location of an imaginary Turnback Signal.
- 258. Signal (noun)
  - a. A wayside appliance which uses colored light aspects to convey information governing train movement. See "Signal Aspect."
- 259. Signal, Cab
  - a. A signal located in the operating cab of the transit car or locomotive.
- 260. Signal, Clear
  - a. A wayside signal displaying an aspect for an indication which permits movement of the train past the signal.
  - b. A cab signal displaying an aspect (speed limit) which permits forward motion of the train.

261. Signal, Controlled
- a. A wayside signal capable of displaying either a stop aspect or an aspect indicating that train movement is permissible, the aspect displayed being determined by fail-safe control circuitry.
262. Signal, Home
- a. A controlled signal located at the entrance to one or more interlocked routes to govern trains entering and using that route or those routes.
263. Signal, Marker
- a. A wayside signal capable of displaying only a stop aspect and used to mark end-of-track locations.
264. Signal, Turnback
- a. A simulated, controlled wayside signal located at a turnback point and used, when approached in its "non-cleared" state, to initiate automatic turnback operation through an interlocking. The location of the turnback point, i.e., the location of the simulated wayside signal, is indicated in the field by a Turnback Sign.
265. Signal, Wayside
- a. A signal located beside the track.
266. Signal Aspect
- a. The appearance of the illuminated lens(es) of a wayside signal conveying an indication, as viewed from the direction of an approaching train.
  - b. The appearance of a cab signal conveying an indication (speed limit) as viewed by an observer.
267. Signal Aspect Name
- a. The specific, unique term used to identify a particular wayside signal aspect; often used as an abbreviation for the indication conveyed by that signal aspect, e.g., "Diverging Clear."
268. Signal Indication
- a. The specific "operating instruction" information conveyed by the aspect of a signal.
269. Signal Rail
- a. See "Rail, Signal."
270. Signals, Back-to-Back
- a. A pair of controlled wayside signals mounted to face in opposite directions along the track, at a track circuit boundary and used to control train movements in both directions across that track circuit boundary.
  - b. Two controlled wayside signals physically mounted back-to-back, i.e., facing in opposite directions between two adjacent tracks, with one signal governing train movements in one direction on one track and the other governing train movements in the opposite direction on the adjacent track.
271. Skip-Stop
- a. The operating procedure or command which causes a train to pass a scheduled station-stop platform intentionally, without stopping.
272. Slide, Wheel
- a. An extreme wheel slip condition wherein the wheel has zero rotational speed and slip speed equals train speed.
273. Slip, Wheel
- a. The condition in which there is a difference between train speed and the surface speed of wheel tread at the rail, usually transient and sporadic.
274. Speed, Balancing
- a. The steady-state speed attained by the carborne traction system when resisting forces are exactly equal to applied forces.

275. Speed Limit, ATC  
a. The upper limit of safe train speed as enforced by the ATP subsystem.
276. Speed Limit, ATO  
a. The upper limit of train speed as enforced by the ATO Subsystem.
277. Speed Limit, Civil  
a. For a given section of track, the maximum speed allowed as determined by the physical characteristics of the track structure and limited to ensure the comfort of passengers on trains and on station platforms.
278. Speed Limit, Safety  
a. The maximum speed at which a train can safely negotiate a given section of track. The safety speed limit is set to minimize potential passenger injury.
279. Speed Sensor  
a. A device which produces an output signal whose frequency is proportional to axle angular velocity.
280. Speed Zone  
a. A section of track which has the same civil speed limit throughout its length. For a given direction of traffic, a more restrictive speed zone is one which has a lower civil speed limit than the preceding adjacent speed zone; a more permissive speed zone is one which has a higher civil speed limit than the preceding adjacent speed zone.
281. Static Testing  
a. All level A, B, C, D and E testing which can be completed without using an electrically energized train.
282. Stock Rail  
a. See "Rail, Stock."
283. Stop, Absolute  
a. A train stop which permits no exceptions such as reduced speed running, movement within restricting limits, or similar alternatives.
284. Stop, Emergency  
a. The stopping of a train by an emergency brake application. Once initiated, the brake application cannot be released until the train has stopped.
285. Stop, Program  
a. The stopping of a train at a station platform under closed-loop braking in accordance with a speed-distance profile which will cause the train to stop at a predetermined point.
286. Strategy Selection and Rescheduling  
a. A set of actions initiated by Central Control designed to compensate for major disturbances to METRO operation. These actions include altering the current schedule, skipping stations, changing routes, and changing the number of trains in revenue service.
287. Subsystem  
a. A subsystem comprises elements within a system which are interconnected to perform a specific function.
288. Subway  
a. That portion of the WMATA-METRORAIL system which is constructed beneath the ground surface.
289. Superelevation  
a. The increased elevation of the outer rail (above the inner rail) of a track on a curve to counteract overturning force. The actual superelevation (Ea) is measured in inches.
290. Superelevation, Unbalanced (Eu)  
a. For a given gauge, radius of curvature, and speed and configuration of rolling stock; the difference between the superelevation required to

- exactly balance the overturning force and the actual superelevation ( $E_a$ ) installed.
291. Switch (Electric)  
a. A device by means of which an electric circuit may be opened or closed.
292. Switch (Track)  
a. A pair of switch points with their fastenings and operating rods providing the means for establishing a route from one track to another. See also, "Turnout."
293. Switch-and-Lock Movement  
a. A device which performs the three functions of unlocking, operating (moving), and locking a derail mechanism or the points of a track switch.
294. Switch Correspondence  
a. Agreement between the called-for alignment of a switch and the actual alignment of that switch.
295. Switch Machine  
a. A general term for a mechanism used to control the movement of a derail mechanism or the points of a track switch.
296. Switch Point  
a. A moveable, tapered running rail, the point of which is designed to fit against one of the stock rails of a switch, and the heel of which is connected to one of the closure rails of the turnout.
297. Switch Position, Normal  
a. See "Normal Position."
298. Switch Position, Reverse  
a. See "Reverse Position."
299. Switch Test Key  
a. A device (twist button or toggle switch) which controls the operation of a turnout (or crossover) without calling for a route over that turnout. If a route over that turnout has already been called and locked, the Switch Test Key shall not be able to control the turnout until the route is unlocked and the Test Key has been restored to correspondence with the track switch position.
300. System  
a. When used alone as a proper noun shall refer to the WMATA Rail Rapid Transit System. When "system" is used alone as a common noun, it shall refer to the specific assemblage of equipment and circuitry under discussion.
301. Tail Track  
a. The portion of a mainline or storage track from a bumping post or other end-of-track location to the first interlocking special trackwork location encountered by that track.
302. Technician, Train Control  
a. An employee whose function is to maintain and repair Automatic Train Control equipment and to perform certain emergency manual operations as required.
303. Terminal  
a. A METRORAIL station and its associated turnback interlocking which is designated as the terminus of a route in the Regional METRORAIL System. Usually located at the outbound end of a "Line." See also "Reverse Terminal".  
b. A device to which electrical conductors may be connected conveniently.
304. Terminal, Temporary  
a. A station and its associated turnback interlocking which is not located at the planned permanent terminus of a route in the Regional METRORAIL System, but which is used as a terminal temporarily until the route can

- be completed.
305. Terminate
- a. To fasten or attach to one or more electrical terminals in a prescribed manner. As used in these Specifications, the term does not necessarily imply stub ending, i.e., a circuit which is "terminated" in a certain location does not necessarily end at that location; more than one wire may terminate on a given terminal.
306. Terminating Receiver
- a. A device for receiving and decoding train detection frequency signal(s) directly from the running rails and driving appropriate track relays. This "receiver" shall be tuned in such a manner that the applicable train detection frequency signal(s) will not be permitted to propagate beyond the point in the track at which the receiver is connected to the track.
307. Time, Door Open
- a. The elapsed time from the instant the train doors are fully open until they are requested to close.
308. Time, Down
- a. The elapsed time during which equipment is not capable of doing useful work because of misadjustment, malfunction, or maintenance in progress.
309. Time, Dwell
- a. The elapsed time from the instant a train stops at a Station Platform until the train begins to move away from that Station Platform.
310. Time, Reaction
- a. See "Reaction Time."
311. Time, Warm-up
- a. The elapsed time from application of power to an operable device until it is capable of performing its intended function.
312. Time Constant
- a. Time interval from the beginning of change of a controlled variable, in response to a step forcing function, to the attainment of a stated value.
313. Time Division Multiplexing (TDM)
- a. The process of transmitting two or more signals over a common path by using different time intervals for different signals.
314. Timetable
- a. A tabulation of the times that trains are expected to arrive at, or depart from certain locations based upon a feasible operating schedule, with time measured by the master clock. The time location information for passenger stations is the same as is found in the schedule to which the timetable is related.
315. Track
- a. An assembly of two running rails and the associated material used to fasten them in parallel a fixed distance apart, for the purpose of supporting the movement of trains of transit cars, locomotives and various work equipment.
316. Track, Main (or Mainline)
- a. A track which is normally under the control of the Automatic Train Control System.
317. Track Circuit, Audio Frequency (AF Track Circuit)
- a. A track circuit designed to be energized by alternating current in the Audio Frequency range.
318. Track Circuit, Power Frequency (60 Hz)
- a. A track circuit designed to be energized by 60 Hz alternating current.
319. Track Circuit, Vital

- a. A normally energized arrangement of electrical and/or electronic equipment and conductors which include defined lengths of the track running rails, and which permits detection of trains and broken rails within the defined limits of the running rails. See also "Circuit, Track."
- 320. Track Transformer
  - a. A transformer designed to couple signal energy to or from the rails of a track circuit.
- 321. Traction Power System (TPS), or Traction Supply System
  - a. The electrical system which supplies and distributes propulsion power.
- 322. Traction System
  - a. The system of wheels, motors, driving mechanism, brakes, direct controls and appurtenances which propel or brake a married pair of transit cars in response to input commands or requests from the train control system.
- 323. Tractive Effort, Negative
  - a. Retarding force developed by the train braking system.
- 324. Tractive Effort, Positive
  - a. Propelling force developed by the train propulsion system.
- 325. Traffic
  - a. Having to do with the direction of train operations over a segment of track between consecutive interlockings and/or sets of signals. See "Traffic, Normal" and "Traffic, Reverse."
- 326. Traffic Circuit
  - a. See "Circuit, Traffic."
- 327. Traffic, Normal
  - a. See "Normal Direction (of Traffic)."
- 328. Traffic, Reverse
  - a. See "Reverse Direction (of Traffic)."
- 329. Traffic Regulation
  - a. The use of changes in dwell time, performance level, and acceleration rate to return a train to its schedule.
- 330. Regulation Program
  - a. An ATS program to correct or stabilize schedule error within the schedule tolerance.
- 331. Train
  - a. A locomotive with or without cars, a single transit car, or a single married pair or multiple married pairs (of transit cars) coupled together to form a single unit, which shall be suitably identified.
- 332. Train, Non-Revenue
  - a. Any train in test, maintenance, emergency or inspection service, which may not be used by the public.
- 333. Train, Revenue
  - a. Any train in transit service on main tracks, which may be used by the public. See "Revenue Service."
- 334. Train Control
  - a. A general term indicating equipment, circuitry, material or documentation related to the controlled operation and routing of the transit vehicles.
- 335. Train Control Equipment Room (TCER)
  - a. A room housing wayside Train control equipment, but no Remote Terminal Unit. A "satellite" Train Control Room located and used primarily to house train control power equipment and AF track modules due to operational distance restrictions imposed by track circuit signal attenuation and voltage drop considerations. See Train Control Room (TCR).

- 336. Train Control Room (TCR)
  - a. A room located in a passenger station or at some other strategic point to house wayside ATC equipment including a Remote Terminal Unit. A major wayside control point for the ATC System.
- 337. Train Detection Equipment
  - a. The track circuits and associated equipment used to detect the presence of trains.
- 338. Train Identity (ID)
  - a. The code assigned to each train which contains the train destination, train number, and train length.
- 339. Train Operator
  - a. An Authority employee aboard the controlling cab of a train in service whose principal duties are to oversee safety and to execute non-automatic operation
- 340. Train Shunt Impedance
  - a. The interrail impedance affected by a train.
- 341. Train-to-Wayside Communications (TWC) System
  - a. A non-vital, bi-directional, digital data communications system for communication, at fixed points, between the trains and wayside.
- 342. Turnback Block
  - a. A contiguous section of track, defined at one end by an interlocking home signal and at the other end by a turnback sign, within which the direction of running of a train leaving the interlocking can be reversed while the track is occupied by that train when the associated turnback signal has not been cleared.
- 343. Turnback Point
  - a. That point along a mainline track, at least maximum train length downstream from the exit point from the Turnback interlocking limits, which will not be passed by a train which is to reverse direction at that interlocking. Required turnback points are indicated by appropriate symbols on the Contract Drawings. Turnback points are always located at a track circuit boundary and shall be identified by a wayside Turnback (TB) sign.
- 344. Turnback Signal
  - a. See "Signal, Turnback."
- 345. Turnout
  - a. An arrangement of a switch and a frog with closure rails by means of which rolling stock may be diverted from one track to another.
- 346. Unsafe Condition
  - a. Any condition which endangers human life or property.
- 347. Universal Crossover
  - a. See "Crossover, Universal."
- 348. Upstream
  - a. Relative to a specified reference point and for a given direction of travel, the area which will have been passed prior to reaching the specified reference point. Used in the same sense as the AAR/AREMA term "in approach of." See also, "Downstream.
- 349. Vital
  - a. Affecting the safety of train operations.
- 350. Wayside (adjective)
  - a. Having to do with, or located along, the trackwork right-of-way.

**PART 2 - PRODUCTS**  
NOT USED

**PART 3 - EXECUTION**

NOT USED

**END OF SECTION**

## SECTION 16902

### ATC ABBREVIATIONS

#### PART 1- GENERAL

##### 1.01 SECTION INCLUDES

- A. Part 1.03 (ATC ABBREVIATION LIST) of this Section lists abbreviations for various organizations and ATC terms and prescribes the meanings for the abbreviations as used in the ATC Specifications. For further definition of the terms abbreviated, see Section 16901, Definition of ATC Terms.
- B. Subsequent sub-sections list Vital and Non-Vital Relay Nomenclature used in the current WMATA ATC System, as follows:
  - 1. Vital ATC Relay Nomenclature
  - 2. Non-Vital ATC Relay Nomenclature
  - 3. Non-Vital Heavy-Duty Interfacing Relay Nomenclature
  - 4. Non-Vital General Purpose Interfacing Relay Nomenclature
- C. The Contractor shall not deviate from this nomenclature without the prior written approval of the designated Resident Engineer (Engineer).

##### 1.02 RELATED SECTIONS

- A. All Sections in the 16900 series.

##### 1.03 ATC ABBREVIATION LIST

<u>Abbreviation</u>	<u>Meaning</u>
A	Amber or Approach or Arrival or Ampere, (suffix) First Alternate
AAI	AAI Transportation Systems Division of AAI Corporation 300 Clubhouse Road P.O. Box 857 Hunt Valley, MD 21030-0857
AAR	Association of American Railroads 50 F Street, N.W. Washington, DC 20001
AC	Alternating Current
ACI	Automatic Car Identification
AEG	Active Element Group
AF	Audio Frequency
AFF	Above Finished Floor
AHD	Ahead

<u>Abbreviation</u>	<u>Meaning</u>
AIIM	Association for Information and Image Management 1100 Wayne Ave., Silver Spring, MD 2091
Amp	Ampere
ANSI	American National Standards Institute, Inc. 1430 Broadway New York, NY 10018
APTA	American Public Transit Association 1201 New York Ave., N.W. Washington, DC 20005
A.R.E.A.	American Railway Engineering Association (Obsolete; See "AREMA")
AREMA	American Railway Engineering and Maintenance-of-Way Association 8201 Corporate Dr., Ste. 1125 Landover, MD 20785-2230
ASQC	American Society for Quality Control 230 W. Wells Street Milwaukee, WI 53203
ASTM	American Society for Testing and Materials 1916 Race St. Philadelphia, PA 19103
ATC	Automatic Train Control
ATO	Automatic Train Operation
ATP	Automatic Train Protection
ATS	Automatic Train Supervision
ATU	Auxiliary Terminal Unit
AWG	American Wire Gauge
AWS	Advance Warning Sign, or; American Welding Society 550 N.W. LeJeune Road, P.O Box 351040 Miami, FL 33135
B	Back or (suffix) Second Alternate
BCD	Binary Coded Decimal

<u>Abbreviation</u>	<u>Meaning</u>
BK	Back
BP	Bumping Post or Bypass or Back Repeater
BR	Terminating Receiver
C	Centigrade (Celcius), or Check, or Central, or Case, or Correspondence, or Curve, or Control
CAU	Computerized Analyzer Unit
CB-CL	Crossbond Conduit Line
C.C.	Curve to Curve
CCW	Counter Clockwise
CD-ROM	Compact Disk - Read-Only Memory
CHK	Check
CHP	Chilled Water Plant
CIA	Communications Interface Assembly
CIOC	Communications Input/Output Channel
Ckt	Circuit
cm	Centimeter
CMOS	Complementary Metal Oxide Semiconductor
COMM	Communications or Communications Equipment Room
CRT	Cathode Ray Tube
C.S.	Curve to Spiral
C.S.A.	Canadian Standards Association
CSS	Covered Surface Structure
CSXT	CSX Transportation (Railroad)
CTS	Carrier Transmission System
CW	Clockwise

<u>Abbreviation</u>	<u>Meaning</u>
CWR	Continuous Welded Rail
DC	Direct Current
DEJ	WMATA IDW/Railroad Derailment/Dragging Equipment Interface Junction Box
DJ	Distribution Junction Box
DIO	Direct Input/Output
DL	Double Line
DOS	Disk Operating System
DPS	Drainage Pumping Station or Design Profile Speed
DR	Dispatch Receiver
DTS	Data Transmission System
E	Light, or East, or End, or Superelevation, or Equivalent, or Emergency
E <sub>a</sub> (E sub a)	Actual Superelevation (in inches)
E <sub>u</sub> (E sub u)	Unbalanced Superelevation (in inches)
E-CTFE	Ethylene-Chlorotrifluoroethylene
EE	Emergency Exit
EIA	Electronic Industries Association 1722 Eye Street, N.W. Washington, DC 20006
EMI	Electromagnetic Interference
EMS	Engineer's Monitoring System
ENTS	WMATA Office of Engineering and Technical Support
E.O.C.	End of Contract
E.O.L.	End of Loop
EOP	End of Platform

<u>Abbreviation</u>	<u>Meaning</u>
E.O.T.	End of Track
EPROM	Erasable Programmable Read-Only Memory
ES	East Stick
ETFE	Ethylene-Tetrafluoroethylene
ETLT	Equal To or Less Than
ETS	Emergency Trip Station
F	Fahrenheit, or Traffic, or Flashing, or Field, or Failure, or Fan
F&I	Fire and Intrusion
FIFO	First-in First-out
FA	Fire Alarm
Fig	Figure
FL	Flasher or Flashing or Fleeting
FOIS	Fiber Optic Interface System (A type of WCS)
FR	Flyby Receiver
FRA	Federal Railroad Administration (Part of U.S. Government – Dept. of Transportation) 400 7th Street, S.W. Room 8206 Washington, DC 20590
F.R.E.	Fiberglass Reinforced Epoxy
FS	Fan Shaft
FSK	Frequency Shift Keyed
ft	Foot, Feet
FT	Flyby Transmitter
FTA	Federal Transit Administration (Part of U.S. Government - Dept. of Transportation; formerly, Urban Mass Transportation Administration) 400 7th Street, S.W. Room 9400 Washington, DC 20590

<u>Abbreviation</u>	<u>Meaning</u>
FTP	Factory Test Procedure
FUT	Future
FUTU	Future (on RTU Scan Sheets)
G	Signal or Guard
G.R.S.	Galvanized Rigid Steel
GRS	ALSTOM Signaling Inc. (Formerly; General Railway Signal Company) P.O. Box 20600 Rochester, NY 14602-0600
GTET	Greater Than or Equal To
I	Interface or Interlocking or Insulated
I.B.	Inbound
ICEA	Insulated Cable Engineers Association 155 East 44th Street New York, NY 10017
I.C.P.	Interlocking Control Panel
ID	Train Identity
IDW	Intrusion Detection Warning
IEEE	Institute of Electrical and Electronics Engineers, Inc. 345 East 47th Street New York, NY 10017
IF	Interface
IFC	Interface Case
IFJ	Interface Junction Box
IJ	Insulated Joint, or Interlocking Junction Box
in	Inch, or Inches
IVP	Interlocking Vital Processor
J	Junction Box, or Jet
JB	Junction Box

<u>Abbreviation</u>	<u>Meaning</u>
JF	Jet Fan
JFC	Jet Fan Control (room, case, or housing)
K	Indication, or Thousand
kcmil	Thousand Circular Mils
L	Loop, or length, or light, or left
LCC	Local Console Controller
LCD	Liquid Crystal Display
LED	Light Emitting Diode
L.H.	Left Hand
LJ	Loop Junction Box
LNJ	Line Junction Box
LMC	Local Manual Control
LSTS	LS Transit Systems, Inc. (Obsolete; now SYSTRA) 2 Whipple Place, Suite 302 Lebanon, NH 03766-1356
LTET	Less Than or Equal To
LW	Lunar White
M	Marker Coil or Maintainer or Manual
mA	Milliampere
MAL	Malfunction
MAS	Maximum Authorized Speed, or Maximum Allowable Speed
max	Maximum
MDF	Main Distribution Frame
MDS	Maintainer's Diagnostic System
METRO	Washington Metropolitan Area Transit Authority See "WMATA"

<u>Abbreviation</u>	<u>Meaning</u>
mg	Milligram
min	Minimum or minute
MIS	Management Information System
MJ	Marker Junction Box
mm	Millimeter
MOV	Metal Oxide Varistor
MTBF	Mean Time Between Failure
MTTR	Mean Time to Restore
N	Normal or North or Negative or Next
NBD	Normal Braking Distance
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association 2101 L St., N.W., Suite 300 Washington, DC 20037
N.I.C.	Not Included in (this) Contract
N.I.S.T.	National Institute of Standards and Technology (Part of U.S. Government Department of Commerce; formerly, National Bureau of Standards) Gaithersburg, MD 20899
NMA	National Micrographics Association (VOID) See "AIIM"
N/mm <sup>2</sup>	Megapascal (Newtons per millimeter squared)
NS	North Stick
NTP	Notice to Proceed
N.T.S.	Not to Scale
NV	Non-Vital
NVIP	Non-Vital Interlocking Processor
O	Overload, or Operating, or Overlap, or On
O.B.	Outbound

<u>Abbreviation</u>	<u>Meaning</u>
OCC	(WMATA) Operations Control Center (Central) (Located in the Jackson Graham Building)
OFS	Order For Services
ORD	Operational Readiness Date
P	Repeater, or Processor, or Panel, or Platform, Or Position
PAU	Portable Analyzer Unit (See CAU)
PB	Pushbutton
PC	Printed Circuit
P.I.T.O.	Point of Intersection (of centerlines) of a Turnout
PL	Panel Lighting or Performance Level
P.O.C.	Point on Curve
P.O.T.	Point on Tangent
PROM	Programmable Read-Only Memory
PS	Point of Switch
PSS	Program Station Stop
PVC	Polyvinyl chloride
P.V.C.	Point of Vertical Curve (Begin Vertical Curve)
P.V.I.	Point of Vertical Intersection (of profile tangents)
P.V.T.	Point of Vertical Tangent (End Vertical Curve)
Q	Request, or Quality Factor
R	Radius, or Red, or Reverse, or Receive, or Right, or Route, or Retract, or Retracted, or Restriction, or Rail, or Restraining, or Resistance, or Remote, or, as a suffix, Vital Relay
RAFTS	Rail Audio Frequency Test Set
RAP	Rail Administrative Procedure (WMATA)
RCVR	Receiver

<u>Abbreviation</u>	<u>Meaning</u>
R.E.	Resident Engineer (WMATA)
R.H.	Right Hand, or Relative Humidity
rms	Root Mean Square
ROD	Revenue Operations Date
RTU	Remote Terminal Unit
R.W.	Retaining Wall
S	Stick, or South, or Station Stop, or Start, or Storage, or System, or Spiral, or Sign
SAS	Supervisory Alarm System
S&I	Service and Inspection (Yard)
SBD	Safe Braking Distance
S.C.	Spiral to Curve
SCI	Substantial Completion Inspection
S.C.&I.	Special Control & Indication (cable)
SEJ	Sewage Ejector
Sig	Signal
SM	Snowmelter
SMF	Snowmelter Failure
SOP	Standard Operating Procedure (WMATA)
SP	Sump Pump
SS	Substation or Station Stop or South Stick
SSR	Substation Return
SSR-CL	Substation Return Conduit Line
S.T.	Spiral to Tangent
STA	Station or Stationing
STAP	Station Processor

<u>Abbreviation</u>	<u>Meaning</u>
SYPM	(Obsolete) Formerly: WMATA Systems Program Management (Part of Department of Design and Construction) Replaced by: SYSP (Part of Department of Transit System Development)
SZJ	(IDW) Sub-Zone Junction Box
T	Track, or Time, or Transmit, or Tunnel, or Tangent
TAILS	Train Arrival Indication Light System
TAWL	Train Approach Warning Light
TB	Turnback, or Tie Breaker
TBS	Tie Breaker Station
TC	Train Control
TCER	Train Control Equipment Room
TCR	Train Control Room
TD	True Distance
TE	Time Element
TJ	Track Junction Box
TK	Track
TM	Track Module
TPS	Traction Power Substation
TRK	Track
TRN	Train
T.S.	Tangent to Spiral
TWC	Train-to-Wayside Communications
TYP	Typical
UE	Unauthorized Entrance
UG	Underground
UL	Underwriters Laboratories

<u>Abbreviation</u>	<u>Meaning</u>
US&S	Union Switch & Signal, Inc. 1000 Technology Drive P.O. Box 420 Pittsburgh, PA 15219-3120
V	Volt(s), or Vital, or Velocity
V <sub>c</sub> (V sub c)	Civil Speed Limit
V <sub>s</sub> (V sub s)	Safety Speed Limit
VAC, Vac	Volts Alternating Current
VC	Vertical Curve (Length)
VDC, Vdc	Volts Direct Current
VP	Vital Processor
VS	Vent Shaft
VXI	VMEbus eXtensions for Instrumentation
W	Switch or West or Warning or White or Wall
WCS	Wayside Coding System (See FOIS)
WMATA	Washington Metropolitan Area Transit Authority 600 Fifth Street, N.W. Washington, DC 20001
WS	West Stick
WTP	Wayside Test Procedure
W.W.	Wing Wall
X	Transmit, or Crossing
X-O	Crossover
XFMR	Transformer
XLPE	Cross-Linked Polyethylene
XMTR	Transmitter
Y	Combination or Collector

<u>Abbreviation</u>	<u>Meaning</u>
Z	Control, or call
ZB	Impedance Bond

#### 1.04 VITAL RELAY NOMENCLATURE

- A. The nomenclature for "vital" relays in the ATC wayside equipment shall always end with the letter "R".

<u>Vital Relay Nomenclature</u>	<u>Meaning</u>
AR	APPROACH RELAY
ASR	APPROACH STICK RELAY
ASAR	APPROACH STICK 1ST MULTIPLE RELAY
ANWR	SWITCH A, NORMAL SWITCH CONTROL RELAY
ARWR	SWITCH A, REVERSE SWITCH CONTROL RELAY
ASTER	APPROACH STICK TIMER RELAY
AVPCHKR	"A" VITAL PROCESSOR CHECK RELAY
AVPOLKR	"A" VITAL PROCESSOR ON-LINE INDICATION RELAY
BNWR	SWITCH B, NORMAL SWITCH CONTROL RELAY
BPR	BYPASS RELAY (IDW OR VBS)
BRWR	SWITCH B, REVERSE SWITCH CONTROL RELAY
BVPCHKR	"B" VITAL PROCESSOR CHECK RELAY
BVPOLKR	"B" VITAL PROCESSOR ON-LINE INDICATION RELAY
CTR	CODE RATE TRANSMITTER RELAY
DETOR	DERAIL TIME OUT RELAY
EASTER	EAST APPROACH STICK TIMER RELAY
ESR	EAST STICK RELAY
EASR	EAST APPROACH STICK RELAY
FOLPR	TRAFFIC EXTENDED OVERLAP STICK STORAGE RELAY
GDR	GROUND DETECTOR RELAY
GFLR	SIGNAL FLASHING RELAY
GOR	GO RELAY
HGR	SIGNAL CLEAR RELAY
HGPR	SIGNAL CLEAR REPEATER RELAY
HGPPR	SIGNAL CLEAR 2ND REPEATER RELAY
HGPAR	SIGNAL CLEAR REPEATER 1ST MULTIPLE RELAY
HGYPR	SIGNAL CLEAR COMBINATION REPEATER RELAY
HGTYP	SIGNAL CLEAR TRACK COMBINATION REPEATER RELAY

<u>Vital Relay Nomenclature</u>	<u>Meaning</u>
IDWR	INTRUSION DETECTION WARNING RELAY
IDWPR	INTRUSION DETECTION WARNING REPEATER RELAY
IDWPAR	INTRUSION DETECTION WARNING REPEATER 1ST MULTIPLE RELAY
LR	LOCK RELAY
LSR	LOCK STICK RELAY
LTYPR	LINE TRACK COMBINATION REPEATER RELAY
LTYPPR	LINE TRACK COMBINATION 2ND REPEATER RELAY
NADR	NORMAL BLOCK CONDITION DECODE RELAY (PRIMARY - DISTANT)
NBDR	NORMAL BLOCK CONDITION DECODE RELAY (SECONDARY - DISTANT)
NAHR	NORMAL BLOCK CONDITION DECODE RELAY (PRIMARY - HOME)
NBHR	NORMAL BLOCK CONDITION DECODE RELAY (SECONDARY - HOME)
NCDYPSR	NORMAL CODE DETECT COMBINATION REPEATER STICK RELAY
NFNR	NORMAL TRAFFIC ENTRANCE RELAY
NFR	NORMAL TRAFFIC RELAY
NFPR	NORMAL TRAFFIC REPEATER RELAY
NFPAR	NORMAL TRAFFIC REPEATER 1ST MULTIPLE RELAY
NFSR	NORMAL TRAFFIC STICK RELAY
NFSPR	NORMAL TRAFFIC STICK REPEATER RELAY
NFSPAR	NORMAL TRAFFIC STICK REPEATER 1ST MULTIPLE RELAY
NFSPBR	NORMAL TRAFFIC STICK REPEATER 2ND MULTIPLE RELAY
NFXR	NORMAL TRAFFIC EXIT RELAY
NFXTEPSR	NORMAL TRAFFIC TIMER REPEATER STICK RELAY
NFXTER	NORMAL TRAFFIC TIMER RELAY
NLCSR	NORMAL LOOP CONTROL STICK RELAY
NSCZR	NORMAL STICK CHECK CONTROL RELAY
NSR	NORMAL STICK RELAY
NSPR	NORMAL STICK REPEATER RELAY
NSAR	NORMAL STICK 1ST MULTIPLE RELAY
NSBR	NORMAL STICK 2ND MULTIPLE RELAY
NSAPR	NORMAL STICK 1ST MULTIPLE REPEATER RELAY
NTVBR	NORMAL TUNNEL VENTILATION BARRIER RELAY (VBS)
NWCAR	NORMAL SWITCH CORRESPONDENCE 1ST MULTIPLE RELAY
NWCBR	NORMAL SWITCH CORRESPONDENCE 2ND MULTIPLE RELAY
NWCCR	NORMAL SWITCH CORRESPONDENCE 3RD MULTIPLE RELAY
NWCAPR	NORMAL SWITCH CORRESPONDENCE 1ST MULTIPLE REPEATER RELAY

<u>Vital Relay Nomenclature</u>	<u>Meaning</u>
NWCR	NORMAL SWITCH CORRESPONDENCE RELAY
NWPR	NORMAL SWITCH POSITION REPEATER RELAY
NWZR	NORMAL SWITCH CALL (CONTROL) RELAY
NWZPR	NORMAL SWITCH CALL (CONTROL) REPEATER RELAY
ODR	OPEN DOOR RELAY
ODYR	OPEN DOOR COMBINATION RELAY
OLR	OVERLAP RELAY
OR	(SWITCH) OVERLOAD RELAY
ORR	OVERRUN RELAY
PBSR	PUSHBUTTON STICK RELAY
PBSAR	PUSHBUTTON STICK 1ST MULTIPLE RELAY
PBSBR	PUSHBUTTON STICK 2ND MULTIPLE RELAY
PBSYPR	PUSHBUTTON STICK COMBINATION REPEATER RELAY
QR	FREQUENCY SELECT RELAY
RADR	REVERSE BLOCK CONDITION DECODE RELAY (PRIMARY - DISTANT)
RBDR	REVERSE BLOCK CONDITION DECODE RELAY (SECONDARY - DISTANT)
RAHR	REVERSE BLOCK CONDITION DECODE RELAY (PRIMARY - HOME)
RBHR	REVERSE BLOCK CONDITION DECODE RELAY (SECONDARY - HOME)
RCDR	REVERSE CODE DETECT RELAY
RCDYPSR	REVERSE CODE DETECT COMBINATION REPEATER STICK RELAY
RCR	ROUTE CHECK RELAY
RCPR	ROUTE CHECK REPEATER RELAY
RFNR	REVERSE TRAFFIC ENTRANCE RELAY
RFR	REVERSE TRAFFIC RELAY
RFPR	REVERSE TRAFFIC REPEATER RELAY
RFPAR	REVERSE TRAFFIC REPEATER 1ST MULTIPLE RELAY
RFSR	REVERSE TRAFFIC STICK RELAY
RFSPR	REVERSE TRAFFIC STICK REPEATER RELAY
RFSPAR	REVERSE TRAFFIC STICK REPEATER 1ST MULTIPLE RELAY
RFSPBR	REVERSE TRAFFIC STICK REPEATER 2ND MULTIPLE RELAY
RFXR	REVERSE TRAFFIC EXIT RELAY
RFXTEPSR	REVERSE TRAFFIC TIMER REPEATER STICK RELAY
RFXTER	REVERSE TRAFFIC TIMER RELAY
RLCSR	REVERSE LOOP CONTROL STICK RELAY
RSCZR	REVERSE STICK CHECK CONTROL RELAY
RSR	REVERSE STICK RELAY
RSAPR	REVERSE STICK 1ST MULTIPLE REPEATER RELAY
RSAR	REVERSE STICK 1ST MULTIPLE RELAY

Vital Relay  
Nomenclature

Meaning

RSBR	REVERSE STICK 2ND MULTIPLE RELAY
RSPR	REVERSE STICK REPEATER RELAY
RTR	REVERSE TRACK RELAY
RTYPR	REVERSE TRACK COMBINATION REPEATER RELAY
RWCR	REVERSE SWITCH CORRESPONDENCE RELAY
RWCAR	REVERSE SWITCH CORRESPONDENCE 1ST MULTIPLE RELAY
RWCBR	REVERSE SWITCH CORRESPONDENCE 2ND MULTIPLE RELAY
RWZR	REVERSE SWITCH CALL RELAY
RWZAR	REVERSE SWITCH CALL 1ST MULTIPLE RELAY
RWPR	REVERSE SWITCH POSITION REPEATER RELAY
SR	STICK RELAY
SSTER	STATION STOP TIMER RELAY
SYPR	STICK COMBINATION REPEATER RELAY
SYPAR	STICK COMBINATION REPEATER 1ST MULTIPLE RELAY
TER	TIMER RELAY
TR	TRACK RELAY
TPR	TRACK REPEATER RELAY
TPPR	TRACK 2ND REPEATER RELAY
TPAR	TRACK REPEATER 1ST MULTIPLE RELAY
TPBR	TRACK REPEATER 2ND MULTIPLE RELAY
TYPR	TRACK COMBINATION REPEATER RELAY
TYPAR	TRACK COMBINATION REPEATER 1ST MULTIPLE RELAY
TYPSR	TRACK COMBINATION REPEATER STICK RELAY
TYPSAR	TRACK COMBINATION REPEATER STICK 1ST MULTIPLE RELAY
TYSPR	TRACK COMBINATION STICK REPEATER RELAY
TYSPPR	TRACK COMBINATION STICK 2ND REPEATER RELAY
TZR	TRACK SPECIAL CONTROL REPEATER RELAY (VBS)
VPCHKR	VITAL PROCESSOR CHECK RELAY
VPPROBR	VITAL PROCESSOR PROBLEM RELAY
WASTER	WEST APPROACH STICK TIMER RELAY
WSR	WEST STICK RELAY
WASR	WEST APPROACH STICK RELAY
ZSPR	ZERO SPEED REPEATER RELAY
ZSPPR	ZERO SPEED 2ND REPEATER RELAY

## 1.05 NON-VITAL LOGIC RELAY NOMENCLATURE

<u>N-V Relay Nomenclature</u>	<u>Meaning</u>
ACN	STAGE A CANCEL RELAY
ADVZ	STORAGE REGISTER ADVANCE RELAY
ADVZP	STORAGE REGISTER ADVANCE REPEATER RELAY
AIS	AUTOMATIC INITIATION STICK RELAY
AISP	AUTOMATIC INITIATION STICK REPEATER RELAY
AISPA	AUTOMATIC INITIATION STICK REPEATER 1ST MULTIPLE RELAY
AIZ	AUTOMATIC ROUTE INITIATION
ANLP	A NORMAL LEVEL (SWITCH CALL) REPEATER RELAY
AOG	AUTOMATIC SIGNAL CONTROL RELAY
AOGP	AUTOMATIC SIGNAL CONTROL REPEATER RELAY
AOCAN,AQCAN	AUTOMATIC SIGNAL CONTROL CANCEL RELAY
APL	APPROACH PLATFORM LIGHT CONTROL
ARTN	STAGE A REVERSE TRANSFER RELAY
ARTNS	STAGE A REVERSE TRANSFER STICK RELAY
ARSD	STAGE A REVERSE STORAGE DESCRIPTION RELAY
ASD	STAGE A STORAGE DESCRIPTION RELAY
ASDP	STAGE A STORAGE DESCRIPTION REPEATER RELAY
ASK	APPROACH STICK INDICATION RELAY
ATN	STAGE A TRANSFER RELAY
ATNP	STAGE A TRANSFER REPEATER RELAY
ATWK	AUTOMATIC TRANSFER SWITCH INDICATION RELAY
AY	TRAILING SWITCH INDICATION RELAY
BCN	STAGE B CANCEL RELAY
BFK	COLLECTIVE BLOWN FUSE INDICATION RELAY
BNLP	B NORMAL LEVER (SWITCH CALL) REPEATER RELAY
BSD	STAGE B STORAGE DESCRIPTION RELAY
BSDP	STAGE B STORAGE DESCRIPTION REPEATER RELAY
BTN	STAGE B TRANSFER RELAY
BTNS	STAGE B TRANSFER STICK RELAY
BY	TRAILING SWITCH INDICATION RELAY
CAN	CANCEL RELAY
CANP	CANCEL REPEATER RELAY
CANS	CANCEL STICK RELAY
CANZ	CANCEL CALL RELAY
CANPB	CANCEL PUSHBUTTON RELAY
CANBPB	CANCEL PUSHBUTTON REPEATER RELAY
CANPBPP	CANCEL PUSHBUTTON 2ND REPEATER RELAY
CANPBS	CANCEL PUSHBUTTON STICK RELAY
CO	CLEAR OUT RELAY
DC	DWELL COMPLETE RELAY
DCP	DWELL COMPLETE REPEATER RELAY
DEK	DRAGGING EQUIPMENT INDICATION RELAY
DP	DUMMY ROUTE REPEATER RELAY
DPS	DUMMY ROUTE REPEATER STICK RELAY

<u>N-V Relay</u> <u>Nomenclature</u>	<u>Meaning</u>
DPSP	DUMMY ROUTE REPEATER STICK REPEATER RELAY
DTO	DWELL TIME OUT RELAY
DTX	DWELL TIME TRANSFER RELAY
ESK	EAST STICK INDICATION RELAY
ESKP	EAST STICK INDICATION REPEATER RELAY
EX	EXIT RELAY
EXP	EXIT REPEATER RELAY
EXPA	EXIT REPEATER 1ST MULTIPLE RELAY
EXZ	EXIT ENABLE RELAY
FL	FLEETING RELAY
FLP	FLEETING REPEATER RELAY
FLS	FLEETING STICK RELAY
FL-CAN	FLEETING CANCEL RELAY
GZ	ROUTE COMPLETION RELAY
GZP	ROUTE COMPLETION REPEATER RELAY
GZPA	ROUTE COMPLETION REPEATER 1ST MULTIPLE RELAY
GZS	ROUTE COMPLETION STICK RELAY
HDO	HOLD DOOR OPEN RELAY
HDC	HOLD DOOR CLOSED RELAY
HP	HOUR PULSE RELAY
IDAK	TRAIN IDENTITY APPROACH INDICATION RELAY
IDAKS	TRAIN IDENTITY APPROACH INDICATION STORAGE RELAY
INDTESTZ	INDICATION TEST CALL RELAY
INHZ	AUTOMATIC ROUTE INHIBIT CONTROL RELAY
LK	LOCK INDICATION RELAY
LKP	LOCK INDICATION REPEATER RELAY
LMC	LOCAL MANUAL CONTROL RELAY
LMCD	LOCAL MANUAL CONTROL DISPATCHER RELAY
LMSQ	LOCAL MODE SELECTION REQUEST RELAY
LMSS	LOCAL MODE SELECTION STICK RELAY
LMSSP	LOCAL MODE SELECTION STICK REPEATER RELAY
LOCAL	LOCAL RELAY
LOCAL-D	LOCAL DISPATCHER RELAY
LOS	LOCAL OPERATION STICK RELAY
LOSP	LOCAL OPERATION STICK REPEATER RELAY
LQ	LOCAL REQUEST RELAY
LRLO	LOCAL REMOTE LOCK OUT RELAY
LRLOA	LOCAL REMOTE LOCK OUT 1ST MULTIPLE RELAY
LRLOB	LOCAL REMOTE LOCK OUT 2ND MULTIPLE RELAY
LS	LONG STOP RELAY
LSP	LONG STOP REPEATER RELAY

<u>N-V Relay</u> <u>Nomenclature</u>	<u>Meaning</u>
MIS	MANUAL INITIATION STICK RELAY
MISP	MANUAL INITIATION STICK REPEATER RELAY
MISPA	MANUAL INITIATION STICK REPEATER 1ST MULTIPLE RELAY
MP	MINUTE PULSE RELAY
MPBP	MANUAL PUSHBUTTON REPEATER RELAY
MPBS	MANUAL PUSHBUTTON STICK RELAY
MSC	MODE SELECTION CONTROL RELAY
MSLOC	MODE SELECTION LOCAL RELAY
MSREM	MODE SELECTION REMOTE RELAY
MSTCQK	MODE SELECTION TRANSFER CONTROL REQUEST RELAY
MWK	MANUAL SWITCH POSITION INDICATION RELAY
MZS	MANUAL PUSHBUTTON ENABLE STICK RELAY
MZSP	MANUAL PUSHBUTTON ENABLE STICK REPEATER RELAY
MZSPA	MANUAL PUSHBUTTON ENABLE STICK REPEATER 1ST MULTIPLE RELAY
N5SKS	NORMAL 484' SKIP STOP RELAY
N12SKS	NORMAL 1200' SKIP STOP RELAY
NCD	NORMAL CODE DETECT RELAY
NFP	NORMAL TRAFFIC REPEATER RELAY
NFK	NORMAL TRAFFIC INDICATION RELAY
NFS	NORMAL TRAFFIC STICK RELAY
NFSK	NORMAL TRAFFIC STICK INDICATION RELAY
NFSS	NORMAL TRAFFIC STICK STORAGE RELAY
NLP	NORMAL LEVER (SWITCH CALL) REPEATER RELAY
NLPP	NORMAL LEVER (SWITCH CALL) 2ND REPEATER RELAY
NLPPA	NORMAL LEVER (SWITCH CALL) 2ND REPEATER 1ST MULTIPLE RELAY
NLS	NORMAL LONG STOP RELAY
NPS	NORMAL PUSHBUTTON STICK RELAY
NSK	NORMAL ROUTE STICK INDICATION RELAY
NSKP	NORMAL ROUTE STICK INDICATION REPEATER RELAY
NSS	NORMAL SHORT STOP RELAY
NVIPCHK	NON-VITAL INTERLOCKING PROCESSOR CHECK RELAY
NWK	NORMAL SWITCH INDICATION RELAY
NWPK	NORMAL SWITCH REPEATER INDICATION RELAY
NWKP	NORMAL SWITCH INDICATION REPEATER RELAY
NWKPA	NORMAL SWITCH INDICATION REPEATER 1ST MULTIPLE RELAY
NWCK	NORMAL SWITCH CORRESPONDENCE INDICATION RELAY
NWZ	NORMAL SWITCH CALL (CONTROL) RELAY
NY	NORMAL TRAILING ROUTE INDICATION RELAY

<u>N-V Relay</u> <u>Nomenclature</u>	<u>Meaning</u>
P	REPEATER RELAY
PBP	PUSHBUTTON REPEATER RELAY
PBPA	PUSHBUTTON REPEATER 1ST MULTIPLE RELAY
PBS	PUSHBUTTON STICK RELAY
PBSP	PUSHBUTTON STICK REPEATER RELAY
PBSPA	PUSHBUTTON STICK REPEATER 1ST MULTIPLE RELAY
PBSPB	PUSHBUTTON STICK REPEATER 2ND MULTIPLE RELAY
PBSS	PUSHBUTTON STICK STORAGE RELAY
PBSSP	PUSHBUTTON STICK STORAGE REPEATER RELAY
PL	PANEL LIGHTING RELAY
PLA	PANEL LIGHTING 1ST MULTIPLE RELAY
PLBP	PULL BUTTON REPEATER RELAY
PLTS	PLATFORM TRACK REPEATER RELAY
R5SKS	REVERSE 484' SKIP STOP RELAY
R12SKS	REVERSE 1200' SKIP STOP RELAY
RC	ROUTE CHECK RELAY
RCD	REVERSE CODE DETECT RELAY
REMOTE	REMOTE RELAY
RFP	REVERSE TRAFFIC REPEATER RELAY
RFS	REVERSE TRAFFIC STICK RELAY
RFSS	REVERSE TRAFFIC STICK STORAGE RELAY
RK	ROUTE INDICATION RELAY
RKP	ROUTE INDICATION REPEATER RELAY
RLP	REVERSE LEVER (SWITCH CALL) REPEATER RELAY
RLPP	REVERSE LEVER (SWITCH CALL) REPEATER REPEATER RELAY
RLPPA	REVERSE LEVER (SWITCH CALL) 2ND REPEATER 1ST MULTIPLE RELAY
RLS	REVERSE LONG STOP RELAY
RPS	REVERSE PUSHBUTTON STICK RELAY (Switch Control)
RPS	ROTATING (ROUTE) PRIORITY STICK RELAY (Automatic Initiation Circuits)
RSC	RESET STICK CANCEL RELAY
RSK	REVERSE STICK INDICATION RELAY
RSKP	REVERSE STICK INDICATION REPEATER RELAY
RSP	ROUTE STORAGE REPEATER RELAY
RSS	RESET STORAGE STICK RELAY (Automatic Initiation Circuits)
RSS	REVERSE SHORT STOP RELAY (Program Stop Ckts.)
RWCK	REVERSE SWITCH CORRESPONDENCE INDICATIO RELAY
RWK	REVERSE SWITCH INDICATION RELAY
RWKP	REVERSE SWITCH INDICATION REPEATER RELAY
RWKPA	REVERSE SWITCH INDICATION REPEATER 1ST MULTIPLE RELAY
RWPK	REVERSE SWITCH REPEATER INDICATION RELAY
RWZ	REVERSE SWITCH CALL (CONTROL) RELAY

<u>N-V Relay Nomenclature</u>	<u>Meaning</u>
RWZP	REVERSE SWITCH CALL (CONTROL) REPEATER RELAY
RY	REVERSE TRAILING ROUTE INDICATION RELAY
RZ	FLEETED ROUTE RESTORATION RELAY
SKS	SKIP STOP RELAY
SKSP	SKIP STOP REPEATER RELAY
SMK	SNOWMELTER INDICATION RELAY
SMYPK	SNOWMELTER COLLECTOR REPEATER INDICATION RELAY
SMZ	SNOWMELTER CALL (CONTROL) RELAY
SMZCAN	SNOWMELTER CANCEL RELAY
SP	COMMON ROUTE STICK REPEATER RELAY
SPP	STICK 2ND REPEATER RELAY
SRK	SELECT ROUTE INDICATION RELAY
SS	SHORT STOP RELAY
SSP	SHORT STOP REPEATER RELAY
SSTEPS	STATION STOP TIMER REPEATER STICK RELAY
STAPCHK	STATION PROCESSOR CHECK RELAY
TAWK	TRAIN APPROACH WARNING INDICATION RELAY
TAWTE	TRAIN APPROACH WARNING TIMER RELAY
TAWTEP	TRAIN APPROACH WARNING TIMER REPEATER RELAY
TB	TRAIN BERTHED RELAY
TCQK	TRANSFER CONTROL REQUEST INDICATION RELAY
TD	TERMINATE DWELL RELAY
TL2	TRAIN LENGTH 2 RELAY
TL4	TRAIN LENGTH 4 RELAY
TL8	TRAIN LENGTH 8 RELAY
TPK	TRACK REPEATER INDICATION RELAY
TRS	TRAIN READY STICK RELAY
TYPK	TRACK COMBINATION REPEATER INDICATION RELAY
TYPKA	TRACK COMBINATION REPEATER INDICATION 1ST MULTIPLE RELAY
TYPKB	TRACK COMBINATION REPEATER INDICATION 2ND MULTIPLE RELAY
TYPSK	TRACK COMBINATION REPEATER STICK INDICATION RELAY
TYPSKA	TRACK COMBINATION REPEATER STICK INDICATION 1ST MULTIPLE RELAY
TYPSKB	TRACK COMBINATION REPEATER STICK INDICATION 2ND MULTIPLE RELAY
TYPSKC	TRACK COMBINATION REPEATER STICK INDICATION 3RD MULTIPLE RELAY
TYPSKS	TRACK COMBINATION REPEATER STICK INDICATION STICK RELAY

<u>N-V Relay Nomenclature</u>	<u>Meaning</u>
UIP	UNIDENTIFIED TRAIN REPEATER RELAY
UIPP	UNIDENTIFIED TRAIN 2ND REPEATER RELAY
UIPS	UNIDENTIFIED TRAIN REPEATER STICK RELAY
UIPSP	UNIDENTIFIED TRAIN REPEATER STICK REPEATER RELAY
WSK	WEST STICK INDICATION RELAY
WSKP	WEST STICK INDICATION REPEATER RELAY
X	FACING SWITCH INDICATION RELAY
XK	EXIT KEYING RELAY

#### 1.06 NON-VITAL HEAVY-DUTY INTERFACING RELAYS

- A. The following list is for non-vital relays having heavy-duty contacts.

<u>Nomenclature</u>	<u>Meaning</u>
NTRNP	NEXT TRAIN REPEATER RELAY
RK	ROUTE INDICATION RELAY
RESET IDW	RESET INTRUSION DETECTION WARNING SYSTEM RELAY
SMZ	SNOWMELTER CALL RELAY
SMZP	SNOWMELTER CALL REPEATER RELAY
SMZPA	SNOWMELTER CALL REPEATER 1ST MULTIPLE RELAY

#### 1.07 NON-VITAL GENERAL PURPOSE INTERFACING RELAYS

- A. The following list is for non-vital reed or crystal can relays mounted on printed circuit cards.

<u>Nomenclature</u>	<u>Meaning</u>
ACS	STAGE A ROUTE CODE STORAGE RELAY
ACSA	COMMON STAGE A ROUTE CODE STORAGE RELAY
BCS	STAGE B ROUTE CODE STORAGE RELAY
BCSA	COMMON STAGE B ROUTE CODE STORAGE RELAY
BF	BLOWN FUSE RELAY
CACS	STAGE A ROUTE CODE STORAGE RELAY
CBCS	STAGE B ROUTE CODE STORAGE RELAY
CIR,PWR,FLR	CIRCUIT POWER FAILURE INDICATION RELAY
DACS	STAGE D ROUTE CODE STORAGE RELAY

Nomenclature

Meaning

NF RECT	NORMAL TRAFFIC RECTIFIER POWER INDICATION RELAY
PSBF	POWER SUPPLY BLOWN FUSE INDICATION RELAY
ROUTE A	ROUTE A RELAY
ROUTE B	ROUTE B RELAY
ROUTE C	ROUTE C RELAY
RF RECT	REVERSE TRAFFIC RECTIFIER POWER INDICATION RELAY
TSR-1N	TEMPORARY SPEED RESTRICTION - 1 NORMAL
TSR-1R	TEMPORARY SPEED RESTRICTION - 1 REVERSE
TSR-2N	TEMPORARY SPEED RESTRICTION - 2 NORMAL
TSR-2R	TEMPORARY SPEED RESTRICTION - 2 REVERSE

**END OF SECTION**

**SECTION 16903  
ATC - INITIAL METRORAIL SYSTEM**

**PART 1 - GENERAL**

**1.01 SECTION INCLUDES**

- A. Basic description of Initial Metrorail System.

**1.02 DESCRIPTION**

- A. The Approved Regional System, constructed in phases, is a 103 mile network serving Washington, D.C. and the nearby areas of Maryland and Virginia. It includes 38 miles of service in the District of Columbia, 35 miles in Maryland and 30 miles in Virginia.
- B. Eighty-three stations (including 4 Bi-Level Stations), of which 49 are in subways and 34 are at grade or on elevated structures. Forty-three of the stations are within the District of Columbia; 24 stations are in Maryland, and 20 stations are in Virginia.
- C. Forty-seven miles of the system have been constructed below the surface, most of it in the highly developed central area. Forty-nine miles are on the surface at grade, and eight miles are on elevated structures, primarily to achieve grade separation.
- D. Extensive use has been made, wherever feasible, of existing rights-of-way along established rail lines and in the medians of existing or proposed highways. The Metrorail System has exclusive rights-of-way for its operation without interruption by any outside vehicular or pedestrian traffic.
- E. The Regional Metrorail System has three main through routes traversing the District of Columbia. Transfer points linking the three main routes are provided at four double-level stations for passenger convenience. Emanating from these main routes are strategically oriented branch routes providing broad coverage throughout the central and suburban areas. The Metrorail System operates five color-designated "lines" over these various routes.
- F. Supporting the Regional Metrorail System are seven storage and maintenance yards situated to obtain the optimum flow of vehicles within the system.

**PART 2 - PRODUCTS**

NOT USED

**PART 3 - EXECUTION**

NOT USED

**END OF SECTION**

## SECTION 16904

### CURRENT AUTOMATIC TRAIN CONTROL SYSTEM

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section includes descriptions of the current WMATA METRO Rail Automatic Train Control (ATC) System and its various major sub-systems. All ATC design, systems and equipment provided by the Contractor under this Contract shall be fully compatible in all respects with the current WMATA METRO Rail Automatic Train Control System.

##### 1.02 AUTOMATIC TRAIN CONTROL SYSTEM

- A. The Automatic Train Control (ATC) System for the first 37 miles of the Regional METRO Rail System, the interlocking control for the major repair facility, the first 150 pairs of cars, and the operation control center were all procured under Contract 1Z2011. This Section briefly describes the ATC system provided by General Railway Signal Company in response to WMATA Contract 1Z2011, and subsequent revisions and additions to the ATC System.

##### 1.03 AUTOMATIC TRAIN PROTECTION

- A. The Automatic Train Protection (ATP) System is that part of the ATC System which provides protection against collisions and overspeed conditions. The ATP System also provides control of interlockings, route security through interlockings, and control of train door operation. Principal functions of the ATP System are Train Detection, Speed Command Selection, Speed Command Transmission, Interlocking Control and Security, Train Door Control, and all related carborne equipment to receive, decode, and safely act upon the ATP commands.
- B. Train Detection
  - 1. Track Circuits
    - a. Train detection is provided by jointless audio frequency track circuits except in certain areas of special trackwork. Mainline track circuits are conventional with tuning unit and impedance bond mounted between the rails at the block boundary. Audio frequency track circuits in special trackwork areas use a shunt bar and loop to inject the signal into the rails and an untuned impedance bond to couple the signal from the rails to the receiver in a center-receive configuration. Balancing impedance type, 60-Hz track circuits are used in the diamond of double crossovers and in the crossover track of single crossovers.
  - 2. Frequencies
    - a. The audio frequency track circuits use eight frequencies (two sets of four) for train detection purposes. The frequencies used are:
      - 1) Set 1 (for Tk 1 & Tk 3)
        - a) F1 - 2100 Hz
        - b) F3 - 2580 Hz
        - c) F5 - 3100 Hz
        - d) F7 - 3660 Hz

- 2) Set 2 (for Tk 2)
  - a) F2 - 2320 Hz
  - b) F4 - 2820 Hz
  - c) F6 - 3370 Hz
  - d) F8 - 3900 Hz

- b. Only one set of the above frequencies is used on a given track and the same set is not normally used on adjacent tracks.

- 3. Adjustment

- a. Audio frequency track circuits that have both the transmitter and receiver in the same room are adjusted for a shunting sensitivity of 0.1 ohm. Track circuits that have the transmitter and receiver in separate rooms are adjusted for a shunting sensitivity of 0.2 ohms.

- C. Speed Command Selection

- 1. Speed command selection is via vital relay contacts. The selection contacts represent the following:

- a. Traffic lockin
    - b. Occupancy of track circuit for which the speed command transmitter is effective
    - c. Occupancy of track circuits downstream of the speed command transmitter
    - d. Occupancy of track circuits upstream of the speed command transmitter if these circuits are within a more restrictive civil speed zone and the more restrictive civil speed limit is less than 2200 feet upstream of the speed command transmitter
    - e. Position of switches downstream of the speed command transmitter
    - f. Status of signal clearing networks downstream of the speed command transmitter
    - g. Position of switches upstream of the speed command transmitter, when the relative location of such switches can create a more restrictive civil speed limit as d. above
    - h. Condition of temporary speed restriction control
    - i. Additional conditions as required to provide safe train separation, speed, and door control and to provide schedule control at station platforms and dispatching locations.

- 2. Where track circuit occupancy and signal clearing network status must be transferred from one train control room to another for speed command selection purposes, such information transfer is accomplished via polar direct current line circuits.

- 3. Typical speed command selection networks and typical room-to-room line circuits are shown in the Contract Drawings.

- D. Speed Command Transmission

- 1. Speed command transmission is via one of two audio frequency carriers, 4550 Hz and 5525 Hz, ON/OFF AM modulated at one of five discrete frequency code rates. One additional code rate is used for the transmission of door opening commands. The command code chart is as follows:

Modulation Code Rate	Audio Frequency Carrier		
	F9 (4550 Hz)	F10 (5525 Hz)	$\overline{F9} + \overline{F10}$
1 3.0 Hz	Open Doors Left (when stopped)	Open Doors Right (when stopped)	Stop
2 4.5 Hz	15 MPH	45 MPH	Stop
3 6.83 Hz	22 MPH	50 MPH	Stop
4 10.1 Hz	28 MPH	55 MPH	Stop
5 15.3 Hz	35 MPH	65 MPH	Stop
6 21.5 Hz	40 MPH	75 MPH	Stop
None of the Above	Stop	Stop	Stop

2. The speed selection network selects a code rate generator output to drive the modulator, and energizes a carrier generator, in accordance with the above code chart, to cause the appropriate command to be transmitted.
3. In all areas, except special trackwork areas, speed command transmission is via the same transmitter as the train detection frequency. The transmitting equipment is shared between the train detection frequency and the selected speed command frequency on a time division multiplexing basis. The multiplexing is controlled by the selected code rate, which alternately keys the train detection and speed command frequencies.
4. In special trackwork areas two speed command transmission methods are used, as follows:
  - a. At shunt bar locations transmission is via the same equipment as the train detection frequency with the code rate slaved from the transmitter on the opposite side of the shunt bar.
  - b. At receive/receive locations and for the loops through 60 Hz track circuits, transmission is via an independent speed command transmitter, the output of which is directed through loop selection networks to energize the proper loop for the routing and position of the train.

#### E. Interlocking Control and Security

1. For purposes of this description, interlocking control and security is divided into the following categories:
  - a. Route Initiation
  - b. Route Completion
  - c. Time Released Approach Locking
  - d. Route Locking
  - e. Detector Locking
  - f. Switch Control and Indication
  - g. Signal Control
  - h. Loop Control
2. Route Initiation
  - a. Route initiation is accomplished by identifying the desired route in terms of the entering signal and the exiting signal. The following methods of accomplishing this function are used:
    - 1) Route Initiation by Local Control Panel
      - a) In this method of initiation, the first signal button actuated

on the local Interlocking Control Panel identifies the entering signal and the second signal button actuated on the local panel identifies the exit. Assuming that the desired exit is available and no conflicts are detected, the result is an energized pushbutton stick (PBS) relay associated with the entering signal and an energized exit stick (XS) relay associated with the exiting signal.

- 2) Route Initiation by Central Control
  - a) In this method of initiation, the central control computer sends a route request, associated with the entering signal, to the local equipment. Receipt of this control causes the same action in the local equipment as the first actuation of a signal button in (1) above. The local receipt of the first route request control is indicated back to central control. Receipt of the entrance received indication at central control keys the computer to stop sending the route request control associated with the entering signal and to start sending the route request associated with the exiting signal. Receipt of this second route request control causes the same action in the local equipment as the second actuation of a signal button in (1) above.
- 3) Route Initiation by Track Circuit Occupancy
  - a) In this method of route initiation, the presence of a train in certain track circuits causes wired logic to initiate a route which the train will subsequently accept. The wired logic provides for storage of route requests when a desired route cannot yet be initiated, priority determination, and determination of exiting signal when a choice exists. The result of this initiation method is an energized PBS relay associated with the entering signal and an energized XS relay associated with the exiting signal. This method of route initiation is used only at certain locations and can be enabled or inhibited from the local control panel or from central control. While this method of initiation is enabled, all other methods of initiation remain effective. In a variation of this method, the route request is not initiated until a "TRAIN READY" indication is received from the train occupying the track circuit.
- 4) Route Initiation by Train Identity
  - a) This method of initiation is the same as route initiation by track circuit occupancy, except that the trigger for an initiation request is the receipt of a train destination and the determination of the desired exiting signal is by the destination of the train. When this method is used, the transfer of the detected train destination information to Central must be coordinated with the occupancy of the designated ADVANCE APPROACH area by the train, and with route availability.
- 5) Route Initiation by Wayside Pushbutton
  - a) In this method of route initiation, the desired route is defined by actuation of a pushbutton located at the entering signal. The entering signal is determined by physical location of the pushbutton box and the exiting

signal is determined by which button in the box is actuated. The result is energization of a manual pushbutton stick (MPBS) relay associated with the entering signal and energization of an exit stick (XS) relay associated with the exiting signal. This method of route initiation is used only at certain signals, signals which also have initiation methods (3) or (4) above, and is active at all times.

- b. The five methods of route initiation described above are coordinated to protect against misrouting and lockups. Coordination includes:
    - 1) Local-remote control to prevent both local control and central control from being active at the same time;
    - 2) Lockout control to prevent any active initiation method from functioning while another method is being used to initiate a route, and;
    - 3) Time-out control to cancel an unidentified entering signal if an exit is not identified in a predetermined time.
  - c. The initiation circuits also include a search of possible routes associated with a defined entering signal. The result of this search is the energization of an exit (EX) relay associated with each "allowable-exit" signal location. The EX relay associated with a given "allowable-exit" signal location must be energized before the XS relay associated with that signal can be energized to identify it as the exiting signal.
  - d. All route initiation circuits are considered non-vital.
3. Route Completion
- a. After the route initiation is completed by identifying both the entering signal (PBS relay energized) and the exiting signal (XS relay energized), the route completion circuits complete the route by:
    - 1) Requesting the proper switch positions;
    - 2) De-energizing the unselected EX relays;
    - 3) Making a preliminary check of the route integrity;
    - 4) Initiating the vital locking, and;
    - 5) Initiating the request for signal clearing.
  - b. Route completion is accomplished as follows:
    - 1) The state of the search relays (BY and AY relays) and the identification of the exiting signal (XS relay) determines the desired position of each switch in the route. This information is used to request the proper switch positions by energizing the appropriate lever repeater (NLP and RLP) relays.
    - 2) Energizing the lever repeater relays causes the EX relays for unselected exit signals to become de-energized because of the requests for switch positions that would conflict with those exiting signals. Energizing the lever repeater relays also causes the switches to be properly positioned by the switch control and indication circuits if it is safe to do so.
    - 3) The identity of the entering signal, non-vital checks of switch correspondence, occupancy within the route, non-vital check of traffic availability beyond the exiting signal, and the identity of the exiting signal are used to provide a preliminary route integrity check. The result of this check is the energization of the Route Check Relay (RCR) associated with the entering signal.
    - 4) Energizing the RCR initiates the vital locking and signal clearing requests.

4. Time Released Approach Locking
  - a. Approach locking with timed release is provided for all mainline signals. One such locking circuit is provided for each signal. This form of locking is initiated when the Route Check Relay (RCR) becomes energized and remains in effect until released by one of the following:
    - 1) The signal is accepted by the train (two track release).
    - 2) The signal is set to stop and no train is within the approach limits.
    - 3) The signal is set to stop and a predetermined time has expired.
  - b. The approach locking relay (ASR) circuits are arranged such that a momentary interruption of track circuit energy will not release the locking. This is accomplished by:
    - 1) Using "two track release", with the two track circuits (the last track within the interlocking, and the first track exiting the interlocking) driven from different branch fuses, and;
    - 2) By cross checking the ASR relays such that, if opposing ASRs are both de-energized, as would be the case with a dc bus failure, time must be run to release the locking.
5. Route Locking
  - a. Route locking is provided to maintain security of the route ahead of the train as it progresses through the interlocking. Route locking is initiated by the initiation of approach locking and is released when approach locking is released and there are no occupancies in the route. In some cases the route is divided into contiguous sections for route locking purposes and locking of the section(s) of the route behind the train are released (sectional route release) as the train progresses through the route.
  - b. Route Locking is performed by Route Stick Relays (NSR and RSR).
6. Detector Locking
  - a. Detector locking is established by the track relay for the track circuit in which the switch is located and prevents switches from being thrown under a train. At interlockings with automatic route initiation, loss of shunt protection is provided by requiring track relays to be energized for a predetermined time before locking is released.
7. Switch Control and Indication
  - a. The switch control relays (NWZ and RWZ) are driven from the switch call relays (lever repeaters NLP and RLP) in the route completion network. The switch control relays are circuited to provide storage of the switch call, provide premature indication prevention, and prevent preconditioning.
  - b. The switch control repeater relays (NWZPR & RWZPR) are vital relays, primarily for maintenance convenience.
  - c. The switch control repeater relays control pole changed energy to the switch operating relays (NWR and RWR) through lock stick relay (LSR) contacts. The lock stick relay contacts are wired to provide a short circuit across the switch operating relays when the lock stick relay is de-energized.
  - d. The lock stick relay (LSR) is used to provide switch stroke completion in the event that the lock relay (LR) becomes de-energized prior to completion of the switch stroke.
  - e. Overload protection of the switch machine motor circuit is provided by the overload (stick) relay (OR), which has one coil in series with the motor circuit. The second coil is used as a stick coil and is energized through a front contact of the same (OR) relay from the drive circuit for the switch operating relays.
  - f. The switch machine motor circuit is a two- wire, pole-changed circuit

controlled by magnetic blow-out contacts on the switch operating relays (NWR & RWR).

- g. Switch position indication is controlled by a set of switch circuit controller contacts within the switch machine which are part of a two wire, pole changed circuit, driving a pair of biased switch repeater relays (NWPR and RWPR). Where two switch machines are operated as one, such as at a crossover, the indication circuit is controlled by the switch circuit controllers in both crossover switch machines to drive a single set of switch repeater relays.
- h. Switch correspondence relays (NWCR & RWCR) are provided to verify that the switch (position) repeater relays (NWPR & RWPR) are indicating that the applicable switch is in the position called for by its switch control repeater relays (NWZPR & RWZPR).

8. Signal Control

- a. Signals are controlled by vital home signal relays (HGR) which are energized by vital route check (RC) networks. The following checks are included in these route check networks:
  - 1) Approach locking is in effect.
  - 2) Route locking is in effect.
  - 3) Traffic locking beyond the exit signal is in effect.
  - 4) Lock and lock stick relays are de-energized.
  - 5) Switches are in proper correspondence.
  - 6) Route is not occupied.
  - 7) Timers associated with release of locking are at zero time.
  - 8) there has not been an overrun of a red signal at the interlocking.
- b. Where a number of control lines extend past a facing point signal location, route sensitive signal repeater relays are provided for use in the speed circuits.
- c. Signal lighting energy is controlled through front and back contacts of the home signal relays (HGR), and the two red lenses of the STOP aspect are independently lighted from different energy buses.

9. Loop Control

- a. Loop control and selection circuits are provided to sequence the transmission of speed commands through interlockings. The circuits and sequencing are such that a speed command never appears behind a train and only one loop is energized downstream of the track circuit occupied by the train.
- b. Loop control circuits are organized to require that the signal be clear and a train be on the first track circuit in the approach before the sequence can begin.
- c. Overrun protection is provided to interrupt the sequence and stop the transmission of all speed commands within the interlocking in the event of an overrun of a red signal.

F. Train Door Control

- 1. Train doors are controlled by commands transmitted via the vital, wayside-to-train command transmission system used for speed commands. Two commands are used; OPEN RIGHT DOORS and OPEN LEFT DOORS. The absence of either of these commands is interpreted as CLOSE DOORS.
- 2. Door control commands can be transmitted only at block boundaries associated with platform ends. Block boundaries associated with side platform stations are equipped to transmit the OPEN RIGHT DOORS command at the normal traffic-leaving end and the OPEN LEFT DOORS at the normal traffic-entering end. Block

boundaries associated with center platform stations are equipped to transmit the OPEN LEFT DOORS command at the normal traffic-leaving end and the OPEN RIGHT DOORS at the normal traffic-entering end.

3. Carborne ATP equipment compensates for direction of travel of the controlling "A" car and ensures that it is safe to open the train doors prior to acting upon the commands. One of the safety checks made is the verification that the train is at a passenger station. This check is accomplished by cycling a bit back and forth between the train and the station via the TWC system. The cycling of the TWC bit is used to keep a vital relay (PSCR) on the train energized as long as the train is in TWC communications with a passenger station.
4. The application of the door control commands is under control of the station dwell control circuits.

G. Carborne ATP

1. The carborne ATP equipment is organized to perform the following functions:
  - a. Receive and decode the speed limit and door control commands;
  - b. Measure train speed and compare it to the speed limit;
  - c. Control the door operations and check door position, and
  - d. Apply Full Service Braking in the event of overspeed or system failures which affect safety.

2. The carborne ATP System has the capacity to receive and decode 12 commands from the front of the train and two commands from the back of the train. The commands are:

<u>Command</u>	<u>Carrier Freq ±0.5%.</u>	<u>Code Rate ±5%.</u>
15 mph	4550 Hz (F9)	CR2- 4.5 Hz
22 mph	4550 Hz (F9)	CR3- 6.8 Hz
28 mph	4550 Hz (F9)	CR4-10.1 Hz
35 mph	4550 Hz (F9)	CR5-15.3 Hz
40 mph	4550 Hz (F9)	CR6-21.5 Hz
45 mph	5525 Hz (F10)	CR2- 4.5 Hz
50 mph	5525 Hz (F10)	CR3- 6.8 Hz
55 mph	5525 Hz (F10)	CR4-10.1 Hz
65 mph	5525 Hz (F10)	CR5-15.3 Hz
75 mph	5525 Hz (F10)	CR6-21.5 Hz
Open Rt.Doors	5525 Hz (F10)	CR1- 3.0 Hz
Open Lt.Doors	4550 Hz (F9)	CR1- 3.0 Hz

- a. Absence of an ATP command is interpreted by the equipment to mean "STOP" when operating in the Automatic mode and "STOP AND PROCEED at 15 MPH" when operating in the Manual mode.
3. Reception and Decoding
  - a. ATP command reception is accomplished through two coils mounted on the cab end of each car. The coils are rigidly mounted to the car body with the center of the coils 31.25 inches ahead of the centerline of the lead axle. The bottoms of the coils are nominally 8 inches above the top of rail and the lateral distance between coil center lines is 44 inches.
4. Receivers
  - a. Two receivers are provided on each "A" car. One receiver, hereafter referred to as the front-end receiver, receives and demodulates the ATP signals presented to the front of the train while the second receiver, hereafter referred to as the back-end receiver, receives and demodulates the ATP signals presented to the back of the train.
  - b. The front-end receiver meets the following specifications:

- 1) Dynamic range of input: 20 dB minimum
  - 2) Sensitivity:
    - a) 90 ma rail current min.
    - b) 60 ma rail current max.
  - 3) Selectivity: -40 dB, 125 Hz or more each side of each carrier frequency
- c. The back-end receiver meets the following specifications:
- 1) Dynamic range of input: 20 dB minimum
  - 2) Sensitivity:
    - a) 90 ma rail current min.
    - b) 60 ma rail current max.
  - 3) Selectivity: -40 dB, 125 Hz or more on each side of each carrier frequency
- d. The code output of the front-end receiver is monitored by six code-rate detectors, each of which drives a vital relay when its associated code rate is present. The worst case time between removal of a speed command to drop away of the associated code rate and carrier relays is 2 seconds. The normal time required to change speed commands is between 0.5 and 1.0 seconds.
5. Decoding
- a. The contacts of the six code-rate relays and the two carrier relays driven from the front-end receiver are fanned to decode the command. The decoding fans are such that the most restrictive command has priority. The command decoding fans output to the following:
    - 1) Speed selection circuits for overspeed protection;
    - 2) Speed selection circuits for automatic speed regulation;
    - 3) Automatic door control;
    - 4) Limiting speed indicators on the control consoles;
    - 5) Brake interface.
6. Overspeed Protection
- a. Overspeed protection equipment that compares the speed selected by the command decoding fan, in connection with the automatic-manual circuits, to the actual train speed is provided. Actual train speed is derived from a speed sensor monitoring the rotation of a gear in a gear unit. Wheel wear compensation is provided in discrete steps to correct for variations in wheel diameter on the axle monitored by the ATP speed sensor.
  - b. The overspeed protection unit energizes a vital relay to indicate that the actual train speed is less than the limiting speed and that the unit is operating properly. In the event of a failure, or if the actual train speed exceeds the speed limit, this vital relay becomes de-energized.
7. Speed Enforcement
- a. When the train is in automatic operation, an overspeed condition detected by the Overspeed Protection System results in the removal of all calls for positive tractive effort and initiates a Full Service Brake application. The Full Service Brake application is enforced until the overspeed condition no longer exists.
  - b. When the train is in the manual-operation-with-overspeed-protection mode, an overspeed condition detected by the Overspeed Protection System results in the removal of all calls for positive tractive effort and initiates a Full Service Brake application. An overspeed warning in the cab is also sounded and persists until the attendant places the master controller into the Full Service Brake position. The Full Service Brake application is enforced until the attendant has placed the master controller in the Full

- Service Brake position and the overspeed condition no longer exists. When the train is in the manual-operation-with-ATP-cutout mode, no action shall be taken by the ATC System as a result of an overspeed condition.
- c. The Overspeed Protection System also includes zero speed detection circuitry. The train is indicated as being at zero speed when the speed is being detected, in a fail-safe manner, to be below 1 mph
8. Door Control
    - a. Signals received by the front-end receiver of the train determine on which side of the train the doors are to open, and also prove that the frontmost side door of the train is within the platform limits. The signal received by the back-end receiver of the train proves that the rearmost side door of the train is within the platform limits.
    - b. The output of the back-end receiver is decoded to detect the presence of code rate 1 (3.0 Hz). The presence of this code rate causes energy to be applied to trainline wires at the back of the train. Door control circuits in the controlling "A" car monitor these trainline wires to provide back-end status.
    - c. A cycle check system is provided in the passenger stations, via the Train-to-Wayside Communications (TWC) System, which is used to confirm that the train is located in a passenger station before doors can be operated.

#### **1.04 AUTOMATIC TRAIN SUPERVISION**

- A. The Automatic Train Supervision (ATS) System is that part of the ATC system which provides centralized monitoring and supervision capabilities and certain automatic ATC supervision facilities at wayside. The ATS system consists of:
  1. A computer system and central control consoles located at the Operations Control Center (OCC) in the Jackson Graham Building;
  2. A Data Transmission System (DTS) linking the equipment at the OCC with that in the TCRs;
  3. Remote Terminal Units (RTUs) located at the wayside Train Control Rooms (TCRs) (The RTUs are hard-wired remote control devices dedicated to the monitoring and supervision of certain wayside ATC functions and devices as well as the electrical and support facilities at the location.);
  4. A Train-To-Wayside Communications (TWC) system to provide a two-way link between the TCR equipment and trains at stations;
  5. An Automatic Car Identification (ACI) system. This system has optical scanners located at certain points next to the tracks. These scanners read the car numbers from a train as it passes the scanner. The car identification is reported to the central computer, which can then determine the car mileage. This information can be used for maintenance purposes and analysis of operations.
- B. Central Control Facility Overview
  1. The central control facility contains a control computer, a hot backup computer, and a computer for software development, which also serves as the ultimate backup computer. The control computer receives and transmits messages between the operations control center and station locations via the DTS. It communicates with the central control operator by providing displays on a large-scale display and video monitors (CRTs), and by accepting operator input from console trackballs and keyboards. The control computer performs schedule adjustments by changing dwell times and interstation run times, both of which are sent to the station RTUs via the DTS. The METRO system can operate as a stand-alone entity without the computer complex at the OCC. However, without the capabilities provided by the ATS software in the central control computer, the display system, and the DTS, the

job of monitoring and controlling the METRO operations, especially to maintain schedules, would be more difficult. This is especially true when an abnormal condition (e.g., a malfunctioning train) is encountered. The general functions provided to aid the central control operators are:

- a. Display System
  - 1) Train System Displays
  - 2) Train and Interlocking Detail Displays
  - 3) Train Information Displays
  - 4) Electrical System Displays
  - 5) Train and Electrical System Alarm Display
  - 6) Geographic Displays
- b. Monitoring Traffic Regulation
  - 1) Schedule Control
  - 2) Schedule Adjustment Strategies
  - 3) Schedule linkage of train put-ins
- c. Supervisory Capability
  - 1) Train Control requests to wayside ATP system
  - 2) Interlocking requests to wayside ATP system
  - 3) Commands to wayside ATS equipment
  - 4) Commands to wayside support system devices
- d. Status Monitoring and Alarm Processing

C. Automatic Train Supervision Software

1. The software for the central computer has been designed in a building block approach and provides the primary functions of Traffic Regulation and Control and Display.
2. Traffic Regulation
  - a. All trains in the METRO system under central computer supervision enter revenue service, run, and terminate revenue service according to times provided by predetermined train schedules. These train schedules are the basis for Traffic Regulation control. A train schedule is defined as a set of arrival and departure times at successive locations which completely dictates a train's intended movement from entry into revenue service until lay up. A train schedule defines, among other things, the scheduled arrival time and the scheduled dwell time at every station traversed by a given train. A unique schedule is defined for each train that is in revenue service or is about to enter revenue service. The system schedules are selected by the central control operators at the start of revenue service on a particular day.
  - b. Traffic Regulation automatically maintains the scheduled headway between all of the trains operating in the territory and regulates train movements for time schedule adherence, proper merging of trains at rail line junction points, and optimum utilization of terminal locations. This is achieved by control of both station dwell time, and train performance (speed) and acceleration levels that govern the interstation running time.
  - c. The four main components of the Traffic Regulation software are Put-in Processing, the Line Algorithm, the Terminal Algorithm, and Strategy Selection. Also, statistics of the actual performance of trains are gathered for off-line analysis.
    - 1) Put-in Processing
      - a) The Put-in Processing software initiates train entry into revenue service either from a storage point, such as a yard or a pocket track, or from a terminal station after a

train reversal. The primary function of the Put-in Processing software is to construct a schedule for the next terminal-to-terminal run of the train so that the Terminal Algorithm and the Line Algorithm can control it. Another function performed is the lighting of warning lamps at yards prior to the scheduled dispatch of a train so that the yard personnel can prepare a train for revenue service.

2) Line Algorithm

- a) The primary function of the Line Algorithm is to attenuate delays due to minor line disturbances as quickly as possible and prior to the arrival of trains in areas where the probability of such delays is high. Line disturbances are events or conditions that cause a train to be early or late with respect to its schedule. Such events cause the Line Algorithm to affect the dwell time of a train at a station and the performance of a train departing from a station. The Line Algorithm minimizes or eliminates the effects of delays by adjusting the dwell and performance level of a train such that the departure schedule error at a station and the arrival schedule error at the next station are both minimized
- b) There are four "Performance Levels" for train operation. Performance Level 1 (PL1) (MAXIMUM) requests the train to run at the maximum safe interstation speed, resulting in the minimum safe interstation run time. The normal schedule for a train is based on PL2 (NORMAL), which is approximately 10 percent slower than PL1. This gives traffic regulation a catch-up capability by allowing it to request PL1 to reduce a train's lateness. PL3 (REDUCED) and PL4 (RETARDED) are approximately 10 percent and 20 percent slower than PL2 and are used when trains are ahead of schedule. The Performance Levels are implemented by imposing applicable maximum ATS speed limits on trains between successive station pairs.
- c) Each of the four performance levels may be combined with a request for either full or half acceleration, thus providing eight different interstation run times. For each station platform the program can select either a normal dwell time or another value which lies within the range of minimum and maximum dwell times for that platform. Dwell times available for some platforms can be varied with the time of day.

3) Terminal Algorithm

- a) A special case handled by a part of Traffic Regulation called the Terminal Algorithm is used to avoid conflicts between trains at terminals having a crossover interlocking located between the terminal station and the penultimate station. Since these interlockings are used to reverse trains, conflicts in the use of the interlockings can be generated by trains arriving at and departing from a terminal station at close headway. A route conflict exists whenever two trains attempt to traverse conflicting routes

- through an interlocking at the same time.
- 4) Strategy Selection
    - a) The central control operators have the capability of providing corrective strategies through the Strategy Selection program whenever required. The control philosophy employed here is that the operator is the best judge of what corrective action is most suitable in any given situation and the computer is most useful as a device to display the options available and to implement the selected option.
    - b) The Strategy Selection programs include Replace Train, Delete Train, Add Train, Eliminate Gap, Create Gap, Offset Schedule, Tilt Schedule and Skip Stop. All act to either modify or maintain the existing schedule.
3. Control and Display Software
    - a. The Control and Display software drives the displays and alarm printers and responds to central control operator inputs through the console trackballs and keyboards. The Control and Display software responds to field changes or when requested by an operator input to update train displays. It examines the data returned from the field and marked as changed by the Data Base Processor software. It then updates displays and alarm messages for the central operator as required.
    - b. The Control and Display software provides the processing of all operator inputs and coordinates execution of the software required by those inputs. These commands allow the central control operators to manually supervise system operation and to request specific displays.
- D. System Hardware
1. The system hardware is used to perform the required Automatic Train Supervision functions and backup functions. The individual components are integrated to provide the means by which the various software components perform their functions.
  2. General Purpose Computer Subsystem
    - a. Three interconnected computers comprise this subsystem. Each computer consists of a central processor with byte addressing, floating point and memory protection instructions, a priority interrupt system, and a power monitoring circuit.
    - b. The computer systems are networked to each other and to the peripheral devices through a dual Ethernet network.
  3. Communications Subsystem
    - a. To handle the specialized data transmission, the central computers are connected to two Front End Processors (FEPs) which are connected to a bank of modems. The modems are connected through the DTS to the various field devices and permit the transfer of data to and from the central control computer. The FEPs receive the raw data from the field and forward change information to the central processors.
  4. Control and Display Subsystem
    - a. The Control and Display subsystem, used by the central control operators in controlling the system, has as its main functions; the presentation of system status, operational data and alarms to the central operator, and; the execution of system commands from the console trackball and keyboard.
    - b. Video monitors (CRTs) provide the display facility with:
      - 1) "Closeup" views of the interlockings;
      - 2) System alarms (Train and E&S Alarms);

- 3) Performance statistics (Train Information);
  - 4) Electrification system (Traction Power) overview,
  - 5) State of mechanical support equipment at a station selected by the operator (Support Station).
- c. In the event that a CRT malfunctions, the central control operators have the capability of reconfiguring the displays so that a desired display can be moved to a working CRT.
  - d. A Large Scale Display System provides an overview display of the METRO System and can also be used to display any of the System's local or special displays.
  - e. All alarm conditions on the METRO System, whether the result of train control indications, calculations, traction power and support system indications or computer indications, are displayed in tabular form on the appropriate alarm display and can be output to a printer. Alarms are also displayed in the alarm area (bottom three lines) of the CRT screen. Each message is accompanied by an audible alarm. The alarm area contains up to three of the most current unacknowledged alarm messages. There is an indication if there are more than three currently unacknowledged alarms.

E. Wayside

1. The following portions of the ATS are located on the wayside, primarily in the Train Control Rooms at passenger stations:
2. Door and Dwell Controls
  - a. The door and dwell control modules provide the local hardware to implement the controls generated by central control or automatically by normal train operations. This hardware is configured to provide a backup means of door and dwell control in the event that control from central is interrupted. The configuration is such that the local backup provisions are exercised on each train movement to make failures self-evident. The sequence of operation is as follows:
    - 1) When an arriving train completes its station stop a TRAIN BERTHED signal is transmitted to the station via the TWC system. Receipt of this signal causes the speed commands to be removed from the platform block and the block downstream of the platform, the door open commands to be applied at both ends of the platform after a 2 second delay, and energy to be applied to the local dwell timer. The TRAIN BERTHED signal is also transmitted to central control via the DTS.
    - 2) Upon expiration of the preset time of the dwell timer, the door open commands are removed and speed commands restored unless override controls are received from central control.
    - 3) The dwell can be terminated prior to the expiration of the preset time by receipt of the TERMINATE DWELL control from central control or by manually closing the train doors.
    - 4) The dwell can be extended beyond the preset time with the doors held open by receipt of the HOLD WITH DOORS OPEN control from central control.
    - 5) The dwell can be extended beyond the preset time with the doors closed by receipt of the HOLD WITH DOORS CLOSED control from central control. In this case the door open commands are removed but the speed commands are not restored until the HOLD WITH DOORS CLOSED control is no longer received.

- 6) At selected stations a local train dispatching system was provided for schedule control in the event of failure of the central control function. At these locations the expiration of the preset dwell time would not terminate the dwell unless it was also time for the train to be dispatched from that station. (The automatic dispatching machines originally installed as parts of this system are no longer being used.)
3. Train-to-Wayside Communications (TWC)
    - a. The TWC system provides the communications link for the following ATS functions between revenue trains and the wayside.
      - 1) Train-To-Wayside
        - a) Train Destination
        - b) Train Number
        - c) Manual Pushbutton Right (Tk 1 & 2)
        - d) Manual Pushbutton Left (Tk 1 & 2)
        - e) Doors Closed Right (Tk 1 & 2)
        - f) Doors Closed Left (Tk 1 & 2)
        - g) PSS Active (Tk 1 & 2)
        - h) ATP in Effect (Tk 1 & 2)
        - i) Train in ATO (Tk 1 & 2)
        - j) Passenger Station Check
        - k) Train Ready
        - l) All Doors Closed
        - m) Train Berthed
        - n) Motion Detection
        - o) Train Length
      - 2) Wayside-To-Train
        - a) Train Destination
        - b) Train Number
        - c) Platform ID
        - d) Passenger Station Check
        - e) ATS Acceleration
        - f) Door Close Warning, Platform 1
        - g) Door Close Warning, Platform 2
        - h) ATS Speed Limit
      - 3) FOR C10 & K06 STATIONS ONLY:
        - a) Train-To-Wayside
          - (1) PSS Active (Tk 3 & 4)
          - (2) Train in ATO (Tk 3 & 4)
          - (3) ATP In Effect (Tk 3 & 4)
          - (4) Manual Pushbutton Right (Tk 3 & 4)
          - (5) Manual Pushbutton Left (Tk 3 & 4)
          - (6) Doors Closed Right (Tk 3 & 4)
          - (7) Doors Closed Left (Tk 3 & 4)
        - b) Wayside-To-Train
          - (1) Platform ID
          - (2) Platform 3 or 4
          - (3) Door Close Warning,
          - (4) Platform 3 & 4
    - b. The TWC System is a continuous-scanning, time-division multiplex transmission system in which communications transmitted to wayside and received from wayside are time-shared.

- c. The carborne TWC System is inductively coupled to the wayside TWC System via coils on the cars. At wayside receiver locations other than flyby locations, the area of effective two-way communications is at least 600 feet long.
- d. The following message formats are transmitted by the train and received by the wayside
- 1) SHORT MESSAGE FORMAT  
Bit No.

1-3	Message Prefix
4-11	Word 1 (Train Destination)
12	Parity, Word 1
13-15	Message Suffix
  - 2) LONG MESSAGE FORMAT  
Bit No.

1-3	Message Prefix
4-11	Word 1 (Train Destination)
12	Parity, Word 1
13-24	Word 2 (Train Number)
25	Parity, Word 2
26	Manual Pushbutton Right
27	Manual Pushbutton Left
28	Doors Closed Right
29	Doors Closed Left
30	PSS Active
31	ATP in Effect
32	Train in ATO
33	Spare
34	Spare
35	Spare
36	Spare
37	Spare
38	Parity, Word 3
39	Passenger Station Check
40	Train Ready
41	All Doors Closed
42	Train Berthed
43	Parity, Word 4
44	Motion Detection
45-47	Train Length
48	Parity, Word 5
49-51	Message Suffix
- e. The prefix bit configuration for the short message mode is MARK-SPACE-MARK. The prefix bit configuration for the long message mode is MARK-MARK-MARK. The suffix bit configuration for both long and short message modes is MARK-MARK-MARK.
- f. The message structure is a non-synchronous, return-to-zero, serial code at a bit rate of 100 bps. There is a 100-millisecond pause between successive message transmissions from the trains. The message starts 60 ms after the transmitter is keyed. The TWC carrier frequency is 9800 Hz.

- g. A frequency of 9950 Hz is interpreted as a "MARK." A frequency of 9650 Hz is interpreted as a "SPACE." Parity is "ODD."
- h. The existing impedance bonds that are tuned to transmit and receive the TWC signals exhibit impedance of approximately 1.0 ohms at 9800 Hz. With this impedance, the TWC system will work reliably with a receiving bond current of .016A rms to 0.3A rms. The transmit rail current produced by the bond is approximately 1.5A rms with a train adjacent to the bond. Input to the TWC receiver is 400-mV p'p'.
- i. The following message formats are transmitted to the trains depending upon the location of the transmitter:

1) SHORT MESSAGE FORMAT

Bit No.

1-3	Message Prefix
4-7	Word 1 (ATS Speed Limit)
8	Parity, Word 1
9-11	Message Suffix

2) LONG MESSAGE FORMAT

Bit No.

1-3	Message Prefix
4-11	Word 1 (Train Destination)
12	Parity, Word 1 (odd)
13-24	Word 2 (Train Number)
25	Parity, Word 2 (odd)
26-33	Word 3 (Platform ID)
34-37	Word 3 (Spares)
38	Parity, Word 3 (odd)
39	Word 4 (Passenger Station Check)
40	Word 4 (ATS Acceleration)
41	Word 4 (Door Close Warning)
42	Word 4 (Spare)
43	Parity, Word 4 (odd)
44-47	Word 5 (ATS Speed Limit)
48	Parity, Word 5 (odd)
49-51	Message Suffix

- j. The long messages are transmitted to trains in response to a received message from the train at all locations other than flyby locations. Short messages are transmitted to trains in response to a received message at flyby transmitter locations.

4. Automatic Car Identification (ACI)

- a. The ACI system provides a means of identifying train consists by car serial number. This data is transmitted to central control via a low speed data channel and presented to the central computer where it is associated with the appropriate train I.D. data. The system is an optical scanning system which recognizes color strip labels affixed to the cars. The labels are a short version (7 digits) of the former standard AAR label.
- b. The scanners are located in the downtown area such that six scanners are sufficient to read the consist of all revenue service train movements.

5. Performance Level Translators

- a. The performance level translator converts the two-bit performance level control received from Central Control into a four-bit binary code, which

identifies the ATS speed limit required to achieve the desired performance level.

- b. The ATS speed limit code produced by the performance level translator for a given performance level code input is determined by the wiring of a programming plug. The correlation between performance level and ATS speed limit (programming plug wiring) for a given station-to-station run is based on computer simulations of station-to-station runs with each of the ATS speed limits.
- c. The performance level translator is a part of the TWC transmitter module. The ATS speed limit code produced by the translator is transmitted to the train via the TWC system. The trains interpret the ATS speed limit code as follows:

<u>ATS</u> <u>CODE</u>	<u>SPEED</u> <u>LIMIT (mph)</u>	<u>ATS</u> <u>CODE</u>	<u>SPEED</u> <u>LIMIT (mph)</u>
0000	79	1000	44
0001	79	1001	49
0010	14	1010	54
0011	19	1011	59
0100	24	1100	64
0101	29	1101	69
0110	34	1110	74
0111	39	1111	79

- 6. Data Transmission System Remote Terminal Units
  - a. The wayside portion of the DTS consists of Remote Terminal Units (RTUs) and their associated interface hardware and wiring.
  - b. Earlier portions of the existing system use model 9600 RTUs manufactured by TRW Controls. These RTUs operate at a bit rate of 1200 or 2400 baud depending on the total number of controls and indications for which the RTU is equipped. The maximum capacity of these RTUs is 836 controls and 892 indications.
  - c. The model 9600 RTUs are interfaced to a voice grade channel between the RTU and central control via model P1224 modems manufactured by TRW Controls.
  - d. Newer portions of the existing system use OUTPOST Model 409 RTUs manufactured by Network Management Technologies, Inc., Sugar Land, Texas.

## 1.05 AUTOMATIC TRAIN OPERATION

- A. The Automatic Train Operation (ATO) System is that part of the ATC System which provides automatic train stopping and starting at passenger station platforms and provides speed control compensation for varying conditions of grade and curvature.
- B. Wayside Portion
  - 1. The wayside portion of the ATO system consists of the markers used to identify grade and curve information and the station stopping markers which provide the distance-to-centerline information as well as the type of stop (long, short, center, or skip) information.
  - 2. The markers are tuned circuits, the inductance of which is an air core coil with an inside diameter of approximately 11 inches. The coil is the coupling element to the carborne equipment and is located between the running rails with its axis vertical.

The top edge of the coil is between 1/4 and 3/4 inches below the top of rail. The relationship between the coil center and the track centerline is as follows:

<u>RADIUS OF CURVE</u>	<u>OFFSET FROM CENTERLINE OF TRACK</u>
Greater than 8500'	0"
8500' - 2900'	1"
2900' - 1750'	2"
1750' - 1250'	3"
1250' - 975'	4"
975' - 800'	5"
800' - 700'	6"
Less than 700'	7"

- a. Offset from centerline of track is toward the outside of the curve. See the Technical Appendix, "Marker Coil Offset vs. Curve Radius."
  3. Each marker location except the 160 ft. marker consists of two independent tuned circuit members. This configuration is used to provide for double direction running and to provide the required amount of data with fewer frequencies.
- C. Carborne Portion
1. The carborne portion of the ATO System consists of marker reception and decoding equipment, station stop control equipment, and speed regulation equipment.
  2. The marker reception and decoding equipment responds to the wayside markers, validates the data and passes the valid data to the speed regulation and station stopping equipment. The station stopping equipment generates a velocity vs. distance profile upon receipt of an initiating marker. The slope of the stopping profile is determined by the grade and curve data also received via the marker system. The stopping point within the station (point at which profile velocity reaches zero) is determined by the type of stop data received via the marker system and the train length determined by the carborne train length measuring circuits. Intermediate station stopping markers are used to correct the velocity vs. distance profile to compensate for differing wheel diameters and the effects of slip and slide.
  3. The speed regulator measures actual train speed and controls the power and braking to cause the actual speed to approximate the desired speed. The desired speed is defined as the lesser of ATP Speed Command, ATS Speed Limit, or Station Stopping Profile Velocity. In normal running the speed regulator will cause the actual speed to be equal to the desired speed +0 mph, -4 mph.
  4. The actual train speed and the distance base for the station stopping profile are derived from axle rotation. Manually adjusted wheel wear compensation is provided to minimize the errors due to changes in wheel diameter over the life of the wheels.

**PART 2 - PRODUCTS**  
NOT USED

**PART 3 - EXECUTION**  
NOT USED

**END OF SECTION**

## SECTION 16905

### ATC - TRANSIT VEHICLE CHARACTERISTICS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section describes the ATC-related characteristics of the five types of existing Metrorail rapid transit vehicles and specifies values and formulae which the Contractor shall use to compute speed, deceleration and safe braking distances for trains of these cars.

##### 1.02 DESIGN CHARACTERISTICS

- A. Some of the basic characteristics of the five types of existing METRO passenger transit vehicles and trains, are shown on pages TA-3 through TA-6, inclusive, of the ATC Technical Appendix (Section 16996). These characteristics and the various acceleration and brake rates, inertia and jerk limits, resistance factors, and electrical equipment characteristics set forth in this Section shall be used in the design of the wayside ATC System under this Contract.

##### 1.03 ACCELERATION AND BRAKE RATES

- A. Maximum acceleration on level, tangent track is as shown on page TA-4 of the ATC Technical Appendix.
- B. The "Full Service" brake rate (negative level 4) for both the ROHR cars, the BREDA cars, and the AAI cars is 2.2 mphps from 50 mph to 0 mph. From 50 mph to 75 mph it decreases linearly to 75 percent of 2.2, i.e., 1.65 mphps.
- C. Full Service braking for the ROHR cars is fail-safe and does not require check circuits to verify retardation. Full Service braking for the BREDA and AAI cars is "brake assured."
- D. The Contractor shall use 75 percent of the Full Service brake rates defined above when computing safe braking distance (SBD).
- E. Load Compensation
  - 1. Since the cars carry a variable live load, a load compensation device has been incorporated into the cars which adjusts tractive effort (positive and negative) to the individual car weight. This compensation is effective up to the nominal gross weight of the car in the acceleration mode and up to the maximum (crush-load) gross weight of the car in the deceleration mode.
  - 2.

##### 1.04 INERTIA AND JERK LIMIT

- A. Inertia
  - 1. For acceleration calculations, total train inertia shall be taken to be 100 lbs./ton per mphps.
- B. Jerk Limit
  - 1. Jerk rate (second derivative of the velocity function) will not exceed 2.0 mphpsps for the ROHR cars and 2.2 mphpsps for the BREDA and AAI cars.
  - 2. For any 0.25 second period, acceleration rate will not experience a step

- change of more than 0.60 mphps.
3. Jerk limit control is effective for all changes in positive or negative tractive effort and for transitions between positive and negative tractive effort. Jerk limit control is provided for the final stop in accordance with the above-specified jerk rate limit, for all ATP and ATO initiated stops.

## 1.05 RESISTANCE FACTORS

- A. Grade Resistance ( $R_g$ )
  1.  $R_g = 20$  lbs/ton per percent of grade
- B. Curve Resistance ( $R_c$ )
  1.  $R_c = 0.8$  lbs/ton per degree of curvature
  2.  $= 0.8 \times (5730/R)$  lbs/ton
  3. Where: R = Radius of curvature in feet
- C. Inherent Car and Train Resistance
  1. The inherent car and train resistance on level, tangent track shall be determined as follows:
    - a. Leading car:
      - 1)  $R_{cl}$  (lbs/ton) =  $1.3 + 116/W + 0.045V + 0.0024AV^2/W$
    - b. Trailing cars:
      - 1)  $R_{ct}$  (lbs/ton) =  $1.3 + 116/W + 0.045V + 0.00034AV^2/W$
    - c. Total inherent train resistance:
      - 1)  $R_{tt}$  (lbs/ton) =  $R_{cl} + (n-1)R_{ct}$ 
        - a) Where:
          - (1) W = car weight in tons
          - (2) V = speed in mph
          - (3) A = car frontal area in square feet
          - (4) n = number of cars in train

## 1.06 ELECTRICAL EQUIPMENT CHARACTERISTICS

- A. The characteristics of the chopper-controlled BREDA vehicle electrical equipment are as follows:
  1. The normal operating frequency of the propulsion and braking chopper will be 273.0 Hz, with a tolerance of +/-6 Hz on the 15th harmonic, which is 4095 Hz.
  2. The normal range of frequency drift of the propulsion and braking chopper, will be +/-0.01 percent.
  3. The level of inductive interference produced by the propulsion chopper and all auxiliary choppers will be not greater than that shown in Graph 1, Level of Induced Interference (in the ATC Technical Appendix), which represents the magnitude of open-circuit rail-to-rail potential vs. the train control frequency spectrum. The open circuit rail-to-rail potential presented in Graph 1 is the worst-case rail-to-rail potential that would be measurable at any point beneath the vehicle with no train control equipment connected to the rails. The values given are a composite from all emitting sources on the married pair.
- B. The level of conductive interference produced by the propulsion chopper and all auxiliary choppers will be not greater than that shown in Graph 2, Level of Conductive Interference (in the ATC Technical Appendix), which represents the magnitude of the AC component of the return current from a single car (4 motors) vs. the train control frequency spectrum. The AC current component shown in Graph

2 is the worst-case composite of the interference produced by all of the electrical subsystems of a single married pair. The train control frequency spectrum is 50 Hz to 15,000 Hz.

**1.07 RELATED SECTIONS**

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
1. Section 16913 ATC Block Design

**PART 2 - PRODUCTS**  
NOT USED

**PART 3 - EXECUTION**  
NOT USED

**END OF SECTION**

**SECTION 16906  
DETERMINATION OF PAYMENT FOR ATC WORK**

**PART 1 - GENERAL**

**1.01 SECTION INCLUDES**

- A. A listing of the various ATC Activity/Equipment items which will be paid for separately as part of the Automatic Train Control (ATC) System.
- B. Reference to guidelines for measuring various ATC subsystems, equipment items, and required design, documentation, testing, and training activities to determine partial payment schedules for same.

**1.02 SEPARATE ACTIVITIES AND EQUIPMENT INCLUDED IN ATC LUMP SUM PRICE**

- A. The total payments for the Automatic Train Control System will equal an ATC Lump Sum Price included in the Unit Price Schedule for the entire Construction Contract.
- B. The ATC System Lump Sum Price for this Contract will be allocated among the following ATC activity and equipment items:

<u>Item Number</u>	<u>Specification Section</u>	<u>Activity/Equipment Description</u>
1	Division 1, Art. VI.A.	
2	16900	ATC Progress Schedules
3	16900	ATC Design Engineering
4	16900	ATC Material & Fabrication
5	16911	ATC Installation
6	16918	Tunnel and Invert Cleaning
7	16919	Tie-In Work, ( <i>Location</i> )
8	16927	ATC System Safety Program
9	16927	Microprocessor Support Systems
10	16931	Drawing Editor Systems
11	16931	Shop Test Station for NVIP PCBs
12	16931	Basic ATC Test and Maintenance Equipment
13	16931	TWC Transmitter Test Fixture
14	16931	TWC Receiver Adjustment Test Fixture
15	16931	Portable Test Fixture for Vital DC Relays
16	16931	Portable Test Fixture for Vital AC Relays
17	16931	Portable Test Fixture for Non-Vital DC Relays
18	16931	Shop Test Fixture for Impedance Bonds
19	16931	Marker Coil Dynamic Test Unit
20	16931	Shop Test Fixture for RTUs
21	16931	Shop Test Fixture for ATP Modules
22	16931	Shop Test Fixtures for Non-Vital Station Processors
23	16931	Shop Test Fixtures for Non-Vital Interlocking Processors
24	16931	Shop Test Fixtures for Inter-locking Vital Processors

<u>Item Number</u>	<u>Specification Section</u>	<u>Activity/Equipment Description</u>
24	16931	Spare Equipment <sup>1</sup> (See Note 2 to Contractor)
25	16932	Selectable Tools and Equipment Components <sup>2</sup> (See Notes 1 & 2 to Contractor)
26	16933	Training Room Equipment/Activity (Where Required)
27	16980	Tie-In Location Testing
28	16980	Intermediate Interlocking Station Location(s) Testing(As Required)
29	16980	Intermediate In-Line Station Location(s) Testing(As Required)
30	16980	Terminal Station/Interlocking Location Testing(As Required)
31	16988	ATC QA Program
32	16991	ATC Drawings & Tracings
33	16992	ATC Instruction Manuals
34	16993	ATC Training Courses

- C. The Total Lump Sum Price for the ATC System shall be distributed over Activity/Equipment Items 1 through 34 inclusive, in a manner to be determined by the Authority.

### **1.03 ATC SYSTEM MEASUREMENT FOR PARTIAL PAYMENTS**

- A. Automatic Train Control System equipment and activities will be measured for partial payments as described in the various individual 16900-series Sections of the Specifications, and in certain other Sections referenced by the 16900-series Sections.

### **1.04 RELATED SECTIONS**

- A. Division 1, General Requirements  
B. All 16900-series Sections

### **PART 2 - PRODUCTS**

NOT USED

### **PART 3 - EXECUTION**

NOT USED

#### **NOTES TO CONTRACTOR:**

- The payments for Item 25, Selectable ATC Tools and Equipment Components will equal a percentage (to be determined by the Authority) of the amount paid for Item 3, ATC Material and Fabrication.
- The payments for Item 25, Selectable ATC Tools and Equipment Components will equal a percentage (to be determined by the Authority) of the amount paid for Item 3, ATC Material and Fabrication.

**END OF SECTION**

**SECTION 16910**

**BASIC WAYSIDE ATC REQUIREMENTS  
(Table of Contents)**

**PART 1 - GENERAL**

**1.01 SECTION INCLUDES**

A. This SECTION lists the various 16910-series Basic Wayside ATC Requirements Specification Sections:

- |    |   |                 |
|----|---|-----------------|
| 1. | Scope of ATC Work                               | (Section 16911) |
| 2. | ATC Submittal Requirements                      | (Section 16912) |
| 3. | ATC Block Design                                | (Section 16913) |
| 4. | Environmental Requirements                      | (Section 16914) |
| 5. | Basic ATC Equipment Requirements                | (Section 16915) |
| 6. | Basic ATC Circuit Requirements                  | (Section 16916) |
| 7. | Basic Interlocking Requirements                 | (Section 16917) |
| 8. | Special ATC Requirements for Specific Locations | (Section 16918) |
| 9. | ATC System Safety Program                       | (Section 16919) |

**PART 2 - PRODUCTS**

NOT USED

**PART 3 - EXECUTION**

NOT USED

**END OF SECTION**

## SECTION 16911

### SCOPE OF ATC WORK

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the physical and geographical extent of the work which shall be performed by the Contractor to fulfill the intent of the Automatic Train Control portion of this Contract. The intent of this part of the Contract is that the Contractor shall provide the following services in the manner specified:
- B. Description and Basic Requirements
  - 1. Provide, in the manner specified herein, the Block Design and the final design, fabrication, delivery, installation, testing, documentation and placing in service of every system, subsystem, circuit and piece of equipment described, required or implied by the Contract Documents to establish a safe, complete, workable, operating wayside Automatic Train Control (ATC) System for the portion of the METRORAIL System of the Washington Metropolitan Area Transit Authority included in this Contract.
  - 2. Employ a qualified railway signal engineer, approved by the designated Resident Engineer (Engineer):
    - a. To check all circuits shown on the Contract Drawings and to notify the Engineer of any discrepancies or omissions, and; To check and sign all circuit drawings furnished by the Contractor before submittal of such circuits to the Engineer.
  - 3. Provide accurate and timely preliminary documentation as a prerequisite to fabrication, procurement and installation work. This shall include complete, detailed cable/conduit/ ductbank/manhole/surface trench documentation submitted to the Engineer for review and approval for each TCR area of control prior to cable installation in each applicable area.
  - 4. Provide accurate ongoing and final documentation in a timely fashion, and in the specified medium(s), content and format. (See Section 16991, ATC Drawings and Tracings.)
  - 5. Provide all required and/or necessary spare equipment, test equipment, and support function hardware and software. (See Section 16930, ATC Facilities and Spare Equipment.)
  - 6. Provide instruction and training to designated Authority personnel concerning the operation and maintenance of certain equipment and subsystems comprising the ATC System. (See Section 16992, ATC Instruction Manuals, and Section 16993, ATC Training Courses).
- C. The ATC System and subsystems provided under this Contract shall be as specified in these documents, and shall be compatible in every respect with the existing Automatic Train Control System described in Section 16904, Current Automatic Train Control System.
- D. The ATC equipment and systems provided under this Contract shall be immune to interference from all transit vehicle electrical subsystems, and to interference from any WMATA VHF hand held radio transmitter or cell phone keyed at a distance of six inches from the equipment or system.
- E. The ATC equipment which the Contractor provides shall be capable of working safely during a temporary imbalance in the magnitude of negative propulsion return currents in the

- running rails in a ratio as high as 2-to-1 for durations as long as 1 second.
- F. The subsystems and equipment included in the ATC System provided under this Contract shall be designed for accessibility and ease of maintenance.
- G. All adjustable ATC equipment and components shall be designed to operate within their 25-percent-to-75-percent adjustment range under all normal conditions, wherever possible. Provide the reason and justification to the Engineer in writing wherever this condition cannot be obtained.
- H. Provide complete ATC lightning and surge protection systems which shall protect ATC equipment and systems from damage due to lightning or other external electrical discharge, and complete grounding systems which shall protect ATC equipment and personnel from damage or injury due to short circuits or overload conditions.
- I. Read and comply with all notes on the Contract Drawings for the Wayside ATC System.
- J. Provide the special facilities and capabilities, and perform the additional work specified in Section 16918, Special ATC Requirements for Specific Locations.
- K. The Contractor's ATC work schedules for the route segment included in this Contract shall be based upon a Notice to Proceed date and certain Access and Completion dates specified in elsewhere in this Specification, and in Section 16995 (Appendix "L").
- L. The Interlocking Vital Processor Systems which shall be used to implement certain vital interlocking control functions and vital speed selection functions shall meet all requirements specified in Section 16928, Interlocking Vital Processor Systems.
- M. Cooperate and coordinate with the appropriate Authority personnel to delineate the method of determining train length on the trains and transferring the indication of this length to the wayside via the existing TWC System.

**1.02 LIMITS OF WORK**

- A. The geographical limits of the segment of new METRO trackage for which the Contractor shall provide a complete, new wayside ATC System under this Contract shall be as follows:
  - 1. Geographical Description & Civil Stationing e.g.: "That portion of the "X" Route mainline tracks starting at TC Stationing Xyyy+zz I.B. & O.B. BK in (Name of City, County and State) and ending at TC Stationing Xggg+hh I.B. & O.B. BK, in (Name of City, County and State)"
  - 2. This area includes (**how many**) new Train Control Rooms and (**how many**) new Train Control Equipment Rooms (TCERs) (constructed by other disciplines) at the following locations:

a. EXAMPLE

Location Name	<u>Location Code</u>	<u>Station/Interlocking Configuration</u>
Naylor Road TCR	F-09	Surface Station. U.G. Emergency X- O
Suitland TCR	F-10	Surface Station

- B. Provide, in close cooperation and coordination with WMATA maintenance and operating personnel, modification and tie-in work at the following existing TCR which is already in Revenue Service:

1. EXAMPLE:

<u>Location Name</u>	<u>Location Code</u>	<u>Station/Interlocking Configuration</u>
Anacostia	F-06	Underground Interlocking; Convert Temporary Terminal to Emergency X-O

2. This work shall be performed at the appropriate times, in such a manner as to cause a minimum of disruption to Revenue Service. (See Section 16918, Special ATC Requirements for Specific Locations).

- C. Provide all ATC final design, equipment and circuitry, and perform all work required to complete the furnishing, installation, reprogramming, testing and documentation of the ATC System in the (designated) TCR area of control, and (EXAMPLE:) to convert the (designated) interlocking from an automatic terminal configuration to an emergency crossover configuration, as indicated on the Contract Drawings and as specified herein. This shall include all necessary additions, deletions and modifications to the existing circuitry and programming, and necessary modifications to, and/or replacement of, the existing interlocking control panel at the (designated ) TCR.
- D. Perform all ATC work stipulated in the Contract and altered or extra ATC work, and furnish all labor and supervision necessary for the prosecution and completion of the ATC work.

**1.03 MAJOR SUBSYSTEMS**

- A. The major wayside subsystems which shall be provided as components of the wayside Automatic Train Control System under this Contract are:
  - 1. Automatic Train Protection (ATP)
  - 2. Automatic Train Operation (ATO)
  - 3. Automatic Train Supervision (ATS)
- B. The Automatic Train Protection System shall be provided as specified herein and shall include all wayside subsystems necessary to provide safe operation of trains. This shall include the control of interlockings and the safe operation of car doors on the trains. This system shall be implemented with vital relays and with vital processor modules as specified in Section 16928, Interlocking Vital Processor Systems.
- C. The "new" interlocking(s) shall be equipped with Non-Vital Interlocking Processor Systems which shall perform the non-vital interlocking functions represented by the non-vital interlocking circuits shown in the Contract Drawings. Non-vital interlocking diagnostic functions shall also be accomplished by means of these microprocessor-based systems, as specified in Section 16926, Microprocessor Systems for Non-Vital Interlocking Functions. The "new" interlocking(s) shall also be equipped with Interlocking Vital Processor (IVP) Systems, as specified in Section 16928.
- D. The Automatic Train Operation System shall be provided as specified herein and shall include all wayside equipment and subsystems:
  - 1. To cause the trains to accelerate and decelerate at the proper rates,
  - 2. To cause the trains to maintain the desired speed under various conditions of grade and curvature;

3. To cause the trains to stop automatically at the proper position at station platforms;
  4. To cause the trains to be capable of automatic door opening and closing, and automatic dwell timing, and;
  5. To automatically control (future) platform train destination signs.
- E. The non-vital functions related to train/station operations shall be accomplished by microprocessor-based systems as specified in Section 16924, Non-Vital ATO & ATS Processor Systems.
- F. The Automatic Train Supervision System shall be provided as specified herein. It shall include all wayside equipment and subsystems necessary to supervise the scheduled performance of trains and to control and monitor certain transit system mechanical support facilities and electrical power facilities. It shall also include additions and modifications to the existing wayside Data Transmission System (DTS), and the furnishing, installation and testing of Remote Terminal Units (RTUs) at each new TCR as specified herein and as shown on the Contract Drawings.
- G. The RTUs at the new Train Control Rooms shall be as specified in Section 16925, Data Transmission System (DTS). In addition, a new RTU of the type specified in Section 16925 shall be provided and delivered to the Authority for training and emergency replacement use. See also Section 16932, Spare ATC Equipment and Selectable Items.

#### **1.04 SUPPORT SYSTEMS**

- A. Provide all systems, equipment and facilities required or necessary to support the major ATC subsystems listed above, and all ancillary support systems and facilities as specified herein.
- B. Electrical Systems
1. Provide ATC Power Distribution Systems as specified in Section 16921.
  2. Provide ATC Lightning/Surge Protection and Grounding Systems as specified in Section 16922.
- C. Provide additions to the Train Control Maintenance Telephone System as specified in Section 16923.
- D. Microprocessor Systems
1. Provide Non-Vital ATO & ATS Processor Systems as specified in Section 16924.
  2. Provide additions to the existing Data Transmission System as specified in Section 16925.
  3. Provide Microprocessor Systems for Non-Vital Interlocking Functions as specified in Section 16926.
  4. Provide Interlocking Vital Processor Systems as specified in Section 16928.
  5. Furnish Microprocessor Support Systems as specified in Section 16909.

#### **1.05 ENVIRONMENTAL REQUIREMENTS**

- E. Provide and maintain all ATC equipment and material under the provisions of Section 16914.
- F. Provide and maintain specific ATC equipment and material to the environmental requirements listed in individual Related Sections.

## **1.06 RELATED SECTIONS**

- A. Division 1 - General Requirements
- B. All Sections in the 16900 series.

## **1.07 REFERENCES**

- A. Listed in individual Related Sections, where applicable.

## **1.08 QUALITY ASSURANCE**

- A. Perform certain pre-design, pre-installation and pre-test field inspections as specified herein, and in Section 16988, ATC Quality Assurance. ATC Subsystems and components shall be inspected and tested as specified in the applicable individual ATC Sections of these Specifications.
- B. The installed wayside ATC equipment, systems and subsystems shall be field inspected and tested as specified in Section 16980, ATC Tests, Inspections and Quality Assurance.
- C. As a general requirement of these Specifications, the ATC test procedures and tests which the Contractor develops and performs shall not only ensure that the ATC equipment, circuits, systems and subsystems are performing the tasks which they are required to be performing, in the manner specified (POSITIVE TESTING), but shall also ensure that the ATC equipment, circuits, systems and subsystems are not performing in any manner which could have an unsafe or undesirable effect upon METRORAIL operations, METRO riders, or the public in general (NEGATIVE TESTING). While the POSITIVE TESTING requirements and some of the NEGATIVE TESTING requirements are set forth in these Specifications in considerable detail, it shall also be incumbent upon the Contractor, based upon past experience and familiarity with his own equipment, to include in the test procedures and tests, requirements for actions and verifications which shall either:
  - 1. Reveal any additional potential or existing unsafe or undesirable conditions, or;
  - 2. Prove that unsafe or undesirable conditions do not exist.
    - a. These requirements shall apply not only to conditions inherent to the ATC systems, but also to potentially unsafe or undesirable conditions resulting from interaction between the ATC systems and other systems or the operating environment.
- D. Comply with the requirements of Section 16988, ATC Quality Assurance.

## **1.09 HOURS OF WORK**

- A. Work such hours per shift, with or without overtime, as many shifts per day and as many days per week as necessary (with the exception of the restrictions noted below), to complete the various parts of the ATC work and the entire ATC work within the dates specified in Section 16995, ATC Appendix "M". This work shall be conducted in accordance with:
  - 1. The Authority's RAIL ADMINISTRATIVE PROCEDURE RAP 100-9, Access to Revenue or Start-Up Railroad Facilities, and;
  - 2. The following WMATA STANDARD OPERATING PROCEDURES:
    - a. SOP #19 - Maintenance and Testing on Revenue Facilities
    - b. SOP #33 - Removal and Restoration of Third Rail Power for Work by Contractor's Forces - Mainline, Revenue System.
- B. Work in the Operating Metro System

1. Submit a weekly work schedule ten days in advance, to the Engineer detailing the type of work, location and hours of work which will take place during the week.
2. Scheduled ATC work in the operating Metro Rail System shall conform to the following allowed hours of work:
 

a.	Track Level	Mon-Fri Sat-Sun	1:00 AM to 4:00 AM 3:00 AM to 6:00 AM
b.	Platform Level		Anytime except rush hours, as coordinated with the Authority
c.	TCR	Mon-Fri Sat-Sun	1:00 AM to 4:00 AM 3:00 AM to 6:00 AM
d.	Jackson Graham Building (OCC)		Possible Times: 10:00 AM to 2:00 PM 8:00 PM to 11:00 PM 1:00 AM to 5:00 AM as coordinated with the Authority
3. No work will be permitted at any location in the operating METRO SYSTEM during the following rush hours:
  - a. 7:00 AM until 9:30 AM - Mon. through Fri.
  - b. 11:30 AM until 2:00 PM - Mon. through Fri.
  - c. 4:00 PM until 8:00 PM - Mon. through Fri.
  - d. No rush hours exist on Saturday or Sunday, but access may be denied due to special events.

## **PART 2 - PRODUCTS**

### **2.01 BASIC REQUIREMENTS**

- A. Furnish, unless otherwise specified or provided in the Contract, all material, implements, machinery, equipment, tools, supplies, protective coverings, air conditioning, dehumidification, dewatering, transportation, cleaning, heat, water, light, and power required or necessary for the prosecution and completion of the ATC work.

### **2.02 SUBMITTALS**

- A. All ATC submittals shall conform to the requirements of Section 16912, Basic ATC Submittal Requirements.

### **2.03 SPECIAL INSTALLATION EQUIPMENT**

- A. Where local conditions, (e.g., close clearances, or tunnel cross adits, or other openings in tunnel walls or retaining walls) make it impossible to install cable or other ATC apparatus in the usual specified manner, it shall be the Contractor's responsibility to design, furnish and install appropriate cable tray and/or special mounting brackets of a type and design approved by the Engineer, at no additional cost to the Authority.

## **PART 3 - EXECUTION**

### **3.01 DESIGN**

- A. Develop and furnish to the Authority a complete block design for the route segment

included in this Contract within 120 days of receipt by the Contractor of NTP. This shall include coordination with, and any necessary modifications to the block design of the tie-in location(s) already in service. This block design shall be based upon the characteristics of imaginary, worst-case-composite WMATA transit vehicles, i.e., transit vehicles which incorporate the worst characteristics, from a safety point of view, of each of the types of WMATA METRORAIL passenger transit vehicles currently in Revenue Service. (See Section 16905, Transit Vehicle Characteristics.)

- B. The ATC block design for the route segment included in this Contract shall be in conformance with the requirements specified in Section 16913, ATC Block Design. This shall include design to meet special requirements set forth in Section 16918, Special Requirements for Specific Locations, and on the Contract Drawings.
- C. Complete the final ATC circuit and detail design in conformance with all requirements and restraints specified herein.
- D. Provide complete mechanical design for installation of the required wayside ATC equipment. The installation of the wayside ATC equipment shall be as specified herein and as indicated on the Contract Drawings wherever possible and practical to best meet the intent of these Specifications. Where local conditions prevent the specified typical installation, it shall be the Contractor's responsibility to design and implement alternate methods of equipment mounting, subject to the approval of the Engineer, at no additional cost to the Authority.
- E. Clearance
  - 1. Design for a clearance envelope four (4) inches larger than the dynamic outline of the transit cars, i.e., ATC equipment shall be so located that all parts of wayside ATC equipment, including open doors or covers of such equipment, are at least four (4) inches from the dynamic outline of the transit cars wherever possible. This shall include allowances for: middle and end overhang of the cars at turnouts and crossovers and on non-tangent track, and; tilting of the cars on superelevated track.
  - 2. Where, due to circumstances beyond the Contractor's control, it is impossible to comply with the "4-inch envelope" requirement for mounting ATC equipment in the normal manner or location, notify the Engineer in a timely fashion and submit one or more alternate mounting designs for the approval of the Engineer. In all cases, a clearance envelope two (2) inches larger (in all directions) than the dynamic outline of the transit cars shall be regarded as an absolute minimum clearance requirement for the mounting of ATC equipment. This envelope shall include allowances for all overhang and tilting of the cars.
- F. Electrical conductor sizes shown in the Specifications shall be regarded by the Contractor as the minimum sizes allowable for specific applications. The Contractor shall, as part of his final circuit design work, make the computations necessary to determine what conductor sizes are required to overcome line losses on cable runs to ensure that the proper operating voltage and current are available at each piece of ATC equipment to be used. These computations shall be submitted to the Engineer. Where conductor sizes larger than the minimum sizes shown in the Specifications are necessary for proper adjustment and operation of the ATC equipment, the Contractor shall include these larger conductor sizes in the final design and provide them at no additional cost to the Authority.

### **3.02 PRELIMINARY SITE INSPECTION**

- A. Conduct within 30 calendar days of individual site availability, a thorough inspection of all TCRs, ancillary rooms and other wayside locations where wayside ATC equipment and support system equipment required by these Specifications is to be installed. This inspection shall include, but not be limited to, the following:
1. Inspect the trackwork right-of-way and promptly notify the Engineer in writing, of any conditions which would interfere with the proper installation, safe operation or proper maintenance or replacement of the wayside ATC equipment.
  2. Inspect the trackwork provided by other disciplines to verify that the as-installed locations of insulated joints are necessary and correct to perform the ATC system functions required. Promptly notify the designated Resident Engineer in writing, of any missing, incorrectly located, extraneous, or obviously defective insulated joints observed in this inspection.
  3. Inspect the special trackwork provided by other disciplines to verify proper location and operation of switch points, correct placement and type of switch rods, and adequate drainage around switch layouts and throughout the interlocking.
  4. Inspect the concrete tunnel walls and, where applicable, the channel inserts installed therein, along the METRO trackage included in this Contract and note any conditions which would interfere with proper installation of cable or other required wayside ATC equipment thereon.
  5. Take special note of wayside conditions that might interfere with the required sight distances for signals.
  6. Take special note of wayside conditions which might interfere with the proper location, installation, replacement, operation or maintenance of switch-and-lock movements, switch rods, wayside signal and pushbutton layouts, impedance bonds, inductive track loops, signal or negative-return bonding, or marker coil layouts.
- B. Submit, within 15 calendar days of performance of each initial preliminary site inspection, a report of this initial preliminary inspection to the Engineer. This report shall list all potential problems noted and indicate the specific actions the Contractor proposes to surmount the problems.
- C. Following the initial site inspections, perform periodic on-site inspections to identify incomplete or incorrect work by other contractors or other disciplines which, if not corrected, will have either an immediate or eventual effect upon the design, installation, testing, operation and/or maintenance of the ATC System specified herein. These inspections shall be for the purpose of identifying any incorrect work by others, or by other disciplines, which must be corrected in order that the ATC systems will operate as specified.
- D. The Contractor shall have the responsibility for coordinating the scheduling of these inspections with the Engineer. However, the Contractor shall assume full responsibility for identifying any item of incorrect related work by others or by other disciplines well in advance of the completion date so that:
1. The Authority and other disciplines or contractors will have sufficient time to take the necessary corrective action.
  2. The Contractor will have sufficient time to install and test the specified Train Control system without impacting the project completion schedule.
- E. Examples of incorrect work include, but are not limited to the following:
1. Missing facilities, such as insulated joints or conduit runs.
  2. Incorrectly located facilities, such as insulated joints, or conduit runs.

3. Improperly prepared sites, e.g., intrusions into the ATC design envelope, or conditions that would prevent proper maintenance or replacement of the ATC equipment.
  4. Improperly installed equipment, e.g., switch rods.
  5. Equipment which is inadequate or otherwise unsuitable for the specified operation of the approved ATC system.
- F. Submit written reports of these inspections to the Engineer within 48 hours of the date they are performed. These reports shall contain the following information:
1. Location and date of inspection.
  2. Attendees at inspection.
  3. Descriptions of problems identified.
  4. Contractor's recommendations for the corrective action necessary.
  5. Contractor's estimate of the latest completion date for corrective action which will not impact his completion schedule.
  6. Contractor's reasons why the problem was not reported on his previous inspections.
  7. Description of the train control work, if any, which is impacted by the problem identified.
  8. If the Contractor fails to identify incorrect work by other contractors or disciplines (which will prevent proper or timely installation or testing of ATC work) and notify the Authority in a timely manner, he shall be responsible for correcting that work as part of this Contract at no additional cost to the Authority. Furthermore, the Contractor shall then be responsible for making any resulting necessary corrections or additions to his own work after the incorrect work of other contractors or disciplines has been corrected, all at no additional cost to the Authority.

### **3.03 FABRICATION AND PROCUREMENT**

- A. Upon receiving approval of required submittals, proceed with the procurement, manufacture, factory testing, shipment and/or storage of all approved material and equipment in such a manner that it is available in good working order, at the time and place scheduled.

### **3.04 DELIVERY, STORAGE AND HANDLING**

- A. Deliver the specified equipment, material and software included in this Contract to the various appropriate TCR and wayside locations no earlier than the respective access dates indicated in Section 16995 (Appendix "M") of the Contract Documents.
- B. Deliver products and material to site under provisions of Section 16911 3.04.
- C. Comply with delivery requirements specifically listed in individual Related Sections, where applicable.
- D. The Contractor shall be responsible for safe and protected transportation and storage of all ATC System equipment and materials from the time of its manufacture or procurement until such time that it is installed.

### **3.05 JOINT PRE-INSTALLATION INSPECTION**

- A. Prior to the field installation of wayside equipment along the track right-of-way in each

TCR area-of-control, participate with the Authority's Engineer in a joint field inspection to determine:

1. The suitability of the Contractor's final design for the installation of wayside equipment relative to existing field conditions, with special emphasis on clearance and sighting considerations;
  2. The final, exact location for each piece of ATC equipment which cannot be installed in the normally specified manner due to some obstruction or restriction.
- B. Produce dimensioned sketches, in duplicate, to document the final, non-standard equipment locations agreed upon. These sketches shall be initialed by the Contractor and the Engineer, and one copy retained by each.

### **3.06 INSTALLATION**

- A. Install all necessary and/or required Train Control Room ATC equipment in the TCRs constructed by others (or by other disciplines). The TCRs will be located in passenger stations wherever practical. Suggested layouts for these rooms are included in the Contract Drawings. Where the proposed or completed lighting arrangement by others (or by other disciplines) in a TCR conflicts with the requirements of the ATC portion of this Contract, the Contractor shall modify the lighting system in an acceptable manner, at no additional cost to the Authority.
- B. Install all necessary and/or required trackside ATC equipment. The types of construction involved are shown on the Contract Drawings furnished with these Specifications and on other drawings available to the Contractor. Any trackside ATC equipment that is installed in such a manner that it does not meet the clearance or sighting requirements specified herein shall be reinstalled properly by the Contractor at no additional cost to the Authority.
- C. All installation work shall be performed in accordance with stamped approved drawings. No installation work shall begin without a copy of the applicable approved drawings on site.
- D. Take all reasonable measures and perform all work necessary to protect the installed ATC equipment and circuitry from damage due to dust, moisture, heat, cold and other potentially damaging conditions, at no additional cost to the Authority.

### **3.07 FIELD DOCUMENTATION**

- A. An as-built copy of the Room Book of Plans shall be kept in each Train Control Room during all phases of installation and test. The room as-builts shall reflect the current status of room and wayside wiring at all times.
- B. Failure to maintain the room as-built plans will result in suspension of all activities until complete up-dates are made.

### **3.08 INSPECTIONS AND TESTING**

- A. Type Acceptance Testing
1. All ATC equipment proposed for use on the WMATA Metrorail System under this Contract which is not identical to ATC equipment already in regular use on the WMATA Metrorail System shall be subject to Type Acceptance Testing to determine whether it meets the specified requirements in a manner acceptable

to the designated Resident Engineer. The Contractor shall devise, perform and document such tests, subject to the direction and approval of, and observation by, the Engineer, at no additional cost to the Authority. The decision of the Engineer with regard to the acceptability of proposed new equipment, equipment configuration, methodology, circuitry and/or programming will be final.

- B. Factory Inspections and Tests
  - 1. Perform and document factory and procurement inspections and tests on ATC materials, equipment and systems to be installed under this Contract as specified in the Quality Assurance portions of the various articles specifying the materials, equipment and systems.
- C. Field Inspections and Tests
  - 1. Perform and document field inspections and tests on all ATC systems and equipment as specified in Section 16980, ATC Tests and Inspections, and as specified herein and in other individual Sections of these Specifications.

### **3.09 TIE-INS AND ACTIVATION**

- A. Work in close cooperation and coordination with the Authority when making the required modifications and additions to existing, operating ATC circuits and equipment in order to place the new ATC systems in operation in a safe and efficient manner without interfering with revenue service or other normal METRORAIL operations. This work shall be done as specified in Section 16918, Special ATC Requirements for Specific Locations.
- B. When the METRORAIL extension or expansion project included in this Contract is put into operation:
  - 1. Disconnect all applicable pre-existing ATC TCR equipment which is no longer required.
  - 2. Remove and deliver to the Authority, in good working condition, all of the Authority's pre-existing wayside ATC equipment which is no longer required, except for wall mounted cable and junction boxes, which shall be left in place.

### **3.10 SAFETY**

- A. Conduct an ATC System Safety Program for all areas of wayside and trackage equipped under this Contract, as specified in Section 16919, to ensure the safety of the ATC equipment, circuits and systems installed, and the safety of all personnel involved in the associated installation and testing activities.

### **3.11 TUNNEL AND INVERT CLEANING (Where Applicable)**

- A. Perform (at the appropriate time after all other installation work in the new "X" Route Trackwork area has been completed, and prior to dynamic train testing, on both the outbound and inbound tracks) the following tunnel cleaning and invert cleaning work in all underground trackwork areas within the limits of this Contract:
  - 1. Cover all drain openings with adequate filter media to prevent entry of wash down debris into the drainage system. Filter media shall be monitored and maintained during the wash down.
  - 2. Clean all tunnel, tunnel invert, safety walk, track and wayside equipment surfaces using a method adequate to remove dust and debris which may become airborne during dynamic train testing. This cleaning shall include, but

not be limited to, the surfaces of junction boxes, cables, fire lines, running rails, restraining rails, third rail, third rail cover boards, track fasteners, conduits, safety walks, cross adits, the areas under the running rails and the contact rails.

3. Remove all debris resulting from the tunnel and invert cleaning.
  4. Remove filter media from the drain openings once all cleaning operations have been completed.
- B. Furnish, through agreement with the local jurisdiction, any water needed for the cleaning operations.
  - C. Take appropriate measures to protect all equipment installed in the area being cleaned. The Contractor shall be responsible for damage to any equipment resulting from the cleaning operation.
  - D. Upon completion of the cleaning operation, inspect each of the drain openings for debris. Remove all debris and prove the drainage system using an adequately sized mandrel.
  - E. The Contractor shall remain responsible for the prevention of airborne dust in the inbound and outbound tunnels for the duration of all dynamic train testing including dynamic system testing.

### **3.12 ATC EQUIPMENT FAMILIARIZATION**

- A. Provide, as a minimum, adequate special instruction and training to thoroughly acquaint appropriate Authority operating and maintenance personnel with ATC equipment and circuits furnished under this Contract which are different from those used on previous operating segments of the METRO system. In addition, provide training as specified in Section 16993, ATC Training Courses, and various other Sections of these Specifications, for certain other specific equipment and systems.

### **3.13 ATC DOCUMENTATION**

- A. Provide both on-going and final, "AS-BUILT" documentation of all ATC equipment, systems, programs, tests, inspections, installation methods, procedures, block design and circuits required or necessary under this Contract in the manner specified in Section 16912, Basic ATC Submittal Requirements, Section 16990, ATC Documentation and Training, and as required by this Section and various other related Sections of these Specifications.
- B. Provide, for each TCR newly equipped or modified under this Contract, a separate magnetic media record (and a separate optical media record) in an Authority standard software program, which indexes each ATC relay coil and heel contact to a specific circuit drawing number in that Room Book of Plans. These records shall be in a spreadsheet or data base format and shall be known as Relay/Contact Location Charts. (See the Contract Drawings for an example format for these charts.) The charts shall be organized by the relay names. The relay names shall be shown on the charts in two sections. The first section is for relay names starting with numbers. The numbered names shall be entered into the chart in ascending order. All relays having the same number shall be entered consecutively into the chart in alphabetical suffix order. Relay names beginning with letters shall be entered into the second section of the chart. All relays beginning with the same letter shall be entered consecutively into the chart according to succeeding letters (alphabetically), numbers (in ascending order) or both.

- C. Provide "Equivalent Circuit" drawings in discrete-component logic style for every Boolean algebra software logic statement used to document the logic used in the ATC microprocessor units furnished under this Contract. These drawings shall include a complete, alphabetical listing of all terms used in the Boolean logic statements and their definition in clear and concise English.

### **3.14 ATC SYSTEM TESTING SUPPORT**

- A. Assist the Authority in the system testing of all mainline/OCC interface circuits, systems and subsystems at no additional cost to the Authority.

### **3.15 BASIS FOR PAYMENT**

- A. The basis for final, total payment for the Wayside ATC System included in this Contract will be the *applicable* lump sum and unit prices listed in the Contract Unit Price Schedule, which will constitute compensation for all ATC material and ATC work required to complete the Contract.
- B. No ATC material will be paid for until the applicable product submittals and Contractor produced drawings have been submitted in proper sequence by the Contractor and approved by the Engineer.
- C. For any given product or subsystem:
  - 1. No circuits will be approved until all applicable product submittals have been approved;
  - 2. No arrangement plans for layouts will be approved until all applicable circuits have been approved,
  - 3. No payments will be made until the applicable arrangement plans or layouts have been approved.
- D. No payment will be made for ATC work executed without approved drawings.

### **3.16 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. ATC equipment, circuits, systems, tests, special programs and documentation will be measured for partial payments as specified elsewhere in the Contract Documents, and as specified in the individual Sections of the ATC Technical Provisions of these Specifications.
- B. Partial payments for ATC work and equipment will be made periodically, based upon the payment schedules established by the Authority, which in turn will be based upon:
  - 1. Compliance with the specified requirements for such payments, to include the timely and accurate submittal of required documentation in the proper format;
  - 2. The percentage of equipment provided and work done in the manner specified,
  - 3. The acceptability of the equipment, systems, programs, or documentation provided, as applicable.
- C. Tunnel and Invert Cleaning (where applicable) will be measured for payment based upon:
  - 1. Satisfactory performance of the work required.
  - 2. Satisfactory completion of dynamic train testing in the tunnel areas.

### **3.17 MEASUREMENT FOR PARTIAL PAYMENTS FOR TUNNEL AND INVERT CLEANING**

- A. Factors which will be considered when determining partial payments for Tunnel and Invert Cleaning will include the following:
  - 1. Satisfactory completion of the required cleaning.
  - 2. Satisfactory completion of dynamic train testing in the applicable area.

**END OF SECTION**

## SECTION 16912

### ATC SUBMITTAL REQUIREMENTS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the various types of ATC submittals and resubmittals required by this Contract, the preparation and delivery to the designated Resident Engineer (Engineer) of these submittals, and various other requirements of the ATC submittal and review process. In case of conflict between the requirements of this Section and those contained elsewhere in these contract documents, the requirements of this Section shall govern ATC Submittals.

##### 1.02 TYPES OF ATC SUBMITTALS

- A. The basic types of ATC submittals required include:
1. Train Control Drawings
  2. Technical Review Documentation
  3. Samples
  4. Certifications
  5. Special Documentation
  6. Inspection Reports
  7. Test Plans and Procedures
  8. Test Reports and Data Sheet
  9. Contract Record Drawings

##### 1.03 BASIC SUBMITTAL REQUIREMENTS

- A. It shall be the responsibility of the Contractor to ensure that competent personnel are assigned and retained for the task of preparing the required ATC submittals and all other documentation necessary to comply with the Specifications. Submitted documents shall be complete. Submitted circuit and equipment drawings shall have been thoroughly checked for completeness and accuracy and shall bear the initials or signature of a fully qualified checker in witness thereof before being submitted to the Engineer for approval.
- B. Submit performance data and final design and installation drawings to the Engineer for approval of all ATC equipment which the Contractor proposes to use under this Contract. The Contractor shall not proceed with the fabrication or procurement of equipment or materials, except at his own risk, until such items have been approved by the Engineer.
- C. When submitting drawings, manuals and other documentation to the Engineer for the initial approval of some product, subsystem, or location, the Contractor shall submit all drawings, manuals and other documentation germane to the subject, at one time. The submittal shall also include all applicable catalog cuts, certified test reports, and any other related items (including samples) which the Engineer considers necessary to evaluate the submittal. This logical grouping of documentation necessary to completely cover the subject concerned, shall be known as a submittal package.
- D. Unless otherwise specified, submittals shall be made at least 90 days prior to the necessary commencement of the work for which approval is required. Submit all required schedules, inspection procedures, inspection reports, progress reports, test procedures, test reports and other specified documentation to the Engineer on a timely basis with respect to the specified progression of the work. See Part 3.01.

##### 1.04 RESPONSIBILITY FOR DAMAGES

- A. The Contractor shall be responsible for, and bear all cost of damages which may result from the ordering of ATC material or from proceeding with any part of the ATC work prior to the approval of specified or directed submittals.

#### **1.05 TRANSPORTATION COSTS**

- A. The Contractor shall pay the transportation costs to facilitate priority shipping of ATC submittals and urgent correspondence from the Engineer's facility to the Contractor's designated point of receipt when priority shipment is necessary in order to meet or reduce delay in authorized work schedules.

#### **1.06 INTERPRETATION OF APPROVAL AND REVIEW**

- A. The approval or review of ATC submittals will be general; neither approval nor review shall be construed as:
  - 1. Permitting any departure from the Contract requirements,
  - 2. Relieving the Contractor of the responsibility for any errors including details, dimensions and materials, or,
  - 3. Approving departures from details furnished by the Engineer, except as otherwise specified
- B. The Engineer's approval will be for the purpose of minimizing changes and delays in the field and shall in no way relieve the Contractor of full responsibility for providing complete, safe, reliable, and coordinated working operating systems and subsystems for Automatic Train Control which are compatible with the current METRO ATC system in every respect.

#### **1.07 RELATED SECTIONS**

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 01250 Contract Modification Procedures
  - 2. Division 0 Contractor Requirements
  - 3. Division 1 Contractor's Submittals
  - 4. Section 16911 Scope of ATC Work
  - 5. Section 16990 ATC Documentation and Training
  - 6. Other 16900-Series Sections, as applicable

#### **1.08 REFERENCES**

- A. ASTM E329
- B. Military Specification MIL-M-09868
- C. Association for Information and Image Management (AIIM) Specification MS32-1985
- D. ANSI PH1.41-1984.

### **PART 2 - PRODUCTS**

#### **2.01 FORMAT AND MEDIA**

- A. The format and media required for the various types of ATC submittals shall be as follows:
  - 1. Train Control Drawings
    - a. Submittals of the following drawings shall be made with the prescribed number of prints on magnetic media in the AUTOCAD format (AUTOCAD Level to be determined by the Authority), or on optical media (format to be determined by the Authority):
      - 1) Double Line Track Plans
      - 2) Cable Plans
      - 3) Control Line Diagrams
    - b. The final submittal of As-Built ATC drawings shall include:

- 1) Mylar Tracings
  - 2) Aperture Cards
  - 3) Magnetic Media in appropriate AUTOCAD format, or on optical media in a format approved by the Authority
  - 4) Prints
- c. See Section 16991, ATC Drawings and Tracings.
2. Technical Review Submittals
- a. The following Review Submittals shall be made with the prescribed number of hard copy sets, and on magnetic media in any MICROSOFT format included in Office Pro (Level to be determined by the Authority), or on optical media (format to be determined by the Authority):
- 1) Block Design
  - 2) Cable/Conduit/Ductbank/Manhole/Surface Trench Installation Layouts for each TCR Area of Control
  - 3) Relay Contact Location Charts
  - 4) All WTP Pre-printed Data Sheets (except for WTP 2.18 and WTP 2.20I)
- b. The following Marker Coil and Cab Signal Level Testing Review Submittals shall be made with the prescribed number of hard copy sets, and on magnetic media in a special, executive software format approved by the Engineer:
- 1) WTP 2.18 Pre-printed Data Sheets
  - 2) WTP 2.18 Test Results
  - 3) WTP 2.20I Data Sheets and Test Results
- c. All WTP series test data (except for WTP 2.18) shall be submitted with four hard copy sets, and on magnetic media in a Microsoft Excel format (Level to be determined by the Authority)
3. Contract Record ATC Drawings
- a. As-built ATC Drawings:
- b. As-built ATC drawings shall include all new Train Control Drawings for the Automatic Train Control System and revisions to all affected existing Authority Record Drawings.
- c. Reproducible As-built drawings, both new and revised, shall be furnished on three-mil plastic film for blackline diazo printing, both sides matte, similar to Mylar and Estar. Images shall be clear, sharp and readily legible.
- d. Revisions to Authority Record Drawings shall match the base drawings in line weights, symbols, and lettering style and size. Drawings shall be provided in AutoCAD magnetic media format. (Level to be determined by the Authority), or on optical media (format to be determined by the Authority).
- e. Completed as-built drawings shall bear the signature of an officer of the Contractor organization, certifying compliance with as-built conditions, using a rubber stamp as follows

AS-BUILT	
<i>Date</i>	
_____	
I certify that this drawing accurately depicts the work as constructed.	
<i>(An Officer of the Contractor)</i>	
_____	
Signature	Title
CONTRACTOR'S NAME	

- f. Microfilmed record drawings:
- g. Upon acceptance of the as-built drawings, the Contractor shall prepare microfilmed record drawings in accordance with the following:
- 1) Military Specification MIL-M-09868 and Association for Information and Image Management (AIIM) Specification MS32-1985, except that the reduction ratio shall be 29:1 and no master roll is required.
  - 2) Employ proper backlighting techniques in order to minimize extraneous background.
  - 3) Furnish three sets of aperture cards, punched, verified and interpreted.
    - a) One set of aperture cards shall contain the silver-gelatin negative camera masters in accordance with ANSI PH1.41-1984. Two sets of Diazo duplicate aperture cards shall also be furnished. Prior to delivery of aperture cards, submit for approval one set of half-size prints reproduced from aperture cards
    - b) The format for punching is:
    - c) columns 1-3                      Three-letter code which identifies the class of information contained in the film chip. See 4) below.
    - d) columns 5-14                    Contract number
    - e) columns 16-28                  Document number
    - f) columns 30-49                  Document description
    - g) columns 51-77                  Microfilm insert, including build-up area for adhesive
    - h) columns 79-80                  Document revision level
  - 4) The three-letter codes are:
    - a) ADJ - Adjacent construction
    - b) ADR - Adjacent restoration
    - c) AFC - Automatic fare collection, rail
    - d) ATC - Automatic train control
    - e) BBL - Bus building
    - f) BFC - Bus fare collection
    - g) BGR - Bus graphics
    - h) BIC - Bike racks and lockers
    - i) BSH - Bus passenger shelters
    - j) BSV - Bus vehicles
    - k) CAT - Cathodic protection
    - l) CCE - Control center equipment
    - m) COM - Communications

- |     |     |   |  |
|-----|-----|---|--|
| n)  | CON | - | Civil construction                                 |
| o)  | COR | - | Corrosion control                                  |
| p)  | DEM | - | Demolition   |
| q)  | ELV | - | Elevators  |
| r)  | ESC | - | Escalators   |
| s)  | ETE | - | Emergency tunnel evacuation carts                  |
| t)  | FIN | - | Finish   |
| u)  | FPL | - | Fire protection lines                              |
| v)  | GEO | - | Geology, soils, etc.                               |
| w)  | GPL | - | General plans                                      |
| x)  | GRA | - | Graphics   |
| y)  | IDW | - | Intrusion detection and warning                    |
| z)  | KSK | - | Kiosks   |
| aa) | LDS | - | Landscapin   |
| bb) | LTG | - | Lighting   |
| cc) | MOW | - | Maintenance of way equipment                       |
| dd) | MVE | - | Miscellaneous vehicles                             |
| ee) | PKG | - | Parking lot  |
| ff) | PLE | - | Parking lot equipment                              |
| gg) | PVM | - | Pavement   |
| hh) | RLV | - | Rail vehicles                                      |
| ii) | ROW | - | Right of way                                       |
| jj) | RTC | - | Revenue transfer cart                              |
| kk) | RVE | - | Revenue equipment, coil and bill<br>counters, etc. |
| ll) | SHO | - | Shop equipment                                     |
| mm) | SIP | - | Site preparation                                   |
| nn) | SMP | - | System maps  |
| oo) | SSG | - | Sheeting and shoring                               |
| pp) | STF | - | Station furniture                                  |
| qq) | SWR | - | Sewers   |
| rr) | TKW | - | Trackwork  |
| ss) | TOP | - | Topography, survey, etc.                           |
| tt) | TRC | - | Traction power components                          |
| uu) | TRP | - | Traction power                                     |
| vv) | TRV | - | Transfer vendors                                   |
| ww) | TST | - | Test pits  |
| xx) | YTC | - | Yard train control                                 |
- 5) The Contractor shall request additional codes for any subject matter not included in 4) above.
  - 6) Deliver three sets of aperture cards to the Engineer not later than sixty days after approval of the as-built drawings.
  - 7) Furnish and deliver with the aperture cards an index to the drawings on standard computer floppy disks in accordance with the following:
    - a) Each original disk shall have a duplicate back up. The disks shall be of the high-density type.
    - b) Originals and duplicates shall be shipped in separate packages, protected by bubble-pack and tightly-packed stiffeners. The shipping method selected shall preclude X-raying of the disks.
    - c) The information shall be furnished in an ACSII file.
    - d) There are 30 fields in the index:

<u>FIELD</u>	<u>SPACES</u>	<u>CONTENT</u>	<u>RESPONSIBILITY</u>
0	8	Control number	Contractor
1	1	Facility category	Contractor*
2	4	Facility	Contractor*
3	5	Facility detail	Contractor*
4	6	Subsystem	Contractor*
5	4	Subsystem element	Contractor
6	5	Document type	Contractor
7	15	Documentation identification (no.)	Contractor
8	35	Document Title/Description	Contractor
9	3	Revision	Contractor
10	6	Revision date (YYMMDD)	Contractor
11	6	Sheet number	Contractor
12	4	Number of sheets	Contractor
13	6	Document source	Contractor*
14	11	M number	Contractor
15	25	Street Address	Contractor
16	4	County/City	Contractor
17	6	Primary chains	Contractor
18	1	+	Contractor
19	5	Chain detail	Contractor
20	6	Secondary chains	Contractor
21	1	+	Contractor
22	5	Chain detail	Contractor
23	1	Aperture card available	Contractor
24	10	Aperture card (master) location	WMATA
25	8	Contract number	Contractor
26	4	PCO number	Contractor
27	10	Document location	WMATA
28	6	Data entry date (YYMMDD)	WMATA
29	3	Inventory	WMATA

\* The Contractor shall request information from the Authority as to the information to be entered in this field.

Field	0	contains eight characters; the first three are alphabetic, derived from the Contractor's business name, while the last five are sequential numbers, starting with 00001.
Field	1	contains a letter: B=Bus, O=Other, R=Rail.
Field	2	may contain a letter/number combination from the Authority's master list.
Field	3	may contain a letter/number combination from the Authority's master list.
Field	4	contains a letter/number combination which identifies a division of the physical plant by subsystem, such as ESC-7, for escalators in Phase VII.
Field	5	contains a letter/number combination, when applicable, which identifies a sub-division of the subsystem listed in Field 4.
Field	6	contains an alphabetic code to identify the type of document; ASBLT = As-Built, SHDWG = Shop Drawing, WKDWG = Working Drawing.

Field	7	contains the document identification, such as a drawing number.
Field	8	contains the document title, if any, or a brief description.
Field	9	contains the revision level.
Field	10	contains the date of the revision recorded in field 9.
Field	11	contains the sheet number.
Field	12	contains the number of sheets.
Field	13	contains the document source. This is an alphabetic code that identifies the organization that is responsible for the content of the document.
Field	14	contains the M number of the document, if any.
Field	15	contains the street address of the facility, if appropriate. Street addresses will not be used when chain markers are used.
Field	16	contains a code for the city or county part of the address, e.g.: District of Columbia - DC Prince George's County - PG
Field	17	contains the number of full chains included in the lower chain marker at one edge of the drawing information.
Field	18	contains a + for the chain marker format.
Field	19	contains the fractional chain marker digits for the lower chain marker at one edge of the drawing information in the format xx.xx.
Fields	20, 21 and 22	correspond to
Fields	17, 18 and 19	except they apply to the higher chain marker at the edge of the drawing information.
Field	23	contains a "Y" if an aperture card is furnished, an "N" if it is not.
Field	24	contains location information for the Authority's storage of the master aperture card.
Field	25	contains the contract number.
Field	26	contains the PCO number, if any.
Field	27	contains the location of the master document in WMATA storage.
Field	28	contains the date the information is entered in the Authority's data base.
Field	29	when Field 7 identifies a major item of equipment, contains the count of that item at that location.

## **PART 3 - EXECUTION**

### **3.01 TIME OF SUBMITTAL**

- A. Make ATC submittals sufficiently in advance of manufacturing/procurement and installation requirements to allow for checking and appropriate action as specified in Section 16911, Scope of ATC Work; Section 16991, ATC Drawings and Tracings, and; Section 16992, ATC Instruction Manuals. This "advance" time shall be no less than:
1. 90 calendar days for Room Book-of-Plans, RTUs, Instruction Manuals, and other large submittals, as deemed necessary by the Engineer.
  2. 30 calendar days for all other submittals.
- B. Large numbers of submittals shall not be made within a short period of time. No more than ten small, or two large submittals shall be made within any seven-consecutive-day period.

### **3.02 TRAIN CONTROL DRAWING SUBMITTALS**

- A. Submit, unless otherwise directed, one reproducible and three legible copies of all Train Control drawings to the Engineer for approval. These drawings shall be complete and detailed. Train Control drawings shall include, but not be limited to, the following:
1. Title Sheets
  2. Index Sheets
  3. Nomenclature Description Sheets
  4. Relay/Contact Location Charts
  5. Cable Plans
  6. Double Line Track Plans
  7. Arrangement Plans
  8. Product Drawings
  9. Equipment Installation Drawings
  10. Circuit Drawings
  11. Typical Drawings (circuits and/or equipment layouts)
  12. Energy Distribution Schematics
  13. Wiring Diagrams
  14. System Drawings
  15. Control Panel Drawings (to include Back-Panel Wiring)
  16. Tie-in Drawings
  17. Interface Drawings
  18. Cut-In Drawings (as applicable)
  19. TC Maintenance Telephone System Drawings
  20. Trenching Plans (both direct burial and surface trench, as applicable)
  21. ATP Speed Command Control Line Diagrams
- B. Submit Train Control Drawings using standard transmittal forms in accordance with detailed instructions furnished by the Engineer. A supply of these forms will be furnished without cost to the Contractor.
- C. Provide the services of a local reproduction service to prepare three copies of all ATC submittals. Reproduction time shall be less than two business days.
- D. Before submitting Train Control drawings to the Engineer for approval, ascertain that:
1. The drawings represent the coordinated efforts of all Train Control subcontractors involved;
  2. The equipment, circuits, or subsystems represented are compatible with the directly related equipment, circuits and subsystems provided by other disciplines, based upon the most up-to-date information available, and;
  3. The equipment, circuits, or subsystems represented, and the manner in which they are represented, are in conformance with the requirements of these Specifications.
- E. Train Control drawings submitted for the approval of the Engineer shall bear the Contractor's stamp of approval as evidence of such checking, coordination, and compatibility. Drawings submitted without this stamp of approval will be returned to the Contractor for resubmission.
- F. The form and content of Train Control drawings and tracings shall comply with the requirements set forth in the related sections of these Specifications. Criteria for the approval of these drawings are set forth in Section 16991, ATC Drawings and Tracings.
- G. Where ATC drawings show variations from the Contract requirements because of standard shop practice or for other reasons, the Contractor shall describe such variations in his letter of transmittal. If acceptable, the Engineer may approve any or all such variations, subject to a proper adjustment in the Contract. If the Contractor fails to describe such variations, he shall not be relieved of the responsibility for executing the work in accordance with the Contract, even though such drawings have been approved.
- H. If the drawings as submitted show variations per paragraph G. above, and show a departure

from the Contract requirements which the Engineer finds to be in the interest of the Authority and to be so minor as not to involve a change in the Contract price or time for performance, the Engineer may approve the drawings.

- I. Upon approval by the Engineer, each copy of the Train Control drawings will be identified as having received such approval by being so stamped and dated. One reproducible set of Train Control drawings will be returned to the Contractor. The Contractor shall return 2 sets of prints to the Engineer within 15 calendar days.
- J. Train Control drawings stamped "Not Approved" and with required corrections shown will be returned to the Contractor for correction and resubmittal by the Contractor within two weeks. The Contractor shall make any corrections required by the Engineer. If the Contractor considers any correction indicated on the ATC drawings to constitute a change to the Contract Drawings or Specifications, notice as required under Section 01250, Contract Modification Procedures shall be given to the Contracting Officer. Resubmittals will be handled in the same manner as first submittals.
- K. When resubmitting drawings, the Contractor shall direct specific attention, either in the transmittal letter or on the resubmitted Train Control drawings, to revisions other than the corrections requested by the Engineer on previous submissions. Resubmittals will be handled in the same manner as first submittals.
- L. When the Train Control drawings have been completed to the satisfaction of the Engineer, the Contractor shall carry out the installation in accordance therewith and shall make no further changes therein except upon written instruction from the Engineer.
- M. When drawings are approved by the Engineer subject to certain revisions, the Contractor shall supply the Engineer with four suitably revised prints of the approved drawings prior to installation of equipment.
- N. Before any payment is made for Train Control drawings, the Contractor shall furnish to the Engineer three sets of record Train Control drawings, all clearly revised and completed and brought up to date, showing the permanent installation as actually made.
- O. Upon written approval of the final ATC As-Built tracings and drawings by the Engineer, the Contractor shall reproduce the tracings on three sets of microfilm aperture cards of the type and size specified in Section 16991, ATC Drawings and Tracings, and deliver these tracings and aperture cards to the Engineer.

### **3.03 TECHNICAL DOCUMENTATION**

- A. Submit ATC technical documentation (other than drawings) as specified herein. This documentation shall include, but not be limited to, the following:
  - 1. Original and three copies of:
    - a. Inspection Procedures & Reports
    - b. Spare Material and Equipment Lists
    - c. Cable Lists
    - d. Test Equipment Lists
    - e. Power Tabulation Sheets
    - f. Operational Descriptions
    - g. Test Procedures & Reports
    - h. Cut-In Procedures
    - i. Progress Reports
- B. Original and five copies of:
  - 1. Instruction Manuals
  - 2. Training Course Outlines

### **3.04 SAMPLES**

- A. Submit samples for approval as specified or as directed, which shall be delivered to the Engineer as specified or directed. Prepay shipping charges on samples. Materials or equipment for which samples are required shall not be used in the work until approved.
- B. Each sample shall be labeled as follows:
  - 1. Name of project.
  - 2. Name of Contractor and subcontractor.
  - 3. Material or equipment represented.
  - 4. Place of origin.
  - 5. Name of producer and brand, if any.
  - 6. Location in project.
- C. Samples of finish material shall have additional markings identifying them under the schedules.
- D. The Contractor shall mail, under separate cover, a letter in triplicate submitting each shipment of samples and containing the information required in Paragraph B. above. He shall enclose a copy of this letter with the shipment and send a copy of this letter to the Engineer. Approval of a sample shall be only for the characteristics or use named in such approval and shall not be construed to change or modify Contract requirements. Substitutions will not be permitted unless they are considered to be in the best interests of the Authority.
- E. Approved ATC samples not destroyed in testing shall be sent to the Engineer. Approved ATC samples in good condition will be marked for identification and may be used in the work. Materials and equipment incorporated in the work shall match the approved samples. Samples which fail testing or are not approved will be disposed of, unless the Contractor requests, at the time of submittal, that they be returned to him at his expense.
- F. Failure of any material to pass the specified tests will be sufficient cause for refusal to consider, under this Contract, further samples of the same brand or make of that material. The Engineer reserves the right to disapprove any material or equipment that has previously proved unsatisfactory in service.
- G. Samples of various materials or equipment delivered on the site or in place may be taken by the Engineer for testing. When a sample fails to meet Contract requirements, it will automatically void previous approvals of the item(s) tested. The Contractor shall replace such materials and equipment to meet Contract requirements or proper adjustment of the Contract price shall be made as determined by the Engineer.
- H. When tests are required, only one test of each sample will be made at the expense of the Authority. Samples that do not meet specified requirements will be rejected. Retesting of additional samples will be performed by the Engineer at the expense of the Contractor.
- I. Copies of all applicable manufacturer's specifications and Contractor's specifications shall be enclosed with each sample for Authority evaluation.

### **3.05 CERTIFICATION**

- A. Submit the original and three copies of ATC certification, unless otherwise specified.
- B. Certificates:
  - 1. Submit the following:
    - a. Certificates to demonstrate proof of compliance with ATC requirements

specified in the technical specifications for each of the following:

- 1) Products and materials
  - 2) Functioning and testing of equipment and systems.
  - 3) Qualifications of personnel, manufacturers, fabricators and installers.
2. Each certificate shall be signed by an official authorized to certify in behalf of the issuing organization and shall bear the project name and location, and the name and address of the Contractor. The quantity and date(s) of shipment or delivery shall also be indicated if the certificates apply to a material.
  3. ATC Certification shall not be construed as relieving the Contractor from furnishing satisfactory material, if, after tests are performed on selected samples, the material is found not to meet the specified requirements.
- C. Certified ATC Material Test Reports:
1. Submit original.
  2. Unless otherwise specified, testing shall be conducted by an independent testing agency which certifies that the applicable testing complies with the recommended requirements of the American Council of Independent Laboratories or ASTM E329.

### **3.06 SPECIAL DOCUMENTATION**

- A. Submit to the Engineer the original and three copies of each of the following when so specified in the ATC technical specifications and as follows:
1. Test reports of previous testing:
    - a. Where specified in the ATC technical specifications, the Contractor may, in lieu of testing, submit certified test reports of previous testing of such items, if the reports were approved under similar Authority contracts.
    - b. Include the following :
      - 1) Certification that materials meet or exceed specified test requirements.
      - 2) Name and address of testing laboratory.
      - 3) Dates of tests to which reports apply.
      - 4) Certification that materials provided are exactly the same as those tested.
    - c. Calculations.
  2. Miscellaneous documentation:
    - a. Specified items such as delivery tickets, batch tickets and bills of materials

### **3.07 INSPECTION REPORTS**

- A. Submit the original and three copies of all ATC Inspection Reports.
- B. Inspections should be performed for acceptance in the areas of specification compliance, workmanship, reliability, possible damage and proper installation.
- C. Required inspection reports should include but not be limited to the following:
1. All wayside ATC equipment (incoming and installation).
  2. All ATC wayside cable (incoming and installation).
  3. All Train Control Equipment (incoming and installation).

### **3.08 TEST PLANS AND PROCEDURES**

- A. Submit an overall test plan to include all applicable factory and field tests by location. Submit a test schedule, which includes the anticipated order, and dates in which each required test will be performed. Submit a cutover plan when interface to an existing location is required.
- B. Submit all required factory and field test procedures.

- C. Required test procedures should include but not be limited to the following:
  - 1. Any general information that aids the test engineer.
  - 2. A general description of the objective of the test
  - 3. The required test equipment and tools needed to perform the test.
  - 4. The facility and location requirements needed to perform the test.
  - 5. The test prerequisite requirements.
  - 6. Test personnel requirements.
  - 7. The test method needed to perform the test.
  - 8. Pass/fail criteria.
  - 9. Sample data sheets and data cover sheets.

### **3.09 TEST REPORTS AND DATA SHEETS**

- A. Submit the original and three copies of pre-printed data sheets in advance of the test report for each required test procedure.
- B. Pre-printed data sheets should include all known variables prior to the collection of any actual test data. Examples:
  - 1. Known expected values (voltages, currents, resistances or frequencies).
  - 2. Track circuit, signal, marker coil, switch machine, cable and impedance bond names, etc.
  - 3. Wayside equipment locations and chain markers.
  - 4. Required routes.
- C. Submit the original and three copies of the completed test reports for all required factory and field test procedures.
- D. A completed test report should include, but not be limited to, the following:
  - 1. Completed cover sheets (standard cover sheet, standard circuit page, standard arrangement plan, equipment usage form and discrepancy action form)
  - 2. Completed data sheets.
  - 3. Any original test drawings needed to record data collection.

### **3.10 CONTRACT RECORD ATC DRAWINGS**

- A. Basic Requirements:
  - 1. During installation and testing of the Train Control system, the Contractor shall maintain a record set of ATC drawings annotated to show all changes incorporated as work progresses. Information shall include, but not be limited to, the following:
    - a. Field changes of equipment, dimensions, wiring and detail.
    - b. Changes accomplished by change orders.
  - 2. Before the scheduled date of the final acceptance of all Contract ATC work, the Contractor shall submit approved as-built mylar original drawings and microfilmed record drawings for the completed ATC work.
- B. As-built ATC drawings:
  - 1. As-built drawings shall include all new Train Control Drawings for the Automatic Train Control System and revisions to all affected existing Authority Record ATC Drawings.
  - 2. Authority Record ATC Drawings are as-built drawings provided to the Authority under previous or concurrent related contracts. The Contractor shall coordinate with the Authority to determine which existing Authority Record Drawings require revision.
  - 3. The Authority will furnish the original Mylars of the Authority Record ATC Drawings that require revision, from which the Contractor shall make reproductions for his use in preparing as-built drawings. The original Authority Record ATC Drawings shall be returned to the Authority not later than 10 calendar days after their receipt from the

Authority.

4. The Contractor shall submit three sets of prints and three electronic file copies of as-built drawings for initial review and approval.
5. Additions and corrections shall be incorporated by the Contractor and three sets of prints and three electronic file copies shall be prepared and submitted to the Authority for review and approval not later than 30 calendar days prior to the date scheduled for final acceptance of the Contractor's work.

### **3.11 REVIEW**

- A. If, in the opinion of the Engineer, a cursory review of a submittal (or resubmittal) indicates that it is substantially incomplete, incorrect or deficient in the furnishing of documentation of the subject concerned, the submittal will be disapproved and no attempt will be made by the Engineer to identify and correct every deficiency in the submittal.
- B. The Engineer's approval will be for the purpose of minimizing changes and delays in the field and shall in no way relieve the Contractor of full responsibility for providing complete, safe, reliable, and coordinated operating systems and subsystems for automatic train control which are compatible with the current WMATA Metrorail ATC system in every respect.

### **3.12 RESUBMITTAL**

- A. It is part of the intent of the ATC portion of this Contract that any ATC product, subsystem, or location shall receive final design approval with no more than one resubmittal. If more than one resubmittal for any product, subsystem or location is necessary, the Contractor shall reimburse the Authority for all costs incurred by the Engineer in reviewing those resubmittals made by the Contractor after the initial resubmittal. These costs will be deducted from the progress payments made to the Contractor under the Measurement for Partial Payments subsections of the applicable 16900-series Sections of these Specifications.
- B. The Engineer will review the initial submittal and no more than one resubmittal of each product, subsystem, or location as part of the requirements of this subsection. It is the responsibility of the Contractor to ensure that in the event a resubmittal of the initial submittal is necessary, he has, in the resubmittal, either:
  1. Responded in the manner suggested to all the Engineer's comments made in the first review, or;
  2. Taken exception in writing to any of the Engineer's first review comments which he believes should not be incorporated by him in his first resubmittal, and responded in the manner suggested to all the Engineer's other comments made in the first review. When taking exception to the Engineer's comments, the Contractor shall state his reasons for not complying, and offer a workable alternative consistent with the intent of the Specifications.
- C. In instances where a supposedly complete submittal or resubmittal is approved by the Engineer, but is later found to be in error or unworkable, the Engineer reserves the right to withdraw the earlier approval and require correction and resubmittal of the earlier submittal. The full cost of correcting such resubmittals, and the cost of the Engineer's time to review such resubmittals shall be borne by the Contractor at no additional cost to the Authority. These costs will be deducted from the progress payments made to the Contractor under the Measurement for Payment subsections of the applicable 16900-series Sections of these Specifications.

**END OF SECTION**

## SECTION 16913

### ATC BLOCK DESIGN

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the design criteria and basic information which the Contractor shall use in preparing the ATC Block Design for the portions of the Metro Rail Rapid Transit System included in this Contract and the responsibilities of the Contractor for simulating, implementing and documenting this block design.

##### 1.02 RELATED SECTIONS

- A. Section 16901 Definitions of ATC Terms
- B. Section 16902 ATC Abbreviations
- C. Section 16904 Current Automatic Train Control System
- D. Section 16905 Transit Vehicle Characteristics
- E. Section 16911 Scope of ATC Work
- F. Section 16917 Basic Interlocking Requirements
- G. Section 16918 Special ATC Requirements for Specific Locations
- H. Section 16924 Non-Vital ATO & ATS Processor Systems
- I. Section 16926 Microprocessor Systems for Non-Vital Interlocking Function
- J. Section 16928 Interlocking Vital Processor Systems
- K. Section 16980 ATC Tests, Inspections and Quality Assurance

##### 1.03 FUNCTIONS OF BLOCK DESIGN

- A. The primary functions of the block design shall be:
  - 1. To provide safe train operation;
  - 2. To enable all of the required "Design" and "Peak Capacity" headways to be achieved and maintained at all specified Performance Level speeds;
  - 3. To allow trains to travel as fast as possible, consistent with speed restrictions.
  - 4. To allow all Performance Level speed limit speeds to be attained in both the Normal and Reverse directions of Traffic.
- B. In addition, the block design shall include such track circuit boundaries as are necessary for the proper operation of the program stop and door control systems, for crossbonding and negative propulsion return requirements, for the operation of interlockings, and, where applicable, for automatic train routing and automatic terminal operation.
- C. The block design shall provide for the operation of both ideal trains and worst-case trains and must assume that an ideal train can become a worst-case train at any instant.

##### 1.04 BASIC INFORMATION

- A. Speed Limits
1. The civil speed limit of a speed zone shall be set for the comfort of passengers on trains and on station platforms. The safety speed limit shall be set to minimize potential passenger injury.
- B. Civil Speed Limits
1. The civil speed limit within all station approach limit areas shall not exceed 50 mph. The civil speed limit on all station platform tracks shall not exceed 40 MPH. The civil speed limit (in the direction approaching a station platform) for each track circuit within the programmed station stopping control limits of a station shall be the lowest ATP speed command (i.e., 40 mph, 45 mph or 50 mph) which can be applied without interfering with normal programmed station stopping at that station.
  2. For all sections of track other than station areas, the civil speed limit shall be the highest ATP speed command not exceeding the civil speed limit of the given section of track as indicated on the Contract Drawings. Civil speed limits for curves shall apply to adjacent spirals. In the case of compound curves, the connecting spiral shall be assumed to have a civil speed limit equal to the lower of the civil speed limits of the two curves.
- C. Safety Speed Limits
1. For speed zones where the civil speed limit is restricted by curves, the safety speed limit,  $V_s$  shall be:
    - a.  $V_s = V_c$  times the square root of the quantity  $1 + \frac{2}{E_a + E_u}$
    - b. Where:  $V_c$  is the civil speed limit of the speed zone (M.P.H.);  
 $E_a$  is the actual superelevation (inches);  
 $E_u$  is the unbalanced superelevation (inches).
    - c. The civil speed limit ( $V_c$ ) is given on the Contract Drawings for each curve.  $E_a$  and  $E_u$  shall be as shown on the applicable trackwork drawings. Safety speed limits for curves shall apply to adjacent spirals. In the case of compound curves, the connecting spiral shall be assumed to have a safety speed limit equal to the lower of the safety speed limits of the two curves.
  2. The safety speed limit in speed zones which result from passenger station areas shall be 60 mph. The safety speed limit where the civil speed limit is restricted by turnouts shall be set equal to the civil speed limit of the given speed zone.
  3. The safety speed limit shall not exceed 75 mph.
- D. Acceleration Factors
1. The acceleration capability of trains shall be determined by the following factors:
    - a. The curvature and the grade of the section of track beneath the train, which shall be based on the actual train length and which shall consider the train as a line mass. The curve and grade resistance factors which shall be used to determine the effect of curves and grades on train motion are given in Section 16905, Transit Vehicle Characteristics.
    - b. The characteristics of the transit cars, given in Section 16905, Transit Vehicle Characteristics.
    - c. The Car Acceleration vs. Speed Tables included in the Technical Appendix or furnished by the Authority.
    - d. The reaction time for power application for acceleration which shall be 1 second.

## 1.05 DECELERATION FORMULAS FOR DETERMINING SAFE BRAKING DISTANCE

- A. The following system of equations shall be used in an iterative procedure to determine the

Safe Braking Distance, SBD, which is the minimum distance that shall be allowed for a train to decelerate from an initial speed  $V(0)$  mph, at location  $L(0)$  feet, to a final speed of zero mph.

- B. The safe braking distance (SBD) is defined to be comprised of two components: the reaction distance (RD) and the braking distance (BD).
- C. The time for the reaction distance shall begin when a train crosses a block boundary into a block transmitting a lower (or zero) speed command. During this reaction-distance time the train shall be considered to maintain its speed while the new speed command (or lack thereof) is being detected and decoded, accelerate at maximum rate during the power removal time, and then maintain the speed reached after acceleration for half the braking buildup time.
- D. The braking distance, in which the brakes are fully applied, shall follow the reaction distance.
- E. To use these equations a train beginning an interval at  $(V(i), L(i))$ , where  $V(i)$  is the speed and  $L(i)$  the location at the beginning of the  $(i+1)$ th interval, shall be moved forward one computing interval at a time. The length of the interval is  $\Delta t$  seconds. The acceleration or deceleration calculated at the beginning of the interval shall be used to determine the speed at the end of the interval,  $V(i+1) - V(i)$ , and the distance traveled during the interval  $L(i+1) - L(i)$ . The coordinates  $(V(i+1), L(i+1))$  shall then be used as the beginning coordinates of the next computing interval. The procedure shall be continued until the speed after the  $n$ th computing interval,  $V(n)$ , is less than or equal to zero mph. If less than zero, the location at which the train's speed equals zero shall be calculated by interpolation using the coordinates  $(V(n-1), L(n-1))$  and  $(V(n), L(n))$ .
- F. The train acceleration shall be the algebraic sum of the acceleration due to tractive effort and the acceleration due to curves and grades. The train deceleration shall be the algebraic sum of the braking rate and the deceleration due to curves and grades. The acceleration and deceleration due to curves and grades shall be calculated at the beginning of each computing interval based upon the weighted average of the curves and grades beneath the train at the beginning of that interval. The weighting factor shall be the fraction of the train length on each of the curves or grades.
- G. Reaction distance, RD, is the distance traveled during the reaction-distance time. The reaction-distance time shall be comprised of three parts:
  - 1. Signal time, i.e., time to detect and decode a more restrictive speed command. This first time period is of 2 seconds duration.
  - 2. Speed regulator (overspeed detector) reaction time (0.75 seconds), plus time to remove power. The time to remove power depends upon the speed of the vehicle and shall be as specified in Section 16905, Transit Vehicle Characteristics.
  - 3. Half the maximum brake building time. Maximum brake buildup time shall be as specified in Section 16905.
- H. In the first part (2 seconds) of reaction-distance time the train shall maintain its initial speed  $V(0)$ :
  - 1.  $RD(1)$  (feet) =  $1.467 \times 2$  (sec.)  $\times V(0)$  (MPH)
  - 2. The location of the train at the end of these two seconds shall be:
    - a.  $L(1) = L(0) + RD(1)$
- I. In the second part of reaction-distance time, the train shall be under full power. The first five computing intervals ( $\Delta t(i)$ ,  $i = 1, 2, 3, 4, 5$ ) shall be of equal duration; the sixth computing interval,  $\Delta t(6)$ , in this part of the reaction-distance time, shall be of equal or less duration than each of the first five intervals. The following formulas shall be used to determine the change in speed and position during this computing interval:
  - 1.  $V(i+1) - V(i) = \Delta t(i) \times [A(V(i) - 0.2G(L(i)) - 0.008C(L(i)))]$

2.  $L(i+1)-L(i) = 1.467 \times \frac{V(i+1) + V(i)}{2} \times \text{delta } t(i)$
  3.  $RD(s) = L(7) - L(1)$
- J. In the third part (0.6 seconds) of reaction-distance time, the train shall maintain the speed  $V(7)$ .
1.  $RD(3) = 1.467 \times V(7) \times 0.6$
  2.  $L(8) = L(7) + RD(3)$
  3.  $RD = RD(1) + RD(2) + RD(3)$
- K. The braking distance, BD, is defined here as the portion of the safe braking distance in which the brakes are fully applied. It immediately follows the reaction distance. Each computing interval in the braking distance (BD) calculations shall be 0.5 seconds, except for the last where interpolation shall be used. The following formulas shall be used to determine the change in speed and position during each computing interval. In these formulas the sign of the deceleration term,  $D(V)$ , shall be negative.
1.  $V(i)-V(i+1) = 0.5 \times [D(V(i))+0.2G(L(i))+0.008C(L(i))]$
  2.  $L(i+1)-L(i) = 1.467 \times \frac{V(i+1) + V(i)}{2} \times 0.5$
  3. If  $L(n)$  is the location at which  $V = 0$ , then:
    - a.  $BD = L(n) - L(8) + 30.0$
  4. The 30.0-foot factor allows for coupler overhang and jerk rate while stopping.
- L. The safe braking distance shall be the sum of the reaction distance and the braking distance:
1.  $SBD = RD + BD$
- M. The following symbols are used in the preceding formulas:
1.  $L(i)$ : The location of the front end of the train after the  $i$  th computing interval.
  2.  $V(i)$ : The train speed (mph) after the  $i$  th computing interval.
  3.  $A(V)$ : Acceleration (mphps) vs. speed,  $V(\text{mph})$ , which shall be derived from the appropriate Car Acceleration vs. Speed Table(s) provided by the Authority.
  4.  $D(V)$ : Safety brake rate (mphps) vs. speed,  $V(\text{mph})$  curve. The safety brake rate equals -1.65 mphps from 0 mph to 50 mph and then tapers linearly to equal -1.24 mphps at 75 mph.
  5.  $C(L(I))$ : The weighted average of the curves in degrees curvature, under a train whose front end is at location  $L(i)$ . The weighting factor shall be the proportion of the train on each of the curves. The factor 0.008 transforms the degrees of curvature into deceleration due to curve resistance in miles per hour per second.
  6.  $G(L(I))$ : The weighted average of the grades, in percent grade, under a train whose front end is at location  $L(i)$ . The weighting factor shall be the proportion of the train on each of the grades. Uphill grades shall be designated as positive. The factor 0.2 transforms the percent grade into acceleration or deceleration (in miles per hour per second) due to grade.
- N. To determine the distance which shall be allowed for a train to decelerate from an initial speed  $V(0)$ , to a final speed limit,  $V$ , which is a more restrictive speed limit, the above formulas shall be modified as follows:
1. The train shall run the entire reaction-distance time at  $V(0)$  mph. Reaction-distance time shall depend on whether the train is an ideal train or a worst-case train. See Part 1.07-E (Train Performance Simulation) of this Section.
  2. At the end of reaction-distance time the brakes shall be assumed to be fully applied and the above formulas shall be used to calculate the distance required for the train to decelerate to the more restrictive speed limit.

- O. The speed limit shall be the civil speed limit for ideal trains and the safety speed limit for worst-case trains. The worst-case trains shall use a braking rate of -1.65 mphps from 0 mph to 50 mph tapering linearly to -1.24 mph at 75 mph. The ideal train shall use the full service braking rate of -2.2 mphps from 0 mph to 50 mph tapering linearly to -1.65 mphps at 75 mph.

## 1.06 BASIC CRITERIA

- A. Safety Requirements:
  - 1. No ideal train shall exceed the civil speed limit of any speed zone.
  - 2. No worst-case train shall exceed the safety speed limit of any speed zone.
  - 3. Every worst-case train shall be at least safe braking distance from the upstream end of any block which is occupied or which is controlled by an interlocked signal if this signal is displaying a STOP aspect.
  - 4. Safe Braking Distance calculations for trains located on vertical curves shall be modified and documented in a manner acceptable to the designated Resident Engineer.
  
- B. Headway Requirements
  - 1. In this section, a "station pair" is defined to be an ordered pair of successive passenger stations. The satisfaction of criteria for successive trains operating over specified routes at specified headways shall be demonstrated using models of ideal-case trains following the specified sets of speed command profiles.
  - 2. Normal Direction
    - a. The block design shall permit two 8-car ideal trains to run in the normal direction of traffic, terminal-to-terminal, over every revenue service route, stopping at each passenger station enroute at the design headway for each station pair, with both trains receiving design profile speed commands in each block. The dwell times for each route shall be those of the "Normal Dwell" column in the Table of Dwell Times, which appears in the Technical Appendix.
    - b. For each station pair, design headway is the lowest feasible headway, not more than 75 seconds, achievable for ideal trains by a block design which meets all the requirements given in the Safety Requirements and Location of Block Boundaries Parts of this Section. Each block shall transmit the same ATP speed command to the third train that was transmitted to the second train when the second train occupied that block. The dwell times shall be taken from the "Normal Dwell" column of the Table of Dwell Times which appears in the Technical Appendix.
    - c. For each station pair, design profile speeds are the highest possible ATP speed commands, not exceeding MAS, that can be transmitted to each of two successive ideal trains which permit these trains to operate at the design headway.
    - d. The block design shall further permit successive 8-car ideal trains to run in the normal direction of traffic, terminal-to-terminal, over every revenue service route, stopping at each passenger station en-route, at peak capacity headway for each station pair with each train receiving peak capacity profile speed commands in each block. The dwell times shall be taken from the "Minimum Dwell" column of the Table of Dwell Times which appears in the ATC Technical Appendix (Section 16996).
    - e. For each station pair, peak capacity headway is the lowest feasible headway, not more than 65 seconds, achievable for successive ideal trains by a block design which meets all the requirements given in the Safety Requirements and Location of Block Boundaries Parts of this Section. The dwell times for each route shall be taken from the "Minimum Dwell" column in the Table of Dwell Times in the ATC Technical Appendix (Section 16996).
    - f. For each station pair, peak capacity profile speeds are the highest possible

ATP speed commands that can be transmitted to successive ideal trains which will permit these trains to operate at the peak capacity headway.

3. Reverse Direction
  - a. The block design shall permit successive 8-car ideal trains to run terminal-to-terminal with both trains starting on the inbound track in the terminal, crossing to the opposite track at one interlocking, crossing back to the original track at another interlocking, and then continuing to the terminal on the original track, stopping at each passenger station enroute, at the design headway for the given route between each station pair, with both trains receiving design profile speed commands in each block for the given route. This shall be possible for every pair of adjacent and every pair of alternate crossover locations on the route. The dwell times at each station shall be those of the "Minimum Dwell" column in the Table of Dwell Times in the ATC Technical Appendix (Section 16996).
  - b. The design headway, determined for each route connecting each station pair, is the lowest feasible headway not more than 110 seconds, achievable for successive ideal trains by a block design which meets all the requirements given in the Safety Requirements and Locations of Block Boundaries Part 1.06 C of this Section. Each block shall transmit the same ATP speed command to the following train that it transmitted to the leading train when the leading train occupied that block. Those ATP speed commands need not be MAS commands. The dwell times shall be taken from the "Minimum Dwell" column of the Table of Dwell Times, which appears in the ATC Technical Appendix (Section 16996).
  - c. The design profile speeds, determined for routes connecting each station pair, are the highest possible ATP speed commands not exceeding MAS that can be transmitted to each of three successive ideal trains which permit these trains to operate at the design headway.
  - d. The block design shall further permit three successive 8-car ideal trains to run terminal-to-terminal with both trains starting on the inbound track in the terminal, crossing to the opposite track at one interlocking, crossing back to the original track at another interlocking, and then continuing to the terminal on the original track, stopping at each passenger station en-route, at the peak capacity headway for the given route between each station pair, with both trains receiving the peak capacity profile speed commands in each block for the given route. This shall be possible for every pair of adjacent and every pair of alternate crossover locations on the route. The dwell times at each station shall be those of the "Minimum Dwell" column in the Table of Dwell Times which appears in the ATC Technical Appendix (Section 16996).
  - e. The peak capacity headway, determined for each route connecting each station pair, is the lowest feasible headway, not more than 100 seconds, achievable for successive ideal trains by a block design which meets all the requirements of the Safety Requirements and Location of Block Boundaries Part 1.06 C of this Section. Each block shall transmit the same ATP command to the following train that it transmitted to the leading train when the leading train was occupying that block. These ATP speed commands need not be MAS commands. The dwell times shall be taken from the "Minimum Dwell" column of the Table of Dwell Times which appears in the ATC Technical Appendix (Section 16996).
  - f. The peak capacity profile speeds, determined for each route connecting each station pair, are the highest possible ATP speed commands, not exceeding MAS, that can be transmitted to successive ideal trains which will permit these trains to operate at the peak capacity headway.
4. Terminals
  - a. For e.1) and e.2) below, the design headway determined for each penultimate/terminal station pair, is the lowest feasible headway, not more

than 110 seconds, achievable for successive ideal trains by a block design which meets all the requirements given in the Safety Requirements and Location of Block Boundaries Parts of this Section. Each block shall transmit the same ATP speed command to the following train that it transmitted to the leading train when the leading train occupied that block. The dwell times shall be taken from the "Minimum Dwell" column of the Table of Dwell Times which appears in the ATC Technical Appendix (Section 16996).

- b. For e.3) and e.4) below, the design headway determined for each penultimate/terminal station pair, is the lowest feasible headway, not more than 75 seconds, achievable for successive trains by any block design which meets all the requirements given in the Safety Requirements and Location of Block Boundaries Parts of this Section. In determining the lowest feasible headway, blocks need not be assumed to be transmitting the same ATP command to each of the successive trains. The successive trains shall be able to depart the penultimate station at the design headway and arrive at the terminal station at the design headway. The dwell times shall be those of the "Normal Dwell" column in the Table of Dwell Times which appears in the ATC Technical Appendix (Section 16996).
- c. For e.1) and e.2) below, the peak capacity headway determined for each penultimate/terminal station pair is the lowest feasible headway, not more than 100 seconds, achievable for successive ideal trains by any block design which meets the requirements given in the Safety Requirements and Location of Block Boundaries Parts of this Section. Each block shall transmit the same ATP speed commands to the following train that it transmitted to the leading train when the leading train occupied that block. These ATP speed commands need not be MAS commands. The dwell times shall be those of the "Minimum Dwell" column in the Table of Dwell Times which appears in the ATC Technical Appendix (Section 16996).
- d. For e.3) and e.4) below, the peak capacity headway, determined for each penultimate/ terminal station pair is the lowest feasible headway, not more than 65 seconds, achievable for successive trains by any block design which meets all the requirements of the Safety Requirements and Location of Block Boundaries Parts of this Section. In determining the lowest feasible headway, blocks need not be assumed to be transmitting the same ATP speed commands to successive trains. Successive trains shall be able to depart the penultimate station and arrive at the terminal station at the peak capacity headway. The dwell times shall be those of the "Minimum Dwell" column in the Table of Dwell Times which appears in the ATC Technical Appendix (Section 16996).
- e. For 1), 2), 3) and 4) below, the peak capacity profile speeds determined for each penultimate/ terminal station pair are the highest possible ATP speed commands not exceeding MAS, that can be transmitted to successive ideal trains which will permit these trains to operate at the peak capacity headway for each given route.
  - 1) "Outbound Track" Turnback
    - a) The block design shall permit successive 8-car ideal trains to depart the penultimate station in the normal direction of traffic and proceed to the adjacent terminal station on the same track, dwell, and reverse direction in the terminal, then cross to the inbound track through the terminal crossover and continue inbound at the design headway, with each train receiving the design profile speed command in each block. The dwell times shall be those of the "Minimum Dwell" column in the Table of Dwell Times which appears in the ATC Technical Appendix (Section 16996).
    - b) The block design shall permit successive 8-car ideal trains

to depart the penultimate station in the normal direction of traffic and proceed to the adjacent terminal station on the same track, dwell, and reverse direction in the terminal, then cross to the inbound track at the peak capacity headway, with each train receiving the peak capacity profile speed command in each block. The dwell times shall be those of the "Minimum Dwell" column in the Table of Dwell Times which appears in the ATC Technical Appendix (Section 16996).

- 2) "Inbound Track" Turnback
  - a) The block design shall permit successive 8-car ideal trains to depart the penultimate station in the normal direction of traffic and cross to the opposite track through the adjacent terminal crossover, dwell, and reverse direction in the terminal, then depart the terminal and proceed inbound at the design headway, with each train receiving the design profile speed command in each block. The dwell times shall be those of the "Minimum Dwell" column of the Table of Dwell Times which appears in the ATC Technical Appendix (Section 16996).
  - b) The block design shall permit successive 8-car ideal trains to depart the penultimate station in the normal direction of traffic and cross to the opposite track through the adjacent terminal crossover, dwell, and reverse direction in the terminal, then depart the terminal and proceed inbound at the peak capacity headway, with each train receiving the peak capacity profile speed commands in each block. The dwell times shall be those of the "Minimum Dwell" column of the Table of Dwell Times which appears in the ATC Technical Appendix (Section 16996).
- 3) Successive "Outbound/Inbound Track" Turnbacks
  - a) The block design shall permit successive 8-car ideal trains to depart the penultimate station and arrive at the terminal at the design headway. The first train shall traverse the route described in 1) above, at the design profile speeds for its route. The second train shall traverse the route described in 2) above at the design profile speeds for its route. The dwell times shall be those of the "Normal Dwell" column in the Table of Dwell Times which appears in the ATC Technical Appendix.
  - b) The block design shall permit successive 8-car ideal trains to depart the penultimate station and arrive at the terminal station at the peak capacity headway. The first train shall traverse the route described in 1) above at the peak capacity profile speeds for its route. The second train shall traverse the route described in 2) above at the peak capacity profile speeds for its route. The dwell times shall be those of the "Minimum Dwell" column of the Table of Dwell Times which appears in the ATC Technical Appendix (Section 16996).
- 4) Successive "Inbound/Outbound Track" Turnbacks
  - a) The block design shall permit successive 8-car ideal trains to depart the penultimate station and arrive at the terminal station at the design headway. The first train shall traverse the route described in 2) above at the design profile speeds for its route. The second train shall traverse the route described in 1) above at the design profile speeds for its

route. The dwell times shall be those of the "Normal Dwell" column in the Table of Dwell Times which appears in the ATC Technical Appendix.

- b) The block design shall permit successive 8-car ideal trains to depart the penultimate station and arrive at the terminal station at the peak capacity headway. The first train shall traverse the route described in 2) above at the peak capacity profile speeds for its route. The second train shall traverse the route described in 1) above at the peak capacity profile speeds for its route. The dwell times shall be those of the "Minimum Dwell" column of the Table of Dwell Times which appears in the ATC Technical Appendix (Section 16996).

5. Converging Junctions (Where Applicable)

- a. The block design shall permit successive converging 8-car ideal trains, operating at twice the design headway for each converging route, operating in the normal direction of traffic on each of two tracks which meet at the junction, to merge at the junction, with alternate trains exiting from the junction at the same point to form a series of trains at the design headway, with each train receiving the design profile ATP speed commands for its route.
- b. The design headway for both station pairs separated by a converging junction, shall be the lowest feasible headway, not more than 75 seconds, measured between arrival times at the station downstream from the junction, which is achievable by a block design which meets all the requirements specified in the Safety Requirements and Location of Block Boundaries Parts of this Section. The lowest headway shall be determined by successive converging ideal trains operating at twice the design headway on each of the tracks approaching the junction, merging to form a series of successive trains at the design headway downstream from the junction. Dwell times from the "Normal Dwell" column of the Table of Dwell Times shall be used in determining the design headway.
- c. The design profile speeds, determined for both sets of station pairs separated by a converging junction, shall be the highest possible ATP speed commands, not exceeding MAS, that can be transmitted to successive ideal trains operating between each set of station pairs, which will permit:
  - 1) alternately converging trains to operate at twice the design headway upstream from the junction, and which will permit merging pairs of such trains to operate at the design headway downstream from the junction, or;
  - 2) non-converging successive trains originating from either upstream station to operate at the normal design headway both upstream and downstream from the converging junction.
- d. The block design shall permit successive 8-car ideal trains, operating at twice the peak capacity headway for converging junctions, operating in the normal direction of traffic on each of two tracks which meet at the junction, to merge at the junction with alternate trains exiting from the junction at the same point to form a series of trains at the peak capacity headway, with each of these trains receiving the same ATP speed command in each block downstream from the junction.
- e. The peak capacity headway through a converging junction, determined for each set of station pairs separated by that junction, shall be the lowest feasible headway not more than 65 seconds, measured between arrival times at the station downstream from the junction, which is achievable by a block design which meets all the requirements specified in the Safety Requirements and Location of Block Boundaries Part 1.06 C of this Section. The peak capacity headway shall be determined with successive ideal trains

operating at twice the peak capacity headway on each of the tracks approaching the junction, merging to form a series of successive trains at the peak capacity headway downstream from the junction. Dwell times from the "Minimum Dwell" column of the Table of Dwell Times shall be used in determining the peak capacity headway.

- f. The peak capacity profile speeds, determined for both sets of station pairs separated by a converging junction, are the highest possible ATP speed commands, not exceeding MAS, that can be transmitted:
  - 1) to successive converging ideal trains operating between each set of station pairs, which will permit these trains to operate at twice the peak capacity headway upstream from the junction, and which will permit merging pairs of such trains to operate at the peak capacity headway downstream from the junction, and;
  - 2) to successive non-converging ideal trains operating between either set of station pairs, which will permit these trains to operate at the peak capacity headway through the junction between either applicable set of station pairs.

6. Diverging Junctions (Where Applicable)

- a. The block design shall permit successive 8-car trains, operating in the normal direction of traffic at the design headway in approach to a given diverging junction, to divide at the junction with consecutive trains exiting from the junction at different points, and with each train receiving the design profile ATP speed commands for its route.
- b. The design headway for both sets of station pairs separated by a diverging junction, shall be the lowest feasible headway not more than 75 seconds, measured between departure times at the station upstream from the junction, which is achievable by a block design which meets all the requirements specified in the Safety Requirements and Location of Block Boundaries Part 1.06 C of this Section. The design headway shall be determined with successive ideal trains, operating at the design headway departing the upstream station, taking different routes upon exit from the junction, with the trains operating on each diverging route at twice the design headway or better downstream from the junction. The dwell times used in determining design headway shall be those given in the "Normal Dwell" column of the Table of Dwell Times which appears in the ATC Technical Appendix.
- c. The design profile speeds, determined for each station pair separated by a diverging junction, shall be the highest possible ATP speed commands, not exceeding MAS, that can be transmitted:
  - 1) to successive diverging trains to permit these trains to operate at the design headway from the upstream station to the junction, and at twice the design headway or better downstream from the junction, and;
  - 2) to successive non-diverging trains to permit these trains to operate at the design headway between either applicable station pair.
- d. The block design shall permit successive 8-car ideal trains, operating in the normal direction of traffic at the peak capacity headway for a given diverging junction, approaching the junction in the normal direction of traffic, to divide at the junction so that consecutive trains exiting from the junction take different routes. Successive trains exiting the junction at the same diverging point shall receive the same ATP speed commands.
- e. The peak capacity headways for both sets of stations separated by a diverging junction, shall be the lowest feasible headway not more than 65 seconds, measured between successive departure times at the station upstream from the junction, which is achievable by a block design which meets all the requirements specified in Parts 1.06 A.& C. (Safety

Requirements and Location of Block Boundaries) of this Section. The peak capacity headway shall be determined by the steady state successive departure times of diverging ideal trains from the upstream station, with consecutive trains taking different routes through the junction and operating on each of the exiting routes at twice the peak capacity headway or better downstream from the junction. The dwell times given in the "Minimum Dwell" column of the Table of Dwell Times (which appears in Section 16996, ATC Technical Appendix) shall be used in determining the peak capacity headway.

- f. The peak capacity profile speeds, determined for each station pair separated by a diverging junction, shall be the highest possible ATP speed commands, not exceeding MAS, that can be transmitted:
  - 1) to successive diverging trains to permit these trains to operate at the peak capacity headway from the upstream station to the junction, and at twice the peak capacity headway or better downstream from the junction, and;
  - 2) to successive non-diverging trains to permit these trains to operate at the peak capacity headway between either applicable station pair.
7. The block design shall meet all specified headway requirements at all required Performance Level speeds. See Part 1.06 C.1.a.5.) The Contractor shall immediately notify the designated Resident Engineer in writing whenever in the design process it appears that it will be physically impossible to comply with this requirement. The Contractor shall furnish complete supporting documentation for each such situation encountered.

C. Location of Block Boundaries

1. Basic Requirements

- a. Block boundaries and associated track circuits shall be located:
  - 1) To ensure compliance with safety and headway criteria;
  - 2) To meet the requirements for negative propulsion return current connections at traction power substations;
  - 3) To provide crossbonding for negative-propulsion return current equalization at designated locations,
  - 4) To provide for proper operation of the wayside ATC system in the vicinity of station platforms and special trackwork locations, and;
  - 5) To enable all specified headway requirements to be complied with at all required Performance Level speeds. e.g., no track circuit shall be of such length that it causes headway degradation at Reduced (PL3) or Retarded (PL4) operating speeds. The Contractor shall furnish complete, accurate design and test documentation in support of this requirement.
- b. Successive Block Boundaries shall never result in a track circuit length of less than 50 feet.
- c. No track circuit shall be effectively cross-bonded at both ends.
- d. At least one of every two consecutive track circuits shall be long enough so that a train entering the track circuit at the MAS of the track circuit shall receive, react to, and charge the timing circuit for the carborne ATC speed command while the front end of the train is still in the track circuit.

2. Fixed Block Boundaries

- a. Fixed (mandatory) block boundaries to meet the requirements specified in 1.a.2), 1.a.3), and 1.a.4), above, are shown on the Contract Drawings at locations established by insulated rail joints, or impedance bonds (with stationings not shown in parenthesis) associated with the ends of station platforms, or with negative propulsion return stub-ups, or with negative propulsion crossbonding stub-ups. These "fixed" block boundaries shall be located as follows:

- 1) A block boundary for each track shall be located at each end of every passenger station platform. The boundary shall not be less than 299 feet and not more than 300 feet from the centerline of the station platform.
  - 2) At each interlocking, block boundaries in approach to facing point switches shall be located a minimum of 15 feet upstream from the point of switch, at the locations indicated on the Contract Drawings.
  - 3) The block design shall permit negative traction power-return bonding within 25 feet of the centerline of each traction power substation-return conduit stub-up. Preferably, these impedance bonds shall be located 10 feet from the negative-return conduit stub-up location, in the direction of the stub-up.
  - 4) The block design shall permit the installation of cross-bonding at intervals of 2000 feet (+\50 ft) maximum wherever it is possible to provide cross-bonding within such intervals. No track circuit shall be cross-bonded at both ends. Cross-bonding shall be provided at one end (only) of each passenger station, unless otherwise authorized in writing by the designated Resident Engineer. For the above purposes, substation return locations shall be considered as effective cross-bonding locations. The Contractor shall install impedance bonds at as many of the cross-bonding conduit locations indicated on the Contract Drawings as are required to meet the maximum cross-bonding interval limitations specified. The Contractor shall notify the designated Resident Engineer in writing of all locations where this maximum spacing requirement cannot be met due to the lack of provision of cross-bonding conduit by other disciplines. Preferably, impedance bonds for cross-bonding purposes shall be located 10 feet from the cross-bonding conduit stub-ups, in the direction of the stub-ups, but in all circumstances the bonds shall be installed within 25 feet of the cross-bond stub-ups unless otherwise authorized in writing by the designated Resident Engineer.
3. Intermediate Block Boundaries
- a. The number and location of all "intermediate" block boundary locations, i.e., additional block boundary locations necessary to meet the requirements specified in item 1.a.1) above, shall be determined by the Contractor in the manner further specified herein. (The "intermediate" block boundaries shown on the Contract Drawings, i.e., the block boundary impedance bonds with stationings shown in parentheses, are shown for illustrative purposes only and do not necessarily represent the number or location of block boundaries or track circuits required.)
  - b. A block boundary shall be located in the normal traffic direction approach to each more restrictive speed zone to slow a train traveling in the normal traffic direction. The distance from this block boundary to the beginning of the more restrictive speed zone shall be at least the larger of the following distances:
    - 1) The distance required for an ideal train to decelerate to the civil speed limit of the more restrictive speed zone;
    - 2) The distance required for a worst-case train to decelerate to the safety speed limit of the more restrictive speed zone.
  - c. The larger of the two distances specified in 3.a.1) and 3.a.2) above determines the closest allowable location for this block boundary (i.e., the "calculated location"). The actual location of the block boundary may be upstream from the calculated location up to a distance which would increase run time at MAS by two seconds compared to placing the block boundary at the calculated location.
  - d. Block boundaries for the normal direction of traffic shall also be used for the

reverse traffic direction. Additional block boundaries shall be provided in the reverse traffic direction approach to each more restrictive speed zone to slow a train traveling in the reverse direction whenever the lack of such a boundary would increase reverse direction run time by at least 10 seconds, compared with placing a block boundary at the calculated location for the reverse direction of traffic. Where an additional block boundary is not provided, the speed of trains running in the reverse direction of traffic shall be down to the appropriate speed limit (i.e., ideal trains to the civil speed limit and worst-case trains to the safety speed limit) of the more restrictive speed zone prior to entering this speed zone.

- e. A block boundary shall be located at the point of entry to a more permissive speed zone for trains traveling in the normal direction of traffic. As soon as the rear of the train, regardless of length, is clear of the more restrictive speed zone, the track circuits in the more permissive speed zone shall transmit the more permissive speed command to the train if the appropriate number of track circuits downstream are unoccupied. This block boundary may be located downstream from the end of the restricted speed zone not more than 50 feet or more than a distance which would increase run time by two seconds, compared with placing the block boundary at the end of the speed restriction. The location of this block boundary shall not be upstream from the end of the more restrictive speed zone by more than 10 feet. These criteria are also applicable for trains traveling in the reverse direction of traffic, except that the block boundary at the point of entry to a more permissive speed zone for trains traveling in the reverse direction of traffic may be located downstream from the end of the restricted speed zone not more than a distance which would increase run time by 10 seconds, compared with placing the block boundary at the end of the speed restriction.
- f. A block boundary shall be located at the entrance to a more permissive speed zone for trains traveling in the normal direction of traffic per the above criteria with the following exception. Suppose a train is entering a more permissive speed zone, with speed limit  $V$ , which is followed by a more restrictive speed zone. Assume that the sum of the four distances (train length, acceleration reaction distance, brake reaction distance, deceleration distance) is greater than the length of the more permissive speed zone. If basing the braking reaction distance and deceleration distance on a speed lower than  $V$ , but more permissive than that of the previous speed zone, can reduce the sum of the four distances to less than the length of the more permissive speed zone, then a block boundary should be located at the entrance of the more permissive speed zone. Under these conditions, the ATP speed shall be limited to the highest ATP speed which results in the sum of the four distances being less than the length of the more permissive speed zone.
- g. The block design shall permit worst-case 8-car trains and ideal 8-car trains, operating automatically, to approach each crossover on each track in both the normal direction of traffic and the reverse direction of traffic, to operate through the crossover using either route, and to be stopped automatically just beyond the crossover and clear of the trailing point of the switch in order to reverse direction manually.
- h. Where the centerlines of two successive passenger stations are less than 3000 feet apart, and where the civil speed limit of the speed zone in which the 1200-foot program stop marker of the downstream station is located is higher than the maximum speed from which an ideal train can execute a programmed stop in the downstream station, a block boundary shall be located a distance upstream from the 1200-foot marker. This distance shall be that required for an ideal train, traveling at the civil speed limit upstream from the 1200-foot marker, to decelerate to the speed required to execute

a programmed stop.

D. Logic Codes

1. The logic codes for each block shall be selected to provide compliance with safety and headway criteria.
2. All blocks shall have at least two ATP logic codes; one for trains entering the block in the normal direction of traffic, and one for trains entering the block in the reverse direction of traffic. In addition, if a crossover or diverging junction is within safe braking distance (as defined for the worst-case train) from the downstream end of a block, there shall be two logic codes in the given block for the direction of traffic approaching the crossover or diverging junction - one for each route through the crossover or junction.
3. Routes for Normal Direction of Traffic
  - a. To calculate all logic codes associated with revenue service routes in the normal direction of traffic, the Contractor shall determine the highest speed command that can be transmitted to a train entering a given block in such a way that safe braking distance from the command speed does not exceed the combined length of each successive number of consecutive unoccupied track circuits downstream from the given block. This shall be done for each number of such track circuits, beginning with the track circuit adjacent to and downstream from the given block. Safe braking distance shall be calculated from the downstream end of the given block.
  - b. MAS, the highest of the ATP speed commands, shall be transmitted as soon as the required track circuits are unoccupied. In addition, the ATP speed commands required in each block for trains to operate at a design headway and peak capacity headway shall be transmitted as soon as the required track circuits are unoccupied.
  - c. A logic code shall be provided (for each direction of traffic on each track) to permit a train to make a station stop at each station platform.
  - d. Intermediate speed commands shall be provided as necessary to meet specified design and operational requirements, subject to the approval of the designated Resident Engineer. This shall include speed commands for all Performance Level speed limits between successive passenger stations.
4. Routes for Reverse Traffic Direction and Emergency Crossovers
  - a. All logic codes associated with revenue service routes in the reverse direction of traffic, or routes using an emergency crossover, shall be provided with as many intermediate speed commands as are necessary to meet the specified design and operational requirements. The intermediate speed(s) used by the reverse traffic transmitter shall be the same as the intermediate speed(s) used for normal traffic transmission to the adjacent track circuit wherever possible.
  - b. Each of these speed commands shall be transmitted to a train entering a block as soon as the combined length of unoccupied track circuits downstream from the block is at least safe braking from the downstream end of that block for that speed.
5. Passenger Stations
  - a. Where there are two or more track circuits in one station platform track, the individual track circuits shall not appear unoccupied to a train upstream of the station unless one of the following conditions exists:
    - 1) All track circuits within the limits of that platform are unoccupied, or
    - 2) The track circuit for the upstream end of the platform track is unoccupied and the train occupying the remaining track circuit(s) has been determined to be leaving the station.
  - b. The determination that a train is leaving the station platform may be non-vital in origin, such as the lack of TWC reception in the platform block.
6. Routes Terminated by Turnback Point Control

- a. If a turnback point is within safe braking distance (as defined for the worst-case train) from the downstream end of a block, there shall be an additional logic code in the given block for the direction of traffic approaching the turnback point - with the turnback control at stop.
- b. Speed commands for the turnback point control at stop shall not permit a worst-case train to pass the turnback point. Speed command assignment for the turnback point control at stop shall permit all trains to clear the downstream exit of the interlocking before stopping. Speed command assignment for the turnback point control at stop shall permit an automatic programmed station stop in automatic mode where reasonable and practical.

## 1.07 QUALITY ASSURANCE

- A. Review and Evaluation
  - 1. The Contractor shall conduct a detailed review and evaluation of the logic codes, track circuits, and location of block boundaries contained in his initial block design.
- B. Review Criteria
  - 1. The Contractor shall review his block design to confirm that the design:
    - a. Meets the requirements specified for safety and headway.
    - b. Uses the minimum number of blocks required to meet the Specifications.
    - c. Complies with the Specifications for the location of block boundaries.
    - d. Complies with the Specifications for Logic Codes.
- C. Safety and Headway
  - 1. The Contractor's review and evaluation of safety and headway shall be based upon the following:
    - a. Safety.
      - 1) Determination that a length of unoccupied track at least equal to safe braking distance for worst-case trains is provided for every speed command in each block, utilizing the criteria for safe braking distance applied to the track profile involved.
    - b. Headway.
      - 1) Determination of the actual design profile speeds, design headways, and peak capacity headways attainable for each route connecting each station pair. Where the design headway or the peak capacity headway are not equal to or less than the upper bounds of headway specified below for each station pair, and where the design profile speeds are lower than MAS, the Contractor shall notify the designated Resident Engineer in writing.
- D. Upper Bounds for Headway
  - 1. Routes in the normal direction of traffic - 75 seconds for design headway; 65 seconds for peak capacity headway;
  - 2. Routes in the reverse direction of traffic or using emergency crossovers - 110 seconds for design headway; 100 seconds for peak capacity headway;
  - 3. Routes described in Parts 1.06 B.4.e.1) & 2), Headway Requirements for Terminals: 110 seconds for design headway; 100 seconds for peak capacity headway;
  - 4. Routes described in Parts 1.06 B.4.e.3) & 4), Headway Requirements for Terminals: 75 seconds for design headway; 65 seconds for peak capacity headway;
  - 5. For non-merging operation of trains in the normal direction of traffic through converging junctions, and for the merged operation of trains leaving converging junctions: 75 seconds for design headway; 65 seconds for peak capacity headway;
  - 6. For *non*-diverging operation of trains in the normal direction of traffic through diverging junctions, and for the operation of diverging trains in approach to diverging

junctions: 75 seconds for design headway; 65 seconds for peak capacity headway.

E. Train Performance Simulation

1. Model Type

a. The Contractor shall develop individual train performance models for; an ideal train, a worst-case eight-car train, and a worst-case two-car train.

1) Ideal Train

a) The model of ideal train performance shall be developed to verify that trains which accelerate and brake precisely as does an ideal train meet all the headway criteria and always obey the civil speed limits of every speed zone. The Ideal Train performance model shall be precisely determined by the following characteristics:

- (1) Acceleration shall be as indicated in Part 1.04-D, (Acceleration Factors) of this Section.
- (2) The braking rates shall be the full-service braking rates specified in Section 16905, Transit Vehicle Characteristics, (or as superceded by the Authority) as constrained by jerk rate limitations. The reaction-distance time shall be the sum of the equipment reaction time to detect and decode a more restrictive command (signal time, 0.8 sec.), plus the speed governor (overspeed detector) reaction time (0.5 sec.) and the time to remove power (1.0 sec. for speeds 40 mph or less and 0.5 sec. for speeds greater than 40 mph), plus one half the maximum brake buildup time (0.6 sec.). These values shall be used to determine the distance required for an ideal train to decelerate from one speed to a lower speed command.
- (3) Ideal trains shall stop in each station using the Program Stop braking profile for the given station.
- (4) The passenger load shall be crush load as specified in Section 16905, Transit Vehicle Characteristics.

2) Worst-Case Train

a) The performance models for the eight-car and two-car Worst-Case Trains shall be precisely determined by the following characteristics:

- (1) Acceleration shall be as indicated in Part 1.04-D., (Acceleration Factors) of this Section.
- (2) To calculate the distance that shall be allowed for a worst-case train to decelerate to obey the safety speed limit of a speed zone, the initial speed of the train shall be taken to be the greater of the ATP speed command which the train is receiving, and the actual train speed. The braking rate to be used shall be the full service braking rate specified in Section 16905, Transit Vehicle Characteristics, as constrained by jerk rate limitations and degraded by 25 percent to allow for inoperative brakes on one truck of each married-pair. The train shall be assumed to run the entire reaction distance at the initial speed. The overspeed detector reaction time shall be 0.75 seconds. Power removal time and maximum brake build-up time shall be based upon speed as specified in

Section 16905.

- (3) To calculate safe braking distance, the distance that shall be allowed for a worst-case train to stop when given a 0-mph speed command, the initial speed of the train shall be taken to be the greater of the ATP speed command which the train is receiving and the actual train speed. The braking rate to be used shall be the full service braking rate specified in Section 16905, Transit Vehicle Characteristics, as constrained by jerk-rate limitations and degraded by 25 percent to allow for inoperative brakes on one truck of each married-pair. The train shall be assumed to accelerate at the maximum rate during the reaction time of the overspeed detector and during the power removal time in order to account for the possibility of a carborne automatic speed regulator failure at the time of receipt of the zero speed command. The overspeed detector reaction time shall be 0.75 seconds. Power removal time shall be based upon speed as specified in Section 16905. An additional 30 feet shall be allowed in determining the safe braking distance. This is to allow for the distance between the front end of a worst-case train and its lead axle plus the distance between the rear end of the next train and its rear axle plus 10 feet for jerk limit flare-out.

2. Simulation

- a. The Contractor shall simulate the performance of a train operating in response to the MAS ATP speed commands and program stop commands, with dwell times as specified for the route in question. Safe braking distance shall be determined for each location on the simulated worst-case train's velocity-location profiles, taking into account the track and civil design characteristics, as well as the braking performance characteristics specified. The smallest theoretical headway between two trains with the resulting velocity-location profile shall then be determined for each station pair, with the trains always separated by at least safe braking distance, and by exactly safe braking distance at one or more locations.
- b. On the basis of the theoretical headway thus determined, the Contractor shall quantify the minimum headway achievable by his block design for trains operating at MAS. Where this minimum headway is larger than the lower bound specified above, the Contractor shall determine whether trains operating at reduced speeds can achieve the desired headway. The performance of trains responding to these revised speed commands shall be simulated. Safe braking distance and the theoretical minimum headways shall be determined as described above. The theoretical headways shall then be quantified into headways achievable by a block design for successive trains by operating at the indicated speeds.
- c. The Contractor shall compare these headways with those specified by the Authority. If the design headway and/or peak capacity headway determined by the review described above are higher than those specified by the Authority, the Contractor shall notify the designated Resident Engineer of these discrepancies and present substantiating data to the designated Resident Engineer to show that the headways specified by the Authority cannot be attained.
- d. Where a route segment included in this Contract does not begin at a passenger station, the Contractor shall include the nearest passenger

station in the current METRO rail system in the simulation.

## **1.08 SUBMITTALS**

- A. The Contractor shall submit a written report of his preliminary field inspection listing all potential block design problems in the areas included in this Contract within 21 days of receipt of Notice to Proceed.
- B. The Contractor shall submit detailed flow charts of his block design simulation programs for the designated Resident Engineer's approval within 60 days of receipt of Notice to Proceed.
- C. The Contractor shall submit copies of his final block design ATP Speed Command Control Line Diagrams for both traffic directions on all route segments included in this Contract, together with calculations and computerized simulation runs used to evaluate this block design within 120 days of receipt of Notice to Proceed. The calculations and simulation runs shall be suitably identified.

## **PART 2 - PRODUCTS**

### **2.01 PROGRAMS AND DOCUMENTATION**

- A. The Contractor shall furnish all safe-braking distance programs, simulation programs, computer time and time by properly qualified train control engineers to create, examine, evaluate and document a block design of the type specified for the route segment included in this Contract.

## **PART 3 - EXECUTION**

### **3.01 PRELIMINARY INSPECTION**

- A. Fixed facility locations shown on the Contract Drawings are based upon the latest design information available at the time this Contract was prepared.
- B. The Contractor shall conduct a field inspection to determine the actual as-built locations of substation-return conduit, crossbonding conduit, station platforms, special trackwork, Train Control Rooms, and all other special facilities which will affect his block design, prior to commencing his block design effort.

### **3.02 DESIGN**

- A. The Contractor shall use the actual locations of station platform ends, insulated rail joints, special trackwork, crossbonding conduit stub-ups and substation return conduit stub-ups as the initial fixed points in determining his block design.
- B. The remainder of the Contractor's block design shall conform to the requirements set forth in this Section, and to other special requirements set forth in these Specifications. (See Part 1.06, BASIC CRITERIA.)
- C. Intermediate block boundaries shown on the Contract Drawings are for illustrative purposes only, and represent the format to be used by the Contractor when submitting his Double Line Track Plans and Panel Layouts for approval. The Contractor's approved block design shall establish the actual number and location of intermediate block boundaries.
- D. The block design effort shall include the determination of the four "Performance Level" speed limits for trains traveling in both directions on each mainline track from all passenger stations included in this Contract. These performance level speed limits shall be determined as follows:

1. The PL1 ("MAXIMUM" PL) speed limit shall allow the train to run at the maximum safe interstation speed (MAS), resulting in the minimum safe interstation run time.
  2. The PL2 ("NORMAL" PL) speed limit shall limit the train speed to approximately 90 percent of the maximum safe interstation speed. (Normal scheduled run times will be based upon this performance level.)
  3. The PL3 ("REDUCED" PL) speed limit shall limit the train speed to approximately 90 percent of the PL2 speed.
  4. The PL4 ("RETARDED" PL) speed limit shall limit the train speed to approximately 80 percent of the PL2 speed.
- E. The Block Design shall include all intermediate block boundaries and intermediate speed commands necessary to fully implement all Performance Level speed limits in both the Normal and Reverse traffic directions.
- F. The Train Control stationing for all block boundaries shall be included in the Contractor's block design submittal. (This may or may not coincide with the civil stationing for block boundaries.)

### **3.03 IMPLEMENTATION**

- A. Block Boundaries
1. The Contractor shall install block boundaries of the type specified in the approved block design at the locations specified herein and as indicated on the approved block design drawings. Impedance bonds shall be installed within the specified tolerance distances from all crossbonding and substation return conduits unless otherwise authorized by the designated Resident Engineer. The use of terminating receivers or other similar devices (in lieu of impedance bonds) to establish block boundaries will not be permitted except as previously approved by the designated Resident Engineer in writing on an individual location basis.
- B. Control Codes
1. The Contractor shall install all hardware and circuitry required to provide the control codes specified in the approved block design.

### **3.04 FIELD TESTING**

- A. The Contractor shall conduct safe-braking-distance and all applicable headway tests as part of the system testing of all trackage included under this Contract to verify that the braking distances and headways specified can be met under actual operating conditions. See Section 16980, ATC Tests, Inspections and Quality Assurance.

### **3.05 MEASUREMENT FOR PAYMENT**

- A. No separate payment will be made for the design, simulation and implementation of the block design. The block design's acceptability will be determined based upon its conformance to the Specifications.

**END OF SECTION**

**SECTION 16914**

**ATC - ENVIRONMENTAL REQUIREMENTS**

**PART 1 - GENERAL**

**1.01 SECTION INCLUDES**

A. DESCRIPTION

1. This Section describes the environmental conditions under which the ATC equipment and systems furnished and installed under this Contract shall function and specifies certain measures which the Contractor shall take to prevent environmental interference with the ATC System.

**1.02 PHYSICAL ENVIRONMENT**

- A. All ATC equipment housed in Train Control Rooms shall function in accordance with the Specifications over a room temperature range of -22 degrees F to +158 degrees F at relative humidities of 5 percent non-condensing to 95 percent, inclusive.
- B. All wayside ATC equipment not housed in Train Control Rooms shall function in accordance with the Specifications over a temperature range of -40 degrees F to +158 degrees F at relative humidities of 5 percent non-condensing to 95 percent, inclusive.
- C. Wayside ATC equipment not housed in Train Control Rooms shall operate in accordance with the Specifications when subject to the climatic conditions indigenous to the Washington, D.C. metropolitan area within the extreme limits of precipitation and wind force recorded in data published by the United States Government, Department of Commerce, National Oceanic & Atmospheric Administration, Environmental Data Service.
- D. All ATC equipment housed in Train Control Rooms shall be so constructed and installed that it will remain fully operational while being vibrated, with simple harmonic motion having an amplitude, acceleration and frequency as listed below, for a minimum period of 15 minutes in each of three mutually perpendicular planes.

<u>Sweep Frequencies</u>	<u>Peak to Peak Displacement</u>	<u>Acceleration</u>
5-12 Hz	0.02 inches	--
12-1000 Hz	--	0.14g peak or 0.10g rms

- E. Wayside ATC equipment not housed in Train Control Rooms shall be so constructed and installed that it will remain fully operational while being vibrated, with simple harmonic motion having an amplitude, acceleration, and frequency as listed below, for a minimum period of 15 minutes in each of three mutually perpendicular planes.

<u>Sweep Frequencies</u>	<u>Peak to Peak Displacement</u>	<u>Acceleration</u>
5-20 Hz	0.2 inches	--
20-1000 Hz	--	4.2g peak or 3.0g rms

- F. All electrical contacts on ATC equipment (including relay contacts, jack contacts and switch contacts) shall be protected from dust and moisture.

### **1.03 ELECTRICAL ENVIRONMENT**

- A. Each system and subsystem element will generally be operated in the unfavorable electrical environment of a Rail Rapid Transit System characterized by heavy direct-current propulsion equipment which will cause electrostatic, electromagnetic, inductive, conductive, and radiated interference.
- B. Some of the possible sources of electrical interference are:
  - 1. Alternating current 60 Hz systems
  - 2. Direct current traction power systems
  - 3. Propulsion power contact shoe and third-rail arcing
  - 4. Rotating machinery
  - 5. Lightning discharges
  - 6. Public and private communications systems
  - 7. Wayside and carborne ATC equipment
  - 8. Highway traffic and traffic control systems.

### **1.04 RELATED SECTIONS**

- A. All 16900-series Sections.

### **1.05 REFERENCES**

- A. ANSI/IEEE C37.90.2
- B. AREMA Signal Manual, Part 2.4.25
- C. Listed in individual Related Sections, where applicable.

## **PART 2 - PRODUCTS**

### **2.01 PRODUCTS AND MATERIAL**

- A. Provide all products and materials necessary for the protection of the ATC System against interference by the physical or electrical environment. The products and materials so used shall not themselves constitute a threat to human health or safety, or interfere with the operation of equipment or systems furnished or installed by other disciplines.

### **2.02 EQUIPMENT**

- A. Provide all wayside ATC equipment which has enclosed, internal air-filled cavities, with appropriate moisture control devices as follows:
  - 1. Where possible, follow the recommendations of Part 2.4.25 of the AREMA Signal Manual to minimize condensation and frost buildup in the wayside ATC equipment.
  - 2. In small items of wayside ATC equipment where the screened, shielded vents and drains or heaters of the AREMA recommendation do not appear to be a practical solution to controlling condensation, exclude moisture-laden air by other means such as true hermetic sealing or displacement of the air by an approved potting compound.
  - 3. Where wires enter a sealed unit, approved heavy-duty plug couplers with minimal internal air spaces and hermetic headers shall be utilized. Cable connections to such plug couplers shall be potted with an approved, flexible, rubber-like compound.

## **PART 3 - EXECUTION**

### **3.01 PHYSICAL INTERFERENCE**

- A. Include in the design, fabrication, and installation, all equipment, systems, and procedures required by these specifications to prevent external or internal physical interference with the proper operation of the ATC System.
- B. Include in the design, fabrication, and installation, all additional equipment, systems, and procedures which may prove necessary to prevent external or internal physical interference with the proper operation of the ATC System.

### **3.02 ELECTRICAL INTERFERENCE**

- A. Ascertain (using ANSI/IEEE C37.90.2 as a standard) the specific electrical environment to which the various elements of the ATC System equipment will be exposed in all areas covered by this Contract.
- B. Incorporate such design techniques and installation practices as are necessary to protect the ATC System furnished under this Contract from any electrostatic, electromagnetic, radiated, or direct electrical interference.
- C. Provide adequate lightning protection equipment on power lines and on line wires that run between equipment in two or more locations which are served by independent grounding systems.

**END OF SECTION**

## SECTION 16915

### BASIC ATC EQUIPMENT REQUIREMENTS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies certain basic requirements for the design and fabrication of ATC systems and equipment, the methods which the Contractor shall use to mount and wire various types of equipment, and the manner in which equipment components, modules and racks shall be arranged.
- B. All ATC metallic cases, junction boxes, support hardware, and fastening hardware furnished and installed by the Contractor inside tunnels or other exposed underground locations shall be made of stainless steel, ASTM A276, Type 304, or approved equal, unless otherwise directed by the designated Resident Engineer. This requirement shall supersede requirements for hot-dip galvanizing, cadmium plating, epoxy coating, or other protective measures for such equipment, unless otherwise directed by the designated Resident Engineer (Engineer).

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16916 Basic ATC Circuit Requirements
  - 2. Section 16922 Lightning/Surge Protection and Grounding Systems
  - 3. Section 16940 ATC Electrical and Electronic Components and Material
  - 4. Section 16970 ATC Mechanical Components

##### 1.03 SUBMITTALS

- A. Prior to the installation of Train Control Room equipment, the Contractor shall submit for the Engineer's approval, drawings showing the proposed layout of equipment racks, cable trays, and wire chases for each TCR.
- B. Submit a tabulation of equipment to be mounted on each rack. Each item of this tabulation shall include a cross-reference to the number of a particular drawing of the subject equipment, which has been previously submitted for approval.
- C. Any finished material or prefabricated apparatus delivered to the site, stored or installed, which is not covered by an approved product submittal, layout drawing or other applicable document, shall be subject, at the discretion of the Authority, to removal from the site by the Contractor at no additional cost to the Authority, whether it has been installed or not.

#### PART 2 - PRODUCTS

##### 2.01 FAIL-SAFE DESIGN CRITERIA

- A. Vital Equipment and Systems
  - 1. Vital equipment and systems proposed for this Contract must be proven fail-safe by in-service experience or be made available for type-acceptance testing. Type-acceptance testing of components shall consist of bench tests on breadboard or prototype units as directed by the Engineer. Type-acceptance testing of systems or subsystems shall consist of bench testing of operational systems or subsystems

and/or field testing of same at the discretion of, and as directed by the Engineer. All expenses incurred during type-acceptance testing shall be borne by the Contractor.

- B. Component or System Failures
  - 1. Self-detecting component or system failures shall cause the train(s) to stop or run at a safe, more restrictive speed than that permitted with no failure.
  - 2. Component or system failures which are not self-detecting shall not cause unsafe conditions, even if added to other failures.
  - 3. Any number of simultaneous components or system failures attributable to the same cause or related causes shall not cause unsafe conditions.
  - 4. Any component or wire becoming grounded or any combination of such grounds shall not cause unsafe conditions.
  - 5. Any amplifier breaking into spurious oscillations shall not result in an unsafe condition.
  - 6. Filters used in fail-safe circuits shall be designed to prevent undesired signals from passing through the filter at a level which could cause unsafe conditions, even in the event of component failures within the filter.
  
- C. Alternative Equipment
  - 1. Should an alternative be proposed for a specified system or components thereof, the function of which affects the safety of train operation and because of its magnitude and integration parameters precludes absolute fail-safe engineering analysis, the Authority will require definitive factory and field tests and documentation of proposer's research and development tests, prior to completing the technical proposal evaluation. The acceptance of such an alternate system or subsystem at the time of technical proposal evaluation does not preclude further factory tests and field tests to determine that the alternate system or subsystem in actual operation, complies with the fail-safe criteria. Should the alternate system or subsystem fail to meet the fail-safe criteria, the Contractor shall furnish the originally specified system or component at no additional cost to the Authority.

## **2.02 PACKAGING OF EQUIPMENT**

- A. Modular design oriented to maintenance efficiency shall be used throughout the ATC System. Electrical and mechanical components shall be organized in plug-in assemblies and shall be rack mounted. The mixing of equipment associated with two subsystems in one plug-in assembly will not be acceptable unless expressly specified or specifically authorized in writing by the Engineer.

## **2.03 COMPONENT PROTECTION**

- A. Components shall be protected from damage in the event a plug-in unit is removed while the equipment is energized.

## **2.04 ADJUSTMENTS**

- A. Adjustable components shall be avoided wherever possible, by the use of appropriate circuitry, stable components, and high-tolerance circuits. Adjustable components, useful during design development to determine experimentally the correct operational settings, shall be eliminated in the final design. Adjustable components, where required, shall have locking devices or shall be self-locking to prevent inadvertent operation and/or drift.
  
- B. Whenever practical, two or more points of adjustment which are required during the same tune-up operation shall be located within 12 inches of each other and in such a way that they can be operated by one man. Interacting adjustments shall be avoided.

- C. The replacement of a component or PC card with a spare shall not require compensating adjustments to the associated components or modules. If compensating adjustments are required, they shall be limited to the device to be replaced or repaired.

## **2.05 TEST POINTS**

- A. Test points for checking essential voltages and wave forms and for injecting test signals shall be provided for trouble-shooting and routine maintenance.
- B. Test points shall be provided to detect defective PC boards and equipment modules without the disconnection of wires.
- C. All test points shall be readily accessible when the equipment is in the normal operating position and shall be clearly labeled.
- D. Test points shall be capable of accepting probes and connectors used with standard test equipment such as voltmeters and oscilloscopes, except where only special test equipment and connectors supplied by the Contractor will serve.

## **2.06 VISUAL INDICATIONS**

- A. Built-in indicators or meters shall be provided when frequent observation or adjustments are necessary, or when portable test equipment would not provide the necessary information or accuracy. Go/No-Go type indicators shall be used as substitutes where feasible.
- B. When built-in indicators or meters are associated with adjustments, the adjustment point shall be sufficiently close to the associated indicator so that both may be manipulated and observed simultaneously by one man.
- C. Visual indicators shall not require removal of covers to view. Exceptions are microprocessors with hinged doors which do not require tools to open.

## **2.07 ELECTRONIC EQUIPMENT**

- A. All electronic equipment used on this Contract shall be semiconductor except as otherwise approved by the Engineer in writing.

## **PART3 - EXECUTION**

### **3.01 RACK ARRANGEMENT IN ROOMS**

- A. Install the equipment racks in the Train Control Rooms and in conformance with the requirements specified in Section 16971, Racks and Cable Trays; as indicated on the Contract Drawings, and; as shown on the Contractor's previously approved TCR arrangement plan drawings. This shall include all mounting and fastening materials necessary to mount the racks in the specified manner.

### **3.02 EQUIPMENT ARRANGEMENT ON RACKS**

- A. Unless otherwise approved by the Engineer, relays and equipment panels shall not be mounted at a height exceeding 6 feet from the floor. The Contractor shall provide a minimum of 10 percent spare space, terminals, and plug connector points on each rack or group of racks serving a common function.
- B. Equipment arrangements within equipment racks shall present a neat and orderly appearance. Equipment serving similar functions shall be in the same relative location on

all racks. Similar types of racks shall be arranged to present an orderly and uniform appearance from Train Control Room to Train Control Room, to the extent possible.

### **3.03 COMPONENT MOUNTING ARRANGEMENT**

- A. Basic electrical and electronic components shall be mounted on and soldered to printed circuit (PC) cards except as permitted herein. Where size and weight prohibit PC card mounting, circuit components shall be mounted on plugboards or rack-mounted equipment chassis or panels.

### **3.04 PANELS**

- A. Equipment panels shall be used to rack-mount circuit components such as transformers, meters, relays, fuse holders, and resistors which cannot be mounted on PC cards.
- B. Input-output terminal and connector panels shall be furnished and installed at the top and to the rear of each equipment rack to be used to terminate cables and wires entering or leaving the rack.
- C. One power-distribution panel shall be located immediately below the terminal and connector panel and shall mount the power connectors, fuses and filters for the equipment rack power.
- D. The terminal and connector panel and the power-distribution panel shall not require more than 18 inches of combined rack space and shall be above all other apparatus mounted on the rack.

### **3.05 EQUIPMENT ACCESSIBILITY**

- A. All equipment and components on racks and on PC cards shall be accessible for testing or replacement without removal of other components wherever possible. Components or subassemblies which must be removable shall be of the plug-in type.

### **3.06 WIRING AND TERMINATION REQUIREMENTS**

- A. Power Rack Wiring
  - 1. Main power feeders shall have segregated facilities for entering and leaving each Train Control Room and shall be terminated on the power rack. Wires distributing ac and dc power within each Train Control Room shall originate from the power rack and terminate on the power distribution panels of the individual racks.
- B. Entrance Rack Wiring
  - 1. All wiring other than main power feeders and track circuit wires entering or leaving each Train Control Room shall be connected to terminals located on the entrance rack. All connections on these terminals shall be solderless.
  - 2. Entrance rack terminations shall be constructed and arranged to permit the room wiring to be isolated from the field wiring, on an individual wire basis, without removing the wires from their terminals.
  - 3. Terminations on the entrance rack for wiring between the entrance rack and the substations, dc tie-breaker stations, and other support facilities shall be of the miniature, pressure-clamp type unless otherwise approved in writing by the Engineer. All wiring shall be supported near terminal points to minimize mechanical stresses caused by vibration or by normal cable movement. The mechanical strength of each connection shall be at least 85 percent of the mechanical strength of the wire. The electrical conductivity of each connection shall be at least 95 percent of the electrical conductivity of the wire.

- C. Wire Terminations
  - 1. All wire termination hardware shall be sized for the wire being used. The use of wire terminal lugs which are one or more sizes larger than the terminal posts to which the connection is to be made will not be permitted. Where large wire must be terminated on relatively small terminals, special adaptor hardware approved by the Engineer shall be provided by the Contractor.
  - 2. Where high voltages (35 volts or more) are present on exposed terminals insulating nuts or protective covers shall be provided.
  - 3. A minimum of 20 percent spare terminals shall be provided on each terminal block. Terminals used for the termination of spare wires shall be considered spare terminals.

### **3.07 EQUIPMENT MOUNTING**

- A. All equipment shall be mounted plumb and level.
- B. The Contractor shall provide special facilities for required protection and grounding of non-rack-mounted equipment, e.g., wall mounted equipment, at no additional cost to the Authority. The methods and materials used to provide such protection shall be as previously approved by the Engineer. See Section 16922.
- C. Unless otherwise specified herein, equipment shall be anchored to concrete walls, floors, or ceilings by machine-bolt type expansion shields and 1/2 inch minimum diameter bolts. Sufficient bolts shall be used to provide a rigid and safe support, subject to the Engineer's approval. Where necessary, concrete bases or pedestals shall be provided by the Contractor, with anchor bolts cast in place for the mounting of equipment.

### **3.08 MEASUREMENT FOR PAYMENT**

- A. No separate payment will be made for the implementation of basic equipment requirements. The cost of work required to meet these requirements shall be included in the cost of the various items of equipment to which the requirements apply.

**END OF SECTION**

## SECTION 16916

### BASIC CIRCUIT REQUIREMENTS

#### PART 1- GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies basic requirements for the various types of vital and non-vital circuits required in the Automatic Train Control System.

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16915 Basic ATC Equipment Requirements
  - 2. Section 16917 Basic Interlocking Requirements
  - 3. Section 16940 ATC Electrical and Electronic Component Requirements
  - 4. Section 16980 ATC Tests, Inspections and Quality Assurance
  - 5. Section 16991 ATC Drawings and Tracings

##### 1.03 FAIL-SAFE CIRCUIT DESIGN CRITERIA

- A. Vital Circuitry
  - 1. Vital circuits shall be based on closed-loop principles; i.e, broken wires, damaged or dirty contacts, a relay failing to respond when energized, or a loss of power supply energy shall not result in unsafe conditions. Fail-safe circuit design for vital circuits shall be achieved by conforming to the fail-safe design criteria specified in Section 16915, Basic ATC Equipment Requirements, in addition to arranging the circuitry in conformance with the principles specified above.
- B. Electronic Circuitry
  - 1. Electronic fail-safe circuit design shall provide protection against the following types of component failures:
    - a. Two terminal devices: open, short, partial open, or partial short
    - b. Multi-terminal devices: any combination of opens, shorts, partial opens, or partial shorts

##### 1.04 VITAL CIRCUITS

- A. The following types of circuits are considered vital to the safety of the ATC system:
  - 1. Track Circuit
  - 2. Loop Energy Stick Circuits
  - 3. ATP Speed Command Circuits
  - 4. Switch Operating Circuits
  - 5. Overload Stick Circuits
  - 6. Switch Repeater Circuits
  - 7. Switch Correspondence Circuits
  - 8. Switch Locking Circuit
  - 9. Approach Locking Circuits
  - 10. Time Locking Circuits
  - 11. Route Locking Circuits
  - 12. Detector Locking Circuits
  - 13. Traffic Locking Circuits
  - 14. Signal Control Circuits
  - 15. Speed Command portion of Intrusion Detection Warning Circuits (where applicable).

- B. Regardless of how they are implemented, vital circuits shall be of fail-safe design.
- C. Except when specified otherwise, all circuits which energize a vital relay located outside of a Train Control Room and all circuits which energize a vital relay located inside a Train Control Room but which contain contacts located outside of the Train Control Room in which the relay is located, shall be two-wire, double-break circuits and shall be energized from an ungrounded dc power supply.
- D. In addition to these requirements, if non-vital relays are used in vital circuits, it shall be assumed that these relays can fail so that front contacts weld, back contacts weld, or any combination of these events may occur. It shall be assumed that the welding of a front contact will not prevent back contacts from conducting when the relay is deenergized, and that the welding of a back contact will not prevent front contacts of the relay from conducting when the relay is energized. It shall also be assumed that an armature may stick in any position. None of the above events, when they occur, shall cause unsafe conditions.
- E. Switch Operation circuits and Switch Repeater circuits shall be two-wire, polar, double-break circuits. Overload Stick Relays shall be circuited to meet the operating requirements established in Section 16943. The remaining vital circuits shall be positive-energy, single-break circuits. All of the relays used in these circuits shall have one side of each relay, or each individually controlled relay coil, connected directly to negative energy (common).
- F. When the number of contacts required in vital circuits demand the use of repeater relays, minor circuits shall be operated by contacts of the repeater relays. Minor circuits are defined as those involved in panel illumination, pushbutton box indication illumination, DTS indications, and other similar circuits. The circuits controlled by the prime relay and its repeaters shall be coordinated so that unsafe or undesirable conditions cannot occur if a repeater relay fails to pick up.

#### **1.05 NON-VITAL CIRCUITS**

- A. The following types of circuits are not considered vital to the safety of the ATC System:
  1. Route Initiation Circuits
  2. Route Selection Circuits except specified Pushbutton Stick Circuits
  3. Level Repeater Circuits
  4. Switch Indication Circuits
  5. Alarm Circuits
  6. Blown Fuse Circuits
  7. Transfer Control Circuits
  8. Mode Selection Control Circuits
- B. Certain circuits are considered non-vital and shall meet the non-vital circuit requirements specified herein, but shall energize vital relays which meet the requirements contained in Section 16943, Vitals Relays. These circuits are as follows:
  1. Switch Control Circuits
  2. Route Check Circuits
  3. Specified Pushbutton Stick Circuits in Route Selection Networks
- C. All non-vital electrical circuits shall be positive energy, single break circuits of the switching type and shall not depend upon timing or precise voltage control for their proper operation. All non-vital relays shall have one side of each relay, or each individually controlled relay coil, connected directly to negative energy (common).

- D. When the number of non-vital relay contacts required demands the use of repeater relays, minor circuits shall be operated by the contacts on the repeater relays. Minor circuits are defined as those involving panel illumination, pushbutton box indication illumination, DTS indications, and other similar circuits.

#### **1.06 ELECTRONIC CIRCUITS**

- A. Electronic circuits interfaced with, or operating in conjunction with ATC relay circuits shall be designed to perform as required by these Specifications.
- B. When electronic circuits are used, either positive one or negative zero logic shall be employed with ground being the other potential.

#### **1.07 OVERLOAD PROTECTION**

- A. The Contractor shall incorporate appropriately sized fuses, circuit breakers or resistors into the positive side of all grounded Train Control circuits for overcurrent protection.
- B. The Contractor shall incorporate appropriately sized fuses, circuit breakers or resistors into both the positive and negative sides of all un-grounded Train Control circuits for overcurrent protection, unless otherwise specified or specifically authorized by the Engineer. Circuit breakers used for such service shall be of the single-unit, dual-breaker type.
- C. The Contractor shall, to the greatest extent practicable, provide sufficient protection devices and shall group the ATC circuits in such a manner that the tripping of a circuit breaker or the blowing of a fuse will affect service on only one track or one portion of an interlocking.

#### **1.08 MULTIPLE-FEED PROTECTION**

- A. The Contractor shall ensure that no circuit is fed from more than one energy bus or from more than one overload protective device on a single energy bus.

#### **1.09 RELAY COIL SNUBBING**

- A. Wherever a capacitor is used in parallel with one or more relay coils for snubbing purposes, a resistor shall be used in series with the capacitor to prevent shorting the circuit in case of capacitor failure.

#### **1.10 QUALITY ASSURANCE**

- A. Check all circuits shown on the Contract Drawings and notify the Engineer in writing of any circuit which the Contractor feels is unsafe or not in conformance with the operational requirements specified in the text of the Specifications.
- B. All ATC System circuits shall be tested as specified in Section 16980, ATC Tests, Inspections and Quality Assurance.

#### **1.11 SUBMITTALS**

- A. The Contractor shall submit his ATC circuits to the Engineer for approval at least 30 days before wiring of the circuits is to begin. The circuits for these submittals shall be drawn as specified in Section 16991; shall produce the type of operation specified for the ATC

system, and; shall have the characteristics specified in this Section and on the Contract Drawings.

## **PART 2 - PRODUCTS**

### **2.01 COMPONENTS FOR VITAL CIRCUITS**

- A. Vital circuits shall be implemented with:
  - 1. Relays specified in Section 16943, Vital Relays
  - 2. Electrical and electronic components specified in Section 16941, Basic ATC Electrical and Electronic Component Requirements
  - 3. Vital signal wire and cable as specified in Section 16949, Signal Wire and Cable
  - 4. Combinations of the above devices

### **2.02 COMPONENTS FOR NON-VITAL CIRCUITS**

- A. Non-vital circuits shall be implemented with:
  - 1. Relays and timer equipment specified in Section 16944, Non-Vital Relays and Timers
  - 2. Electrical and electronic components specified in Section 16941, Basic ATC Electrical and Electronic Component Requirements
  - 3. Printed Circuit Cards specified in Section 16942, Printed Circuit Cards
  - 4. Combinations of the above devices
- B. Vital relays specified in Section 16943 may also be used in non-vital circuits.

## **PART 3 - EXECUTION**

### **3.01 NUMBER OF RELAYS**

- A. When the number of relays to perform a function is specified herein, the number specified is meant to establish standards for the required performance and circuit design and as such the number specified shall be the minimum number of relays required to meet the specified basic performance requirements. Repeater relays, parallel relays, and other necessary relays shall be supplied in addition to the number of relays specified so that all of the system performance requirements and spare contact requirements are met.

### **3.02 ADJUSTABLE CIRCUIT COMPONENTS**

- A. Potentiometers, adjustable resistors, and other adjustable circuit components shall be electrically sized and inserted in the circuits in such a manner that acceptable test results can be achieved by the related circuits when the device is adjusted to no less than 25 percent of its range and to no more than 75 percent of its range. The only exception to this requirement will be when compliance would result in a potentially unsafe condition in a vital circuit.

### **3.03 WIRES PER TERMINAL**

- A. No more than two wires shall be connected to a single terminal or contact pin other than an AAR terminal unless specifically authorized in writing by the Engineer. No more than three wires shall be connected to a single AAR terminal.

### **3.04 TRACK CIRCUIT INDICATION**

- A. The failure of any track circuit shall result in a "track occupied" indication.

- B. For platform-track track relays driven by a terminating receiver, this indication shall be achieved by double-breaking contacts of this intermediate track circuit track relay into the positive leads for the two coils of the associated full track relay in the manner shown on the Contract Drawings.

### **3.05 ENERGY LOOPS**

- A. Wherever energy is fed from a bus to more than one equipment point in succession, the energy feed wire shall be looped back to the same bus terminal or another terminal on the same bus. Where the energy feed is through an overload-protective device, both sides of the loop shall originate at the same protective device.
- B. Energy loops shall be subject to the following limitations unless specifically authorized by the Engineer in writing:
  - 1. No more than 30 equipment points or circuits shall be fed from a given energy loop.
  - 2. No more than four rows of equipment shall be fed from a given energy loop.
  - 3. Each energy loop wire shall be sized to carry the maximum normal load which could be imposed by the equipment and/or circuits fed by that loop.

### **3.06 MEASUREMENT FOR PAYMENT**

- A. No separate payment will be made for the implementation of basic circuit requirements. The cost of work required to meet these requirements shall be included in the cost of the various items of equipment included in the circuits to which the requirements apply.

**END OF SECTION**

**SECTION 16917  
BASIC INTERLOCKING REQUIREMENTS**

**PART 1        GENERAL**

**1.01    SECTION INCLUDES**

- A.     This Section specifies the basic requirements for interlockings which the Contractor shall furnish, install and test, or partially modify and test under this Contract. The interlockings to be provided or activated fall into three basic categories as follows:
  - 1.     Automatic Terminal Crossover (Mainline)
  - 2.     Emergency Crossovers (Mainline)
  - 3.     Tail Track Half Pocket
  
- B.     Each interlocking shall be provided with a full complement of safety facilities. These facilities shall meet the requirements of all applicable FRA regulations.
  
- C.     All ATC circuitry for the interlockings shall be as specified in Section 16916, Basic ATC Circuit Requirements, and as shown on the Contract Drawings.
  
- D.     Although relay type interlocking circuits are shown on the drawings, the Contractor shall implement certain interlocking functions with microprocessors as specified in Sections 16926 and 16928.

**1.02    RELATED SECTIONS**

- A.     Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1.     Section 16904            Current Automatic Train Control System
  - 2.     Section 16913            ATC Block Design
  - 3.     Section 16916            Basic ATC Circuit Requirements
  - 4.     Section 16918            Special ATC Requirements for Specific Locations
  - 5.     Section 16926            Microprocessor Systems for Non-Vital Interlocking Functions
  - 6.     Section 16928            Interlocking Vital Processor Systems
  - 7.     Section 16940            ATC Electrical and Electronic Components and Material
  - 8.     Section 16970            ATC Mechanical Components
  - 9.     Section 16980            ATC Tests, Inspections and Quality Assurance

**1.03    INTERLOCKING LIMITS**

- A.     Interlocking limits shall be defined by special track circuit boundaries and controlled wayside signals as indicated on the Contract Drawings. These track circuit boundaries will include insulated joints furnished by other disciplines.
  
- B.     The signal aspects, names and indications to be used by the controlled wayside signals shall be as follows:
 

<u>ASPECT</u>	<u>NAME</u>	<u>INDICATION</u>
1.     RED over RED	STOP	Stop
2.     LUNAR WHITE (STEADY)	NORMAL ROUTE CLEAR	Normal Interlocking Route locked and clear. Proceed according to cab speed indicator.
3.     LUNAR WHITE (FLASHING)	DIVERGING ROUTE CLEAR	Diverging Interlocking Route locked and clear. Proceed according to  cab speed indicator.

- C. Wayside route selection pushbutton layouts shall be installed in conjunction with certain interlocking home signals as specified in Section 16966, and as shown on the Contract Drawings.

#### **1.04 INTERLOCKING TRACK CIRCUITS**

- A. Mainline "through" (main) track routes within interlocking limits shall be equipped with two-rail Audio Frequency (AF) track circuits for both train detection and speed command transmission. These circuits shall be basically the same as those used for main line track circuits and shall meet all of the requirements specified for such circuits in Section 16961, Audio Frequency Track and Loop Circuit Layouts.
- B. Certain AF track circuit connections to the running rails within interlockings shall be made by means of inductive loops rather than by impedance bonds. See Section 16961 and the Contract Drawings. The shunting characteristics of AF track circuits installed within interlockings shall be such that their track relays shall not be down if the specified train shunt resistance is further than **twenty** feet beyond an impedance bond or loop defining the end of the track circuit **or if the shunt is beyond the interlocking limits**. Each interlocking AF track circuit relay shall be down while the specified train shunt resistance is located between the bonds, insulated joints or loops defining the track circuit.
- C. Mainline crossover tracks shall be equipped with power frequency track circuits and superimposed ATP speed command loops as indicated on the Contract Drawings and as specified in Sections 16961 and 16963. The number of insulated joints within each interlocking will be kept to a minimum required to provide for proper operation of the power frequency track circuits.
- D. Loss of shunt protection shall be provided for switch detector tracks involved in automatic switch operation. This protection shall consist of a delay in the track relay restoration and shall be provided by a vital timer circuit as shown on the Contract Drawings.
- E. The number, type and boundaries of track circuits to be used within interlockings shall be as shown on the Contract Drawings.

#### **1.05 TRACK SWITCHES**

- A. Interlocking track turnouts and crossovers will be fabricated with 115 lb. RE rail by other disciplines.
- B. The Contractor shall furnish and install track switch operating layouts for all newly installed interlocking turnouts and crossovers as specified in Section 16964, and as shown on the Contract Drawings.

#### **1.06 SPEED COMMANDS**

- A. Transmission of speed commands shall be prevented within interlocking limits until a properly aligned route is available and electrically locked.
- B. Speed commands shall not be transmitted in the track circuit upstream of an interlocking home signal until that signal has cleared.
- C. Unless otherwise specified, circuits shall be arranged in such a manner that, should a train pass a wayside signal at STOP, the transmission of speed commands to all trains within the interlocking shall be turned off when the STOP signal is passed. See Section 16916, Basic ATC Circuit Requirements, and the Contract Drawings.

#### **1.07 LOCKING REQUIREMENTS**

- A. Electric locking shall be provided to prevent unsafe switch operation and to prevent the clearing of signals for opposing or conflicting routes. The Contractor shall provide the following types of locking:
1. Approach Locking-Approach Locking shall be provided to lock switches within a route governed by a cleared wayside signal and to prevent clearing signals for opposing or conflicting routes when a cleared wayside signal is set to STOP and a train is closer than safe braking distance from that signal. Approach Locking shall also prevent simultaneous clearing of opposing signals at a given interlocking. One Approach Locking Relay shall be provided for each wayside signal as shown on the Contract Drawings.
  2. Time Locking-Time Locking shall be provided to lock switches within a route governed by a cleared wayside signal and to prevent clearing wayside signals for opposing or conflicting routes when a cleared wayside signal is set to stop. Time Locking shall also prevent simultaneous clearing of opposing signals within an interlocking. One Time Locking relay shall be provided for each wayside signal as shown on the Contract Drawings.
  3. Route Locking-Route Locking shall be provided to lock switches within a route after a train has accepted the wayside signal governing the entrance to the route and to prevent the clearing of opposing signals within the interlockings. Two Route Locking Relays, one for each direction of traffic, shall be provided for each section of track between opposing interlocking signals. Additional Route Locking Relays shall be provided to permit sectional release of Route Locking as required by the Contract Drawings.
  4. Switch Locking (Detector Locking)-Switch Locking shall be provided to prevent operation of a track switch when the track in which the switch is located is occupied, i.e., the track relay is down, or it is otherwise unsafe or undesirable to throw the switch. One Switch Locking Relay shall be provided for each single turnout, for each single crossover, and for each half of a double crossover, all as shown on the Contract Drawings.
  5. Traffic Locking-Traffic Locking shall prevent clearing opposing signals into a section of track between two interlockings or intermediate signals, or combinations thereof. Individual Traffic Locking circuits shall be provided for each mainline track between each pair of interlockings, (or intermediate signals) as shown on the Contract Drawings. A signal governing movement into a section of track for which traffic locking is effective shall not clear until traffic direction has been established and locked in the direction of movement for which the signal governs. Traffic Locking shall also prevent the established direction of traffic in a traffic block from being reversed so long as the traffic block is occupied.

#### **1.08 NEGATIVE TRACTION RETURN**

- A. See Section 16968 and the Contract Drawings for negative return bonding requirements in the interlocking areas.
- B. The Contract Drawings establish the basic guidelines for the Contractor's design of the negative traction return system at interlockings.

#### **1.09 ROUTE CONTROL**

- A. At end-of-line terminal interlockings (temporary or permanent) having the terminal crossovers located at the inbound end of the terminal station, the Contractor shall provide control of route selection by four selectable methods:
1. Central Control shall be able to control the route initiation network to select a route through the interlocking.
  2. Local equipment shall be provided to automatically establish routes to the station platform tracks for trains approaching the terminal on the outbound track. The local route selection circuitry shall automatically route the train to an unoccupied terminal

track in accordance with the position of a three position mode selector switch as follows:

- a. Mode 1: A train approaching the interlocking on the outbound track shall be automatically routed to the station platform on track 1 as soon as that track is available, and upon leaving the terminal in the inbound direction shall automatically be routed to the inbound track.
  - b. Mode 2: A train approaching the interlocking on the outbound track shall be automatically routed to the station platform on track 2 as soon as that track is available, and upon leaving the terminal in the inbound direction shall automatically be routed to the inbound track.
  - c. Mode 3: A train approaching the interlocking on the outbound track shall be automatically routed to the platform on either track 1 or track 2, depending upon which is first available, and if neither platform track is occupied or otherwise unavailable, the train shall be automatically routed through the crossover to the platform on the "inbound" track. Upon leaving the terminal in the inbound direction, the train shall automatically be routed to the inbound track.
3. If, due to equipment malfunction, the route cannot be selected in accordance with 1. or 2. above, the train operator shall be provided with the means to set the route manually. This will require that the operator place the train in a manual mode of operation, having been stopped by the ATP System, and move the train to a preselected location at which a trackside interlocking control pushbutton panel (wayside pushbutton layout) shall be located. Once the route is manually requested by the train operator and set and locked, the operator will return the train to an automatic control mode and the ATC System shall cause the train to proceed under automatic control, providing all other conditions allow safe movement of the train.
  4. Two local Interlocking Control Panels, one mounted in the Dispatcher's Room and one mounted in the Train Control Room shall provide the capability for manually initiating or canceling routes through the terminal interlocking as specified in Section 16956. The control panels shall be designed for operation by pushbuttons.
- B. At emergency crossovers, the Contractor shall provide for control of route selection by two methods:
1. From Central Control
  2. By manual operation of a local Interlocking Control Panel
- C. At interlockings located outbound of a terminal station on Yard Lead tracks or Tail Tracks, the Contractor shall provide for control of route selection as follows:
1. From Central Control, or (with Central's permission) from either the Dispatcher's Control Panel or the Local (TCR) Interlocking Control Panel.
  2. By Emergency Release from either the Dispatcher's Control Panel or the Local (TCR) Interlocking Control Panel, with the Local Interlocking Control Panel Emergency Release having the highest priority.
- D. Coordination and priority shall be provided between the methods of route initiation to achieve the operation described in Sections 16904, 16913, 16916, 16918, and 16956, and as indicated on the Contract Drawings.

#### **1.10 QUALITY ASSURANCE**

- A. The quality of the Contractor's final interlocking design and the conformance of his design to the requirements specified herein shall be verified by an employee of the Contractor who is well versed in AREMA recommended practices for interlocking safety design requirements and is familiar with established principles in interlocking signaling. This employee shall have had a minimum of 15 years experience in railway signaling design including at least five years experience in rapid transit signaling design.

- B. It shall be the Contractor's responsibility to check the location of insulated joints shown on the Contract Drawings for conformance with all interlocking safety requirements and for conformance with specified civil stationing. It shall also be the Contractor's responsibility to verify by field inspection and testing that the insulated joints (provided by other disciplines) have been located correctly and are functioning properly.
- C. All interlocking components and systems shall be tested as specified in Section 16980 and in the Sections describing specific components and systems.

#### **1.11 SUBMITTALS**

- A. The Contractor shall submit three copies of his final interlocking circuit design for each interlocking included under this Contract to the designated Resident Engineer for approval within 180 days of receipt of Notice To Proceed. These drawings will not be considered for approval by the designated Resident Engineer until they have been signed by the Contractor's designated, qualified signal engineer to indicate that they have been checked and approved by the Contractor.
- B. The Contractor shall submit three copies of a complete written description of any portion of his final interlocking design which does not conform with the requirements specified herein. This description shall include:
  - 1. An explanation of each change and how it will affect operation of the interlocking.
  - 2. The reason for proposing each change.
  - 3. A statement of benefits accruing to the Authority as a result of each change.
  - 4. Verification that the changes will not require changes in the existing METRO carborne or wayside ATC systems.

### **PART 2 PRODUCTS**

#### **2.01 ELECTRICAL AND MECHANICAL EQUIPMENT**

- A. All electrical equipment for audio frequency (AF) track circuits, power frequency track circuits, speed-command loops, track switch operating layouts, signal layouts, pushbutton layouts, negative return bonding, signal rail bonding, interlocking control panels, and vital and non-vital interlocking circuitry furnished under this Contract shall be as specified in Section 16960 of these Specifications and as shown on the Contract Drawings.
- B. All mechanical ATC equipment for interlockings furnished and installed under this Contract shall be as specified in Section 16960 and Section 16970 of these Specifications and as shown on the Contract Drawings.

### **PART 3 EXECUTION**

#### **3.01 INSTALLATION**

- A. The various electrical and mechanical devices composing each interlocking control system shall be installed as specified in the Sections describing those devices and as shown on the Contract Drawings.

#### **3.02 OPERATION**

- A. The final operation of interlockings furnished and installed or modified under this Contract shall conform to the operation of similar types of interlockings described in Section 16904, Current Automatic Train Control System, unless otherwise specified.
- B. Local manual control by means of Interlocking Control Panels and Dispatcher Control Panel shall be as specified in Sections 16918 and 16956.

- C. Where applicable, when diverging (or turnback) route selection is initiated automatically by detection of Train Identity, the transfer of the detected train destination information to Central shall be coordinated with the occupancy of the designated ADVANCE APPROACH area by the train, and with route availability.

**3.03 MEASUREMENT FOR PAYMENT**

- A. Interlockings will not be measured for payment as such.
- B. The Contractor will be reimbursed for the various components and systems comprising an interlocking on the basis of measurement specifications for the components of the interlockings and for the acceptance testing of those components and systems.

**END OF SECTION**

## SECTION 16918

### SPECIAL ATC REQUIREMENTS FOR SPECIFIC LOCATIONS

#### PART 1 GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies special ATC equipment, work, and operating requirements for certain locations involved in this Contract in addition to the basic ATC requirements specified elsewhere.
- B. Wherever the term "...at the appropriate time..." appears in these ATC Specifications or on the ATC Contract Drawings, it shall be interpreted to mean, "... at the appropriate time as determined by the designated Resident Engineer (Engineer)."

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16901 Definition of ATC Terms
  - 2. Section 16904 Current Automatic Train Control System
  - 3. Section 16911 Scope of ATC Work
  - 4. Section 16913 ATC Block Design
  - 5. Section 16916 Basic ATC Circuit Requirements
  - 6. Section 16917 Basic Interlocking Requirements
  - 7. Section 16920 Wayside ATC Systems
  - 8. Section 16930 ATC Facilities and Spare Equipment
  - 9. Section 16940 ATC Electrical and Electronic Components and Material
  - 10. Section 16950 Train Control Equipment Modules
  - 11. Section 16980 ATC Tests, Inspections and Quality Assurance
  - 12. Section 16997 RTU Scan Sheets

##### 1.03 (EXAMPLE LOCATION SPECIFICATIONS SHOWN) ANACOSTIA (F06) TIE-IN WORK

- A. The Contractor shall provide all equipment, circuitry and logic, and perform all work necessary, to convert the Anacostia interlocking and station from its temporary terminal configuration to an emergency crossover/inline station configuration in the manner specified herein and as shown on the Contract Drawings. This shall include, but not be limited to, the following activities at the appropriate times:
  - 1. Removal of Train Control Room DTS/RTU wiring for:
    - a. Possible future Tiebreaker Station
    - b. Existing Chiller Plant
    - c. Future Station Destination Signs.
    - d. See the RTU Scan Sheets and the Contract Drawings.
  - 2. Installation, testing, and placing in service the necessary number of new Audio-Frequency track circuits for the Anacostia TCR area of control, and all speed commands in the Anacostia TCR control area outbound of the station platform.
  - 3. Activation of the number 20 and 24 turnback "signals" for the inbound end of the Anacostia interlocking, and the number 10 and 14 turnback "signals" for the outbound end of that interlocking. The Contractor shall furnish and install new wayside "TURNBACK" signs at the appropriate locations.
  - 4. Activation and testing of the inbound programmed-stop marker coil layouts on the outbound end of the station. The Contractor shall furnish and install STATION STOP signs for the inbound approaches to Anacostia Station.

5. Removal of all "terminal algorithm" circuits, logic and equipment, and performance of all necessary reprogramming. (WMATA will maintain the existing algorithm for daily normal terminal revenue operation until the final cutover of the system.)
  6. Removal of wayside signal pushbutton layouts and START ATC and END ATC signs.
  7. Removal of Route Cancel pushbutton layouts and any existing Flyby-Transmitters.
  8. Replacement of terminal station transceivers with inline type transceivers, and performance of all necessary reprogramming for same.
  9. Modifications to the existing Interlocking Control Panel in the TCR, or replacement of the existing faceplate.
  10. All necessary revisions and additions to the RTU wiring for both ATC and ancillary functions, e.g., addition of new track circuit indications in prescribed sequence, and removal of Automatic Terminal Mode controls and indications, all as indicated on the RTU Scan Sheets and as shown on the Contract Drawings. This work shall be done in close cooperation and coordination with Authority personnel at times designated by the designated Resident Engineer.
  11. Provision/activation of the Anacostia TCR area portion of all necessary Anacostia/Congress Heights vital traffic and vital and non-vital repeater circuits.
  12. Performance of a complete examination of all existing, new, and revised circuits and logic in the Anacostia Station area, and completion of all remedial work necessary to ensure that no unsafe conditions exist. This shall include, but not be limited to, examination and remedial action to ensure that no unsafe speed commands can be issued to normal or reverse-running trains in the area due to:
    - a. omission of necessary circuitry, and/or;
    - b. omission of appropriate "traffic" or other necessary contacts in existing or necessary new speed control circuits.
- B. The Contractor shall, at the appropriate times, provide temporary, base-of-rail clamped 1000 KCMIL negative return bonding around the insulated rail joints (by others) at first O.B. Sta. F203+85 and first I.B. Sta. F203+85 in the vicinity of the existing bumping posts at Sta. F203+97 on the existing F-Route tracks.
- C. The Contractor shall, at the appropriate times, replace the temporary negative return rail bonding at first O.B. Sta. F203+85 and first I.B. Sta. F203+85, with permanent compression-bolted rail-web bonding of the normally specified type, all as indicated on the Contract Drawings.
- D. The Contractor shall disconnect and tag & tape the existing external 25-Pair DTS-4 cable at the TCR entrance rack and at the RTU entrance rack. (The originally proposed new Tiebreaker Station has been eliminated. See Dwg. ATCF06-G-004 and the RTU Scan Sheets.)
- E. The Contractor shall disconnect and tag & tape the existing 50-Pair DTS-5 cable at the TCR entrance rack and at the RTU entrance rack. (The DTS is no longer used to control and indicate Chiller Plants. See Dwg. ATCF06-G-004 and the RTU Scan Sheets.)
- F. The Contractor shall extend the existing 1R and 2N Speed Restriction Zones to include all new track circuits added to the Anacostia TCR area of control. See the Contract Drawings and the RTU Scan Sheets (Section 16997).
- G. The ATC testing at Anacostia shall include:
1. All new or revised circuitry, equipment and logic
  2. All static and dynamic testing which could not be completed in the normal manner in the past.

3. The Contractor shall furnish new AS-BUILT tracings, prints, magnetic media and aperture cards for all new ATC drawings created and for all existing ATC drawings revised as part of the work in the Anacosita RTU area of control.

**1.04 (EXAMPLE LOCATION) CONGRESS HEIGHTS (F07)**

- A. The Contractor shall provide the DTS/RTU connection from the Congress Heights TC/Comm Interface Cabinet for the Fire and Intrusion indications for Emergency Exit F2, which is physically located in the Anacostia TCR Area of Control. See Contract Drawings ATCF07-G-004 and G-019.

**1.05 (EXAMPLE LOCATION) SOUTHERN AVENUE (F08)**

- A. The Contractor shall take special note of the large gap in stationing on the I.B. Track inbound of the emergency crossover, and the considerable overlap in stationing on both tracks outbound of the emergency crossover. (See Dwg. ATCF08-G-007).
- B. The Contractor shall provide an Inclement Weather (RETARDED PERFORMANCE LEVEL) TWC Fly-By Transmitter System for the inbound approach to this Station. See Section 16924, the RTU Scan Sheets and the Contract Drawings.

**1.06 (EXAMPLE LOCATION) NAYLOR ROAD (F09)**

- A. The Contractor shall provide special overhead protection for the power disconnect switch (by other disciplines), and for any Train control racks or other equipment mounted below the area where cable ducts enter through the ceiling of the Train Control Room. See Dwg. ATCF09-G-003. This protection shall divert any liquids entering the room in this area in a manner satisfactory to the designated Resident Engineer.
- B. The Contractor shall provide an Inclement Weather (RETARDED PERFORMANCE LEVEL) TWC Fly-By Transmitter System for both approaches to this Station. See Section 16924, the RTU Scan Sheets and the Contract Drawings.
- C. The Contractor shall provide Snowmelter Layouts for the Naylor Road Interlocking. See Section 16969 and the Contract Drawings.

**1.07 (EXAMPLE LOCATION) SUITLAND (F10)**

- A. The Contractor shall provide one, or possibly two, fly-by transmitters on the outbound track (for control of the approach to Branch Avenue Terminal) in the Suitland TCR area of control. See the double line track plans.
- B. The Contractor shall provide Inclement Weather (RETARDED PERFORMANCE LEVEL) Fly-By Transmitter Systems for both normal approaches to this location. See Section 16924, the RTU Scan Sheets and the Contract Drawings.

**1.08 (EXAMPLE LOCATION) BRANCH AVENUE TERMINAL (F11)**

- A. The Contractor shall provide "END ATC" signs at the southeast (outbound) end of the station platform, and "START ATC" signs at the northwest (inbound) end of the station platform, as indicated on the Contract Drawings.
- B. The Contractor shall provide a complete complement of automatic terminal equipment, circuitry and logic for the Branch Avenue terminal interlocking and station. This shall provide three modes of automatic terminal operation as follows:

1. Mode 1 - Use platform track 1 only
  2. Mode 2 - Use platform track 2 only
  3. Mode 3 - Use first available unoccupied, unrestricted station platform track, with preference given to track 1, the inbound track.
  4. The mode selection shall be appropriately limited before a move is permitted from either of the yard lead tail tracks to an unoccupied Station platform track.
- C. Request for an inbound route from either of the station platform tracks shall be initiated by a TRAIN READY signal from the train rather than by any automatic "First In/First Out" feature.
- D. The Contractor shall provide complete equipment, circuitry and logic for the control and monitoring of the East (yard lead/storage track) interlocking. In addition to the normal safety circuits for this interlocking, the Contractor shall provide interfacing circuitry and logic which will make it possible for a "train" to safely move from the yard lead tail tracks to an occupied station platform track, once train motion on the platform track has ceased. (Such moves will be required to allow cars to be added to existing train consists at the station platform). Part of this special circuitry and logic shall include, but not be limited, to the following features:
1. No outbound speed commands shall be transmitted to a train on either platform track upon completion of the station dwell time for that train.
  2. Upon completion of the dwell time and time unlocks, provision shall be included to override the platform track "traffic" circuit if a route request is received from one of the storage tracks to the platform track.
- E. Additional interfacing shall be provided for safe and logical interaction between the East (temporary storage track) interlocking and the automatic terminal logic on a first-come, first served basis. As an example, with the terminal interlocking functioning in "automatic" mode and no outbound train approaching the station, a route request from storage track 1 or 2 to unoccupied platform track 1 would be granted only after the terminal interlocking crossover 1 was aligned and locked Normal, and the terminal mode selection was limited to platform 2. The Contractor shall prepare and submit complete operating plans for the coordinated operation of the two interlockings, and receive the Engineer's written approval of same, before proceeding with the final circuit and logic design to implement the agreed upon and approved operating plans.
- F. The Contractor shall provide three Terminal Algorithm Fly-by Transmitters for the Branch Avenue terminal; two on the outbound track upstream from the Branch Avenue terminal interlocking, and one on the inbound track downstream from the terminal interlocking as indicated on the Contract Drawings. (The first, and possibly the second, of these Fly-by Transmitters on the outbound track may have to be installed within the Suitland TCR area of control.) These Fly-by Transmitters shall be circuited to implement the terminal algorithm, i.e., to enable Central Control to reduce congestion at the Branch Avenue terminal interlocking by controlling train performance levels at these locations. The Contractor shall determine the exact locations for these Fly-by Transmitters, subject to the approval of the designated Resident Engineer.
- G. The Contractor shall provide two Interlocking Control Panels (I.C.P.s) at Branch Avenue - one in the main TCR and one in the Dispatcher's Room. Each of these panels shall be capable of controlling and monitoring both the West (automatic terminal) and East (yard lead track) interlockings. (If necessary due to space limitations, or operational necessity, or as directed by the Engineer, the Dispatcher's I.C.P. shall be provided on two separate cabinets, but with both faceplates showing the station platform area, at no additional cost to the Authority.) See the Contract Drawings and Section 16956.
- H. The Contractor shall provide complete, constantly energized automatic and manual

control circuitry for the control of the illuminating energy (furnished by others) for the NEXT TRAIN signs furnished and installed by others in the Branch Avenue Station. The "automatic" logic for this control circuitry shall be based on "First In/First Out" principals, but provision for manual override control from the Dispatcher's Interlocking Control Panel shall also be included. This logic shall not be included in the STAP. The Contractor shall install control wiring and any necessary suppression devices for the heavy duty control relays (by others) in the existing NEXT TRAIN Sign interface cabinet (by others) in the AC Service Room. See Section 16949 and Contract Drawing ATCF-C-011.

- I. The Contractor shall provide logically located extra rack space and spare terminals in the TCR to accommodate possible future Branch Avenue track circuit equipment for mainline track circuits and speed commands which might be installed southeast (outbound) of the Branch Avenue Station location in the future. This shall include sufficient extra rack space to mount 50 US&S PN-150 or GRS B1 vital relays in addition to the 20 percent spare space normally required.
- J. A Train Control Equipment Room (TCER F98) has been furnished by others at the Branch Avenue Tiebreaker Station. The Contractor shall provide Automatic Transfer and Bypass-Isolation equipment and internal power distribution and lightning/surge protection and grounding systems for all Train Control equipment and circuits installed in this TCER. The Contractor shall provide all power supplies for the necessary ATC equipment and circuitry in this TCER and for the East (Yard Lead) Interlocking Switch Machines, all yard lead signal lighting, and for the yard lead 60 Hz Track Circuits. The Contractor shall provide all vital and non-vital interfacing circuitry between this TCER and the main TCR at Branch Avenue Station.
- K. The Contractor shall (if possible) coordinate with the contractor providing the Branch Avenue Train Control Room and Branch Avenue Yard TCER lighting to ensure that rack lighting arrangements meet the requirements of these Specifications. If the lighting has already been installed, it shall be the Contractor's responsibility to make any necessary revisions and/or additions to these lighting arrangements to meet the Specifications of this Contract, at no additional cost to the Authority.
- L. The Contractor shall provide an Inclement Weather (RETARDED PERFORMANCE LEVEL) Fly-By Transmitter System for the normal outbound approach to Branch Avenue Station. See Section 16924, the RTU Scan Sheets and the Contract Drawings.
- M. The Contractor shall provide Snowmeter Layouts for both interlockings at this location. See Section 16969 and the Contract Drawings.

#### **1.09 QUALITY ASSURANCE**

- A. The Contractor shall perform in the field at the Tie-In location (Example-Anacostia), all tests required to ensure that the ATC system he has furnished or modified is safe and compatible with the existing ATC system and that the complete system operates as described and required by these Specifications.
- B. The Contractor shall review the work to be done at the tie-in location and produce a list of all the tests necessary to verify the safe and proper operation of all affected equipment at the tie-in location. This list shall include, but not be limited to, all tests included in Section 16980 which pertain to new equipment and circuitry installed, existing equipment and circuitry reworked, and areas where the revisions allow testing which was not previously possible.
- C. The Contractor shall perform in the field at the Tie-In location (Example-Anacostia) all

static and dynamic tests and retesting necessary due to wiring changes and track changes involved in the conversion of the area to its final, emergency crossover configuration. This shall include all testing which was not previously possible in the normal manner due to the temporary terminal track configuration.

- D. Testing by the Contractor at the Tie-In location (Example-Anacostia) shall be in close cooperation and coordination with the Authority's ATC operation and maintenance personnel.
- E. All testing at the Tie-In location (Example-Anacostia) shall be performed in accordance with procedures and schedules previously approved by the Engineer and at the appropriate times specified by the Engineer.

#### **1.10 SPECIAL SUBMITTALS**

- A. Unless otherwise specified, the Contractor shall submit drawings of all proposed new circuits and revisions to existing circuits, and descriptions and equivalent circuits for all proposed microprocessor reprogramming for Anacostia at least 120 calendar days prior to planned start of installation of such circuits or revisions.
- B. The Contractor shall submit plans and schedules for conducting the revisions and tie-in work at Anacostia. These plans and schedules shall be submitted to the Engineer at least 120 calendar days before the planned commencement of such work. The Contractor's method of placing the new or revised circuitry, programming, and/or equipment in service, and the method of disconnecting, revising and/or removing existing circuitry and/or equipment, shall be described in a written proposal of a procedure which shall have minimum effect on existing revenue service.
- C. At least 120 calendar days prior to commencing testing at Anacostia, the Contractor shall submit to the Engineer for approval a written description of the scope of testing required for that location. Copies of detailed test procedures and data sheets for these tests shall be included with this submittal. The submittal shall describe in detail all necessary tests and partial tests, identifying those tests which require complete retesting and those for which partial testing is sufficient. Any partial testing shall be properly identified and all items to be tested shall be documented in the submittal. No testing will be permitted until the Contractor has received approval of the test plan and schedule for the location involved.
- D. (EXAMPLE LOCATIONS ANACOSTIA, SOUTHERN AVENUE, AND NAYLOR ROAD SPECIFICATIONS SHOWN) The Contractor shall, within 180 calendar days of receipt of Notice-to-Proceed, submit to the Authority for approval complete operational descriptions of the following:
  - 1. The final Anacostia, Southern Avenue, and Naylor Road emergency crossover interlockings, complete with all of their applicable turnback and DTS operational features.
  - 2. The final Branch Avenue automatic terminal crossover interlocking area, complete with its final automatic route selection and all applicable TWC, Fly-by Receiver, Fly-by Transmitter and DTS control facilities, and special facilities to allow additional transit cars to be added to trains at the Branch Avenue Station platforms in a safe manner.
  - 3. The initial operation of controls and indications for the Branch Avenue East Yard Lead universal crossover interlocking and tail tracks.
  - 4. The special provisions for the future operation of the East (Yard Lead) interlocking with Branch Avenue Yard in service.

- E. These documents shall not only describe the "normal" operations envisioned, but also how the systems will operate under abnormal and unusual conditions, and what actions will take place or be prevented by the systems proposed in order to ensure safe and efficient operation. These documents shall serve two purposes;
  - 1. They shall ensure that there is a "meeting of the minds" between the Contractor and the Authority with regard to the movements to be provided and the movements to be prevented by the Contractor's ATC equipment and circuitry in the applicable TCR control areas, and;
  - 2. They shall, in their approved form, serve as the basis for the Contractor's submittals of Operations Manuals for these areas.
- F. The Contractor shall, at least 60 days prior to commencement of such work, submit detailed plans for the proposed bonding methods and equipment to be used to provide 1000 kcmil negative-return isolation bonding from shunt bars and impedance bonds to the negative-return moles (by others) in the Branch Avenue TBS area. These plans shall also show the exact location and number of cables for each such bond.
- G. The Contractor shall, at least 60 days prior to commencement of such work, submit detailed plans for the installation of any impedance bonds or marker coils which cannot be installed in the normally specified manner or location due to the presence of guard rail or restraining rail mounting hardware, or to the location of closure rails in turnout areas. These plans shall include details of the proposed cutting of guard rails and modifications or relocation of supports for impedance bonds, marker coils, guard rails and/or restraining rails (as applicable) at each specific location.

## **PART 2 - PRODUCTS**

### **2.01 THE PRODUCTS AND MATERIALS REQUIRED BY THIS SECTION SHALL BE AS DESCRIBED ELSEWHERE IN THESE SPECIFICATIONS.**

## **PART 3 - EXECUTION**

### **3.01 EXAMPLE LOCATIONS ANACOSTIA, SOUTHERN AVENUE, AND NAYLOR ROAD SPECIFICATIONS SHOWN)**

### **3.02 REQUIRED OPERATION AT ANACOSTIA INTERLOCKING**

- A. The Contractor shall, at the appropriate time, modify this interlocking to eliminate automatic terminal operation and to provide emergency crossover operation with automatic turnback capability as indicated on the Contract Drawings and as specified herein.

### **3.03 REQUIRED OPERATION OF THE NAYLOR ROAD AND SOUTHERN AVENUE INTERLOCKINGS**

- A. The Contractor shall provide emergency crossover operation with automatic turnback capability for these interlockings as indicated on the Contract Drawings and as specified herein.

### **3.04 REQUIRED OPERATION OF BRANCH AVENUE INTERLOCKINGS**

- A. The Contractor shall design and install these terminal and yard lead crossover interlocking systems:
  - 1. to provide safe automatic terminal operation;
  - 2. to safely allow additional cars (from the yard lead storage tracks) to be added to

- 3. existing train consists at the Branch Avenue Station platform;  
to allow Central to control both the east (Yard Lead) interlocking and the west (Terminal) interlocking;
  - 4. to allow control of the West (Terminal) interlocking to be transferred by normal means, to either the Branch Avenue TCR I.C.P., or the Branch Avenue Dispatcher's I.C.P., by Central;
  - 5. to allow control of the East (Yard Lead) interlocking to be transferred by normal means, to either the Branch Avenue TCR I.C.P., or to the Branch Avenue Dispatcher's I.C.P., or to the (future) Branch Avenue Yard Control Machine, by Central, and;
  - 6. to allow authorized personnel at the Branch Avenue TCR I.C.P. or the Dispatcher's I.C.P. to seize control of the West (Terminal) interlocking or the East (yard lead) interlocking by operating the applicable EMERGENCY RELEASE pushbutton for that interlocking, with the TCR I.C.P. having priority and the capability to override the Dispatcher's EMERGENCY RELEASE capability.
- B. all as indicated on the Contract Drawings and as specified herein. See Section 16956, Interlocking Control Panels, and the Contract Drawings.

### **3.05 TUNNEL CLEANING (Where Applicable)(Example Specifications)**

- A. The Contractor shall, at the appropriate time after all other installation work in the (Location "A" Name and Location "B" Name) TCR areas of control has been completed, and prior to dynamic train testing, perform the following tunnel cleaning work in the two tunnels, including all cross-adits and shaft access points, outbound of Sta. X000+00:
- 1. Cover all drain openings with adequate filter media to prevent entry of wash down debris into the drainage system. Filter media shall be monitored and maintained during the wash down.
  - 2. Clean all tunnel and covered surface structure surfaces using a method adequate to remove dust and debris which may become airborne during dynamic train testing.
- B. Cleaning shall include, but not be limited to:
- 1. The surfaces of junction boxes, cables, fire lines, running rails, third rail, third rail cover boards, track fasteners, conduits, safety walks, cross adits, the area under the running rails and under shafts.
  - 2. Removal of all debris resulting from the tunnel cleaning.
  - 3. Removal of filter media from the drain openings once all cleaning operations have been completed.
- C. The Contractor shall, upon completion of the cleaning operation, inspect each of the drain openings for debris. The Contractor shall remove all debris and prove the drainage system using an adequately sized mandrel.
- D. The Contractor shall be responsible for damage to any equipment resulting from the cleaning operation. Appropriate measures shall be taken by the Contractor to protect all equipment installed in the area being cleaned.
- E. The Contractor shall furnish, through agreement with the local jurisdiction, any water needed for the cleaning operations.
- F. The Contractor shall remain responsible for the prevention of airborne dust in the tunnels for the duration of all dynamic train testing including dynamic systems testing.

### **3.06 MEASUREMENT FOR PARTIAL PAYMENTS FOR ATC TIE-IN WORK**

- A. Converting the (interface location name) interlocking and station operation from a Temporary Terminal configuration to an Emergency Crossover configuration, except testing, will be considered to be ATC Tie-In Work.
- B. Measurement for partial payments for ATC Tie-In Work will be based upon:
  - 1. Timely and acceptable submittal of all required special reports, descriptions, procedures and schedules for conducting the required tie-in work.
  - 2. Approval of the ATC Tie-In Work actually completed.
  - 3. Final Acceptance of the Tie-In Location
- C. The cost of "Tunnel Cleaning" work specified in this Section will not be paid for separately, but will be included in the payments for the installation work. All other work specified in this Section, except ATC Tie-In Work, will be measured for payment as described in the Sections under which the applicable type of work is specified.

**END OF SECTION**

## SECTION 16919

### ATC SYSTEM SAFETY PROGRAM

#### PART 1 GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the establishment and maintenance of an ATC System Safety Program which shall be developed by the Contractor and integrated into the ATC phase of this Contract. The ATC System Safety Program shall provide a disciplined approach to methodically evaluate the ATC system's design in regard to safety and to identify hazards and prescribe corrective action in a timely, cost effective manner.

##### 1.02 DESCRIPTION

- A. The ATC System Safety Program shall prescribe a formal approach to the elimination of hazards through engineering, design, education, management policy, and supervisory control of conditions and practices.
- B. The Contractor's ATC System Safety Program shall constitute a portion of the overall WMATA System Safety Program. The ATC System Safety Program shall supplement the fail-safe design requirements of these Specifications, but shall not relieve the Contractor of fail-safe design responsibility in any way.

##### 1.03 REQUIREMENTS

- A. The Contractor shall be responsible for the management and operation of the ATC System Safety Program. The responsibilities and functions of those directly associated with system safety policies and implementation of the program shall be clearly defined. The authority delegated to this organization and the relationship between line, staff, and interdepartmental, project, functional, and general management organizations shall be identified. It is not the intent of this article to prescribe or imply organizational structure, management methodology, implementation procedures, or internal documentation.
- B. The Contractor shall identify system safety interface links between the ATC system and other WMATA systems. These links shall include machine/machine interfaces, man/machine interfaces, training, maintenance, rules and procedures.
- C. The Contractor shall conduct a hazard mode and effect analysis for the entire ATC System covered by this Contract and for the following subsystems and potential hazard areas:
  - 1. Automatic train protection
    - a. Train separation
    - b. Route protection
  - 2. Automatic train operation
  - 3. Automatic train supervision
  - 4. Data transmission system
  - 5. Miscellaneous subsystems
    - a. TC Maintenance Telephone System
  - 6. Interface between train control system and operating personnel
  - 7. Interface between ATC system and non-ATC systems such as the Train Propulsion System.

##### 1.04 HAZARD CATEGORIES

- A. Hazards identified shall be classified and assigned a relative qualitative measure in accordance with the following categories:
  - 1. Category I - Catastrophic
    - a. Hazardous conditions such that human error, environment, design deficiencies, subsystem or component failure, or procedural deficiencies will cause death or serious injury to human beings or major system loss.
  - 2. Category II - Critical
    - a. Hazardous conditions such that human error, environment, design deficiencies, subsystem or component failure, or procedural deficiencies will cause personal injury or major system damage.
  - 3. Category III - Marginal
    - a. Hazardous conditions such that human error, environment, design deficiencies, subsystem or component failure, or procedural deficiencies can be counteracted or controlled without personal injury or major system damage.
  - 4. Category IV - Negligible
    - a. Hazardous conditions such that human error, environment, design deficiencies, subsystem or component failure, or procedural deficiencies will not result in personal injury or system damage.

#### **1.05 TASKS AND PROCEDURES**

- A. The ATC System Safety Program shall specifically describe the procedures which the Contractor shall follow in order to accomplish certain safety oriented tasks. These tasks shall include, but not be limited to, the following:
  - 1. Correct safety irregularities in the ATC design phase as early as possible.
  - 2. Eliminate from the system the evoking of any false proceed commands or false proceed signal aspects.
  - 3. Minimize the number of false restrictive or stop commands and false stop signal aspects.
  - 4. Evaluate design changes and the impact these changes will have on the safety of the complete ATC System.

#### **1.06 OBJECTIVES**

- A. The Contractor's objectives shall be in consonance with WMATA system safety objectives.
- B. The primary objective of the System Safety Program shall be to eliminate hazards of a vital nature, whether actual or potential, from the ATC System. These are hazards which could result in personal injury, unrefurbishable property damage, or loss of a portion of the Train Control System. This applies both directly and indirectly, i.e., whether the injury, damage, or loss were to be caused directly by Train Control System malfunction or indirectly by the resultant unsafe operation of one or more trains.
- C. The secondary objective of the System Safety Program shall be to minimize the seriousness of injury to patrons or personnel and the extent of damage to equipment and property due to any malfunction of the Train Control System or the trains themselves.

#### **1.07 SUBMITTALS**

- A. The Contractor shall submit a detailed description of his proposed ATC System Safety Program for the applicable route segment within 60 calendar days of receipt of the applicable Notice to Proceed. This description shall include, but not be limited to, all of the items required by this article. It shall also detail the methods to be used to achieve the specified objectives of the program and delineate how the ATC System Safety Program is to be implemented and documented.

- B. The Contractor shall submit an initial System Safety Report within 90 calendar days of receipt of the applicable Notice to Proceed. Supplementary System Safety Reports shall be submitted as necessary. These reports shall include, but not be limited to, descriptions of hazards detected and progress in implementing corrective measures to eliminate or reduce the seriousness of hazards within the ATC System. The discussion of hazards in this section of the report is intended to be limited to hazards, or safety-related design problems, of an unexpected or unusual nature. It is not intended that the monthly safety report contain a comprehensive discussion of all hazards related to rapid transit operation (or ATC operation) in general. The ATC System Safety reports shall include an interface section which identifies hazards to the ATC System which are best corrected external to the ATC System such as by changes in rules, procedures, training or maintenance. The interface section shall also identify external hazards which shall be corrected in the ATC System, such as protection against mismanipulation of controls or failure of incoming power.
- C. The Contractor shall submit separate reports evaluating the impact of design changes on the safety of the ATC System.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS AND EQUIPMENT**

- A. The Contractor shall supply all the materials, tools, equipment, computer time, reference literature and other items which are necessary to meet the requirements of the ATC System Safety Program.

## **PART 3 - EXECUTION**

### **3.01 ATC SYSTEM SAFETY COORDINATION**

- A. The Contractor shall designate one of his employees as ATC System Safety Coordinator. The ATC System Safety Coordinator shall have the following responsibilities:
  1. Direct the activities of the ATC System Safety Program personnel.
  2. Coordinate the activities of the ATC System Safety Program with the overall WMATA System Safety Program.
  3. Supervise the Contractor's Hazard Mode and Effect Analysis of the ATC System and its individual subsystems and interface areas.
  4. Keep records of all time charged to the ATC System Safety Program. These records shall be available to the designated Resident Engineer on 48 hours notice.
  5. Take immediate appropriate action to prevent personal injury or system damage when a category I or category II hazard is identified.
  6. Determine what changes could be made in the ATC System, operating rules, training procedures, equipment, maintenance procedures, physical structure, or other systems to permanently reduce category I and category II hazard conditions to a category III or category IV status and recommend these changes to the designated Resident Engineer.
  7. Determine which category III hazard conditions should be reduced to a category IV status and how this could best be accomplished. Recommend these changes to the designated Resident Engineer.
  8. Implement those safety changes approved or required by the designated Resident Engineer, which fall within the Contractor's area of responsibility.
  9. Submit the supplementary ATC System Safety Reports to the designated Resident Engineer.

### **3.02 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. The ATC System Safety Program will be measured for partial payments based upon:
1. The designated Resident Engineer's approval of the ATC System Safety Program submitted by the Contractor
  2. The Contractor's implementation and continuing management and operation of this program, as reflected in the supplementary ATC System Safety Reports
  3. The designated Resident Engineer's approval of the final documentation of the ATC System Safety Program.

**END OF SECTION**

## **SECTION 16920**

### **WAYSIDE ATC SYSTEMS**

(Table of Contents)

#### **PART 1 - GENERAL**

##### **1.01 SECTION INCLUDES**

A. This SECTION lists the various 16920-series Wayside ATC Systems Specification Sections:

- |    |   |                 |
|----|---|-----------------|
| 1. | ATC Power Distribution System                                 | (Section 16921) |
| 2. | Lightning/Surge Protection and Grounding Systems              | (Section 16922) |
| 3. | TC Maintenance Telephone System                               | (Section 16923) |
| 4. | Non-Vital ATO and ATS Processor Systems                       | (Section 16924) |
| 5. | Data Transmission System                                      | (Section 16925) |
| 6. | Microprocessor System for<br>Non-Vital Interlocking Functions | (Section 16926) |
| 7. | ATC Microprocessor Support Systems                            | (Section 16927) |
| 8. | Interlocking Vital Processor Systems                          | (Section 16928) |

#### **PART 2 - PRODUCTS**

NOT USED

#### **PART 3 - EXECUTION**

NOT USED

**END OF SECTION**

## SECTION 16921

### ATC POWER DISTRIBUTION SYSTEMS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing and installation of a complete Power Distribution System inside each of the new Train Control Rooms included in this Contract. Each of the Power Distribution Systems shall include all power supplies, transformers, transfer and bypass equipment, buses, feeders, and mains required to accept electrical energy from the two 3-phase power sources in the Train Control Room, modify this energy as required, and distribute it at the proper voltages to the various pieces of ATC equipment.
- B. Design each Power Distribution System to achieve the best load balance practicable.
- C. Each Power Distribution System shall include a power failure and overcurrent alarm system circuited as shown on the Contract Drawings. If a Remote Terminal Unit (RTU) is located in the Train Control Room, this alarm system shall include a check of the 5 volt internal power supply of the RTU.
- D. Certain monitoring, isolation, and protection devices shall also be included, as indicated on the Contract Drawings and as specified herein.
- E. All power supply distribution systems, regardless of rated system voltage, current or frequency, shall deliver the system voltage to the module, device or appliance connected to that system at not less than 95 percent, nor more than 105 percent of the nominal voltage rating of the module, device or appliance.

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16916 Basic ATC Circuit Requirements
  - 2. Section 16917 Basic Interlocking Requirements
  - 3. Section 16918 Special ATC Requirements for Specific Locations
  - 4. Section 16922 Lightning/Surge Protection and Grounding Systems
  - 5. Section 16925 Data Transmission System (DTS)
  - 6. Section 16941 Basic Electrical and Electronic Components
  - 7. Section 16946 Transformers
  - 8. Section 16947 Ground Detectors
  - 9. Section 16949 Signal Wire and Cable
  - 10. Section 16951 Transfer and Bypass Equipment
  - 11. Section 16952 DC Power Supplies
  - 12. Section 16971 Racks and Cable Trays
  - 13. Section 16977 Tagging and Marking
  - 14. Section 16978 Miscellaneous Train Control Components and Material
  - 15. Section 16980 ATC Tests, Inspections and Quality Assurance

##### 1.03 POWER SOURCE

- A. A "Normal" 208Y/120V, 60-Hz, 3-phase, grounded neutral service and a "Reserve" 208Y/120V, 60-Hz, 3-phase, grounded neutral service, each with its own grounded neutral

conductor, will be terminated by other disciplines on overcurrent-protected disconnect switches in power junction boxes located in each TCR. The overcurrent protection in these boxes will be sized to protect the feeders and service transformers only. At stations, the Normal (Essential) service will be served by the inverter of the Station Uninterruptible Power Supply System. The rating of both the Normal (Essential) and the Reserve (Emergency) services will be 9 KVA. These services have been sized with a demand factor of 70 percent. These two services, the disconnect switches and power junction boxes complete with terminals and the overcurrent protection devices for the on-site source equipment, will be provided by other disciplines at each TCR.

- B. Examine the equipment described in the preceding paragraph and the on-site transformers and feeders for these two services to determine whether they are of sufficient size to carry the required ATC loads in the manner specified herein. If the Contractor finds that any of the AC source equipment furnished by other disciplines has not been properly installed or connected or is insufficient to handle the required loads in the manner specified, he shall notify the Engineer in writing.

#### **1.04 BASIC TCR POWER DISTRIBUTION REQUIREMENTS**

- A. The Power Distribution System for each TCR which does not service one or more interlockings shall be equipped with the following:
1. A Normal 208Y/120V, 60-Hz, 3-phase, 4-wire, grounded neutral bus supplied by the Normal service
  2. A Reserve 208Y/120V, 60-Hz, 3-phase, 4-wire, grounded neutral bus supplied by the Reserve service
  3. An uninterruptible 120V, 60-Hz, single-phase bus energized through an automatic transfer switch by the third phases of the Normal or Reserve 208Y/120V, 60-Hz, 3-phase buses, but isolated from the transfer switch by an isolation transformer and monitored by an AC ground detector. This bus (UBX120-UCX120) shall supply all ATC loads requiring uninterruptible 60-Hz energy. These loads include power frequency track circuits, signal lighting circuits and power supplies for traffic circuits and for miscellaneous loads such as station dwell timers. A suitably interlocked bypass-isolation switch shall be provided in combination with the automatic transfer switch.
  4. A grounded 28V DC local energy bus (B28G-N28G) used to supply the DTS Remote Terminal Unit (RTU), all vital DC circuits which are totally confined to that TCR, and all non-vital 28V DC circuits.
    - a. The ends of this bus shall be energized by two identical sets of regulated power supplies. One set of these power supplies shall be fed from the Normal 208Y/120V, 60-Hz bus, and the other set shall be fed from the Reserve 208Y/120V, 60-Hz bus. Each of these power supply sets shall consist of an even number of individual power supplies divided equally between two of the three phases of each 3-phase power bus, as shown on the Contract Drawings. Each half of each of these power supply sets shall be capable of continuously providing at least 50 percent of the normal MAXIMUM load for the B28G-N28G bus.
    - b. As an option, the Contractor shall furnish and install two identical sets of 3-phase-input regulated power supplies to feed the ends of the B28G bus. Each of these power supply sets, one fed from the Normal 208Y/120V AC, 3-phase bus and the other fed from the Reserve 208Y/120V AC, 3-phase bus, shall be capable of continuously providing at least 100 percent of the normal MAXIMUM load for the B28G-N28G bus.
    - c. The negative terminals of these 28V DC local power supplies shall not be

connected directly to the negative side of the local 28V DC bus. Instead, both the N28G bus and the negative terminals of the 28V DC local power supplies shall be connected directly to the TCR prime ground bus, as shown on the Contract Drawings.

5. An ungrounded 28V DC line energy bus (LB-LC) used to supply all vital 28V DC circuits that extend outside of the TCR. The ends of this bus shall be energized by two identical regulated 28V DC power supplies. Each of these power supplies shall have a continuous output current rating of at least 100 percent of the normal maximum load for the LB-LC bus. One of these power supplies shall be fed from the third phase of the Normal 208Y/120V, 60-Hz bus, and the other shall be fed from the third phase of the Reserve 208Y/120V, 60-Hz bus. The LB-LC bus shall be monitored by a DC ground detector.
6. A grounded 5V DC bus (B5G-N5G) used for electronic station control and energy distribution failure alarm circuits inside the TCR.
  - a. The ends of this bus shall be energized by two identical regulated 5V DC power supplies. Each of these power supplies shall have a continuous output current rating of at least 125 percent of the normal maximum load for the B5G-N5G bus. One of these power supplies shall be fed from the third phase of the Normal 208Y/120V, 60-Hz bus, and the other shall be fed from the third phase of the Reserve 208Y/120V, 60-Hz bus.
  - b. The negative terminals of these 5V DC power supplies shall not be connected directly to the negative side of the 5V DC bus. Instead, both the N5G bus and the negative terminals of the 5V DC power supplies shall be connected directly to the TCR prime ground bus as shown on the Contract Drawings.
7. While these Specifications call for a DC system potential of 28 volts, nominal, the Contractor may request the Authority to consider, and if approved, supply equipment utilizing a different nominal voltage, provided that the equipment supplied is adequately engineered for safety, reliability and efficiency and provided that the equipment complies with the following conditions:
  - a. The nominal system potential utilized shall not be greater than 28 volts DC.
  - b. Voltage tolerances stated in these Specifications shall, when converted to a percentage basis, apply to the alternate system potential.
  - c. The separation and differentiation between grounded and ungrounded DC power buses shall be retained.
  - d. All equipment supplied to operate on the alternate supply potential shall be properly designed to operate at that potential.
  - e. Contact ratings and wire, conduit, terminal, and junction box sizes stated in these Specifications shall be increased where necessary to accommodate the increased current necessitated by a lower system potential, and as required to hold voltage losses to the levels specified elsewhere in this Section.
  - f. At all interface locations, equipment provided shall be capable of operating with the equipment of existing adjacent locations and at existing voltages without modification to the existing locations, except as required by other sections of these Specifications.
  - g. The alternate system potential shall not result in a system which requires significantly more rack space than that allotted in these Specifications.
  - h. Equipment supplied at locations equipped, or partially equipped, on a previous contract for purposes of tie-in, or revision of configuration, shall be of the same type and function at the same voltage as the equipment already installed.

## 1.05 ALTERNATE VOLTAGE RELATED SECTIONS

- A. Areas of these Specifications in which the effects of an alternate DC system potential must be considered shall include, but not be limited to, the following:
1. Section 16916 Basic ATC Circuit Requirements
  2. Section 16921 ATC Power Distribution Systems
  3. Section 16922 Lightning/Surge Protection and Grounding Systems
  4. Section 16924 Non-Vital ATO & ATS Processor Systems
  5. Section 16925 Data Transmission System (DTS)
  6. Section 16926 Microprocessor Systems for Non-Vital Interlocking Functions
  7. Section 16931 ATC Maintenance and Test Facilities
  8. Section 16943 Vital Relays
  9. Section 16944 Non-Vital Relays and Timers
  10. Section 16949 Signal Wire and Cable
  11. Section 16952 DC Power Supplies
  12. Section 16953 ATP Track Modules
  13. Section 16955 Track and Alarm Indication Panels
  14. Section 16956 Interlocking Control Panels
  15. Section 16980 ATC Tests, Inspections and Quality Assurance
  16. Section 16997 RTU Scan Sheets

## 1.06 POWER DISTRIBUTION FOR TCRs SERVICING INTERLOCKINGS

- A. For Power Distribution Systems in TCRs servicing one or more interlockings, the Contractor shall provide all of the basic power distribution equipment and buses specified for non-interlocking TCRs, plus the following:
1. An ungrounded WHB DC bus to supply switch-and-lock movement loads and, where applicable, snowmelter control circuit loads.
    - a. The ends of this bus shall be fed by two identical sets of 3-phase-input regulated power supplies. One of these power supply sets shall be fed by the 208Y/120V, 60 Hz, 3-phase Normal bus, and the other set shall be fed by the 208Y/120V, 60 Hz, 3-phase Reserve bus.
    - b. As an option, each end of the WHB-WHC bus shall be fed by a set of three identical single-phase-input regulated power supplies, one set fed from the three phases of the 208Y/120V, 60 Hz, Normal bus, and the other set fed from the three phases of the 208Y/120V, 60 Hz, Reserve bus.
    - c. In either case, each of these sets of power supplies shall be capable of supplying enough current to operate five switch-and-lock movements simultaneously, and the WHB bus shall be of sufficient capacity to carry this current without voltage drop at the movement which exceeds the limits stated in these Specifications.
  2. Two 120V, 60 Hz buses for signal lighting, each fed from the uninterruptible 120V bus through separate overcurrent protection devices.
  3. A single 120V, 60-Hz "flashing" energy bus for signal lighting. This energy bus shall be provided by breaking energy from the first signal lighting bus over the heavy duty contacts of a vital flasher relay having a "flashing" rate of 56 to 64 flashes per minute. This relay shall be energized only when one or more track switches within the interlocking are aligned in their "diverging" position.
  4. As many separately protected track transformers and local track relay coil taps as are required to supply the 60-Hz, AC track circuits used in the interlockings.

## 1.07 QUALITY ASSURANCE

- A. Inspect each Power Distribution System installed and shall promptly correct any deficiencies noted at no additional cost to the Authority. Each inspection shall be conducted in accordance with the requirements of the Contractor's Installation Inspection Procedure for Power Distribution Systems, as approved by the designated Resident Engineer.
- B. Test each new Power Distribution System and promptly correct any deficiencies noted, at no additional cost to the Authority. The testing shall be conducted in accordance with the requirements of the Contractor's Test Procedure for Power Distribution Systems, as approved by the designated Resident Engineer.

## 1.08 SUBMITTALS

- A. Submit the following to the designated Resident Engineer for approval at least 60 calendar days prior to the fabrication or procurement of the power distribution apparatus:
  - 1. Power Computations
    - a. Compute the power requirements for each bus and each type of train control load for the Power Distribution System of each newly equipped TCR included in this Contract. These computations shall include provisions for adequate wire sizing, taking into account the specifications concerning the requirements for the various overload capacities, the maximum and minimum applied voltage, and the maximum voltage loss.
    - b. When computing power requirements for a TCR and determining the proposed arrangement and capacity of its Power Distribution System, include the capacity for all ATC circuits and equipment which would logically be energized and controlled from that room, whether or not the wayside circuits and equipment can all be installed under this Contract. This shall include capacity for circuits and equipment for planned future track circuits, interlockings, and wayside ATC support functions for future stations which are delineated in Section 16918, Special ATC Requirements for Specific Locations.
    - c. Based upon these computations, the extra capacity and maximum voltage loss requirements of these Specifications and the requirements of the National Electrical Code (NEC) and applicable local electrical codes, determine and list the sizes and ratings of all buses and other power distribution equipment which he proposes to use in each Power Distribution System.
    - d. Submit complete computations for internal TCR power circuits which show the maximum voltage drop from room power source to each appliance, and the minimum working voltage which will be applied at each appliance.
    - e. Submit complete computations for all TC power circuits which leave the TCRs which show the maximum line voltage drop from the TCR to the apparatus or remote field location, and which show the line wire size(s) necessary to provide acceptable minimum working voltage and current at the remote device or location.
    - f. The Contractor shall include power equipment size lists with the complete power computations.
  - 2. Technical Data
    - a. Submit ratings, performance data, and mechanical and electrical drawings for the items of equipment which are proposed to be used as part of the Power Distribution Systems under this Contract. Equipment which does not conform with these Specifications shall not be used as part of any Power Distribution System or addition unless specifically approved by the designated Resident Engineer in writing.

- B. Submit the following to the designated Resident Engineer for approval at least 60 calendar days prior to the commencement of installation work on Power Distribution Systems:
  - 1. A complete power distribution layout for each TCR. Each of these layouts shall include the number, physical size, and electrical rating for all buses and other electrical apparatus comprising the layout, and drawings showing the physical location of the various Power Distribution System components in the TCR and showing complete circuits and details of the manner in which the various components are to be interconnected electrically. Each layout shall include provisions for power failure and overcurrent alarms, monitoring equipment, equipment grounding, and ground detection where required. Each layout shall also include provisions for isolating major components of the ATC Power Distribution System without interfering with the primary supply of ATC power, as indicated on the Contract Drawings and as specified herein.
  - 2. A Field Inspection Procedure for the Power Distribution Systems, which shall be used to check the installation of each TCR Power Distribution System or addition. This procedure shall be in accordance with the requirements specified for inspection procedures in Section 16980, ATC Tests, Inspections and Quality Assurance.
  - 3. A complete Field Test Procedure for the Power Distribution Systems which shall be in accordance with the requirements specified for field test procedures in Section 16980.
- C. For each TCR Power Distribution System installed, the Contractor shall submit a complete field inspection report within 15 calendar days of the completion of that installation.
- D. For each TCR Power Distribution System installed, the Contractor shall submit a complete field test report within 60 calendar days of the completion of that installation.

## **PART 2 - PRODUCTS**

### **2.01 MAJOR COMPONENTS**

- A. Power racks, cable trays, conduit, cable, power supplies, power transformers, automatic transfer switches, bypass-isolation switches, and ground detectors shall be as specified in other Sections of these Specifications.

### **2.02 FEEDERS AND MAINS**

- A. Feeders and mains shall be of sufficient size to carry the rated load, with voltage variation of not more than plus-or-minus 5 percent of the rated voltage of the appliance, measured at the appliance under full load and no load conditions. The continuous load rating for ATC feeders and mains shall be at least 125 percent of the total load that could reasonably be imposed by the part of the ATC system fed therefrom.

### **2.03 PROTECTIVE DEVICES**

- A. Circuit breakers and fuses shall be as specified in Section 16941, Basic Electrical and Electronic Components, and shall be of appropriate continuous current ratings for the loads to be supplied. In addition, circuit breakers and fuses protecting power supply equipment and buses shall be of the electrical indicating type. The protective devices of the ATC Power Distribution System shall be properly coordinated to provide selective tripping protection of the system against overloads and short circuits with a minimum of disruption

to the functioning of the ATC system. Protective devices for the automatic transfer switch shall be such that the contacts of the transfer switch are protected from welding.

#### **2.04 MISCELLANEOUS POWER DISTRIBUTION EQUIPMENT**

- A. Furnish and install all mounting and fastening hardware, insulating nuts or covers, cable lugs, conduit, and other miscellaneous components required to provide complete Power Distribution Systems or additions.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. Install all TCR Power Distribution Systems as indicated on the power distribution layouts approved by the Engineer. These systems shall be in compliance with the requirements of the NEC, all applicable local electrical codes, these Specifications, and the Contract Drawings. The Contractor shall not proceed with the installation of any TCR Power Distribution System until he has obtained the designated Resident Engineer's written approval for the proposed layout of that ATC Power Distribution System and all components thereof.
- B. Arrange grounded or ungrounded power buses so that ground loops do not exist in the bus or its connecting wiring. That is, only one path for current shall exist between the current source and the point of current application.
- C. Make the connections between the power buses on the power racks and the point of application with a twisted-pair of wires of the correctly calculated wire gauge. No parallel path shall exist between the source and the point of application. The current flow in both conductors of the twisted pair connections shall be, at all locations, equal in magnitude and opposite in direction.
- D. One twisted-pair may supply more than one appliance only if the conditions in B and C above are met and if irregularities of current draw of any one appliance will not effect the operation of any other appliances obtaining power from the same pair.

#### **3.02 IDENTIFICATION**

- A. Tag and label the equipment, cables, and buses comprising each ATC Power Distribution System as specified in Section 16977, Tagging and Marking, and as shown on the Contract Drawings.

#### **3.03 POWER TRANSFER SENSIVITY**

- A. The ATC Power Distribution System shall be so configured that normal inrush current during a power transfer by the Automatic Transfer Switch shall not trip any input or output fuses or breakers.

#### **3.04 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. For measurement purposes, ATC Power Distribution Systems for TCRs newly equipped under this Contract shall consist of:
  - 1. Buses, feeders and mains used for power distribution
  - 2. Disconnect and overcurrent protection devices

3. Isolation transformers
  4. Power failure and overcurrent alarm system
  5. Transfer and bypass equipment
  6. DC power supplies
  7. Ground detectors
  8. TCR equipment for power frequency track circuits (as applicable)
  9. All associated mounting and identifying hardware
  10. All associated wiring and terminations
- B. For purposes of payment, the transfer and bypass equipment, DC power supplies, ground detectors and power frequency track circuit equipment will not be included, but will be measured for payment separately as specified elsewhere.
- C. Power Distribution Systems will be measured for payment based upon:
1. Approval of all the preliminary submittals required
  2. Installation of the system by the Contractor and approval of the installation by the designated Resident Engineer

**END OF SECTION**

## SECTION 16922

### ATC - LIGHTNING/SURGE PROTECTION AND GROUNDING SYSTEMS

#### PART 1 GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing, installation, and testing of lightning protection, surge protection and grounding systems for Train Control Rooms, and the grounding of signals, Train Control equipment cases, junction boxes, and other Train Control equipment or apparatus hereinafter specified or shown on the Contract Drawings to require grounding. It is the intent of these Specifications that the Contractor shall perform all work and furnish and install all equipment necessary to provide complete, operating lightning protection, surge protection and grounding systems which are effective in protecting all Train Control systems from damage and operational malfunction.
- B. Ground connection to the track rails or use of the neutral conductors of the power company or any signal power supply system will not be permitted.
- C. The Contractor's design shall preclude any "closed loops" in the Train Control Room lightning protection and grounding systems. A "closed loop" in these systems is a condition which may occur due to multiple contact points between two or more sections of cable tray, or between any combination of cable tray, cable shielding, ground wire, and ground bus bar. Where shielded cable is used, the cable shield shall be grounded, but no electrically contiguous segment of the cable shielding shall be grounded at more than one point.
- D. Provide a complete system of devices to protect the Train Control circuits and equipment from lightning and other electrical surges. This shall be accomplished by providing as many applicable types and stages of protection as necessary to protect each type of circuit and equipment involved. The protection system designed by the Contractor shall comply with the requirements specified herein and shall be subject to Type Acceptance Testing.

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16918 Special Requirements for Specific Locations
  - 2. Section 16923 TC Maintenance Telephone System
  - 3. Section 16924 Non-Vital ATO & ATS Processor System
  - 4. Section 16925 Data Transmission System (DTS)
  - 5. Section 16926 Microprocessor Systems for Non-Vital Interlocking Functions
  - 6. Section 16927 ATC Microprocessor Support System
  - 7. Section 16928 Interlocking Vital Processor Systems
  - 8. Section 16947 Ground Detectors
  - 9. Section 16952 DC Power Supplies
  - 10. Section 16955 Track and Alarm Indication Panels
  - 11. Section 16956 Interlocking Control Panels
  - 12. Section 16965 Signal Layouts
  - 13. Section 16966 Wayside Pushbutton Layouts
  - 14. Section 16969 Snowmelter Layouts
  - 15. Section 16971 Racks and Cable Trays
  - 16. Section 16980 ATC Tests, Inspections and Quality Assurance
  - 17. Section 16996 ATC Technical Appendix

### 1.03 QUALITY ASSURANCE

- A. Inspect the lightning, surge protection and grounding systems for the Train Control Rooms and the grounding of wayside signals, equipment cases, pushbutton layouts, and other Train Control equipment which requires grounding, and correct any deficiencies noted. The inspection shall be conducted in conformance with the requirements of the Contractor's Installation Inspection Procedure as approved by the Designated Resident Engineer.
- B. The final tests of the TCR lightning, surge protection and grounding systems and the grounding of wayside signals, pushbutton layouts, equipment cases, and other grounded Train Control equipment shall be in conformance with the requirements of Section 16980, ATC Tests and Inspections, and shall be conducted in compliance with the approved Field Test Procedure for TCR and TC equipment lightning, surge protection and grounding systems.
- C. If, after the installation of any outside ground, it is found that the ohmic resistance between equipment and earth exceeds 15 ohms, furnish and install additional ground rods and any associated material required to connect them to the first ground rod driven, to meet the resistance requirement of 15 ohms or less. The Contractor shall retest the first ground rod after the multiple ground rods have been installed and connected, and record the results in accordance with Section 16980. Any additional ground rods installed to meet the 15-ohms-or-less requirement shall be either multiple ground rods or sectional ground rods. Rods connected in multiple shall be spaced a minimum distance of six feet apart.
- D. Within Train Control Rooms provided by others, if ground tests disclose that the resistance between earth ground and the room prime ground bus exceeds 15 ohms, the Contractor shall notify the Designated Resident Engineer.

### 1.04 SUBMITTALS

- A. Submit circuit, schematic and detail drawings showing design and details of each Train Control Room lightning, surge protection and grounding system for approval of the Designated Resident Engineer. These, drawings shall form a part of the Contractor's overall Train Control Room drawing submittal for equipment racks, entrance racks and cable trays as required by these Specifications.
- B. The Contractor's design and details of the lightning, surge protection and grounding systems for each Train Control Room shall be shown on one or more separate drawings dedicated to those systems. The combination of the lightning, surge protection and grounding system drawings with the cable tray layout or any other drawing will not be permitted, but details of the bonding of cable tray joints shall be shown on the Contractor's grounding system design drawings.
- C. Submit an Installation Inspection Procedure for lightning/surge protection and grounding equipment.
- D. Submit a Field Test Procedure for lightning/surge protection and grounding systems for Train Control Rooms and Train Control equipment.
- E. Submit an Inspection Report for the installation of lightning/surge protection and grounding equipment in each TCR and its area of control.
- F. Submit a Test Report for the lightning/surge protection and grounding systems in each

TCR and its area of control.

## **PART - 2 PRODUCTS**

### **2.01 OUTSIDE GROUNDING EQUIPMENT**

- A. When grounding rods are required, the rod and clamp shall be in accordance with requirements for grounding material as specified in Section 16978, Miscellaneous Train Control Components and Material. The connection between the ground rod and the apparatus shall be No. 6 AWG soft drawn, extra-flexible copper wire, or 4/0 wire if more than one ground rod is necessary.

### **2.02 INSIDE GROUNDING EQUIPMENT**

- A. Grounding bus bars furnished under this Contract shall have a minimum cross section of one and one-half by one-quarter inches, and shall be made of hard drawn pure copper having a minimum conductivity of 98 percent per ASTM B187-73. Each bar shall be straight and of rectangular cross section. All surfaces shall be true and free of imperfections. Train Control Room "prime" ground bus bars shall be at least two feet in length.
- B. Miscellaneous hardware, including but not limited to such items as lugs, washers, studs, and bolts used for ground connections, shall be bronze.

### **2.03 GROUND DETECTORS**

- A. Ground detectors shall be as specified in Section 16947.

### **2.04 LIGHTNING AND SURGE PROTECTION EQUIPMENT**

- A. Primary surge arresters shall have the ability to shunt relatively high current surges to ground with relatively little overshoot.
- B. Secondary surge suppressors shall have the ability to shunt-to-ground any surge overshoot from the primary arrester devices.
- C. The intermediate impedance devices shall have characteristics which will allow them to assist the initiation of operation of the primary arresters and protect the secondary surge suppressors, and yet not interfere with the normal operation of the Train Control circuits and equipment they are assisting to protect.
- D. Appropriately sized and rated metal oxide varistors (MOVs) shall be provided as a third stage of lightning protection for micro-processor circuits which exit the TCR. The rating for these devices shall be 50 percent greater than the working voltage of the protected circuit.

## **PART 3 - EXECUTION**

### **3.01 GROUNDING OF OUTSIDE EQUIPMENT**

- A. The following items of wayside equipment at locations external to Train Control Rooms shall each be grounded in the manner specified:
  - 1. All controlled signals and marker signals shown on the Contract Drawings or required by the final design.
  - 2. All metallic Train Control equipment cases and cable junction boxes shown on the Contract Drawings or required by the final design.

- B. The grounding of each piece of outdoor equipment shall be provided by the Contractor by means of an individual connection to a driven copper ground rod, or rods driven in series, i.e., one on top of the other. Where ground rods must be driven in parallel, the minimum distance between rods shall be six feet. The resistance of the connection from each piece of equipment to earth ground shall not exceed 15 ohms.
- C. The connection between the equipment and the ground rod shall consist of No. 6 AWG stranded copper wire, or 4/0 wire as necessary for proper protection.
- D. No more than three pieces of equipment to be grounded shall be connected to each driven ground.
- E. The ground connection wire from each piece of equipment to its associated ground rod shall be run in as direct a path as practicable. No looping or cascading of ground connection wires will be permitted.
- F. All ground rods shall have the grounding wire attached to the ground rod four inches above grade in order to facilitate maintenance inspection. The ground rod shall be driven in such a location that it does not create a tripping hazard.
- G. The Contractor shall take care to avoid previously buried cable when driving ground rods. The Contractor shall furnish all labor and material required to repair or replace any underground equipment damaged by his ground-rod-driving operations. This repair and/or replacement work shall be done to the satisfaction of the Designated Resident Engineer, and at no additional cost to the Authority.

### **3.02 GROUNDING OF INSIDE EQUIPMENT**

- A. Train Control equipment located in TCRs (or Dispatcher Rooms) provided by others shall be grounded as follows:
  - 1. Each equipment rack and entrance rack shall be grounded via a single point ground to overhead grounding bus bars which shall be installed continuously along each row of racks. Each grounding bus bar shall be properly sized and supported at sufficient intervals to prevent sagging. The grounding bus bars shall be mechanically attached via stand-off insulators to the cable tray support system. Joints in the cable tray shall be bonded and each cable tray, consisting of one, two or more sections so bonded, shall be single-point connected to the adjacent ground bus bar. All ground connections to racks, trays and other equipment shall be arranged to facilitate easy removal to allow the testing of the electrical isolation between each item of equipment and the ground bus. Surfaces of equipment shall be cleaned of paint, rust, corrosion, oil, or other possible insulating material, before ground connections are made. Joints in ground bus bar shall be kept to a minimum. When joints are necessary, they shall be shown in detail on the Contractor's design drawings for the grounding system, as approved by the Designated Resident Engineer.
  - 2. Wall mounted and desk mounted Interlocking Control Panel cabinets (where applicable) shall be grounded with a separate, insulated No. 6 AWG, extra-flexible soft drawn copper wire (or greater wire size as necessary to meet specified resistivity requirements) from the cabinet frame to the Train Control Room prime ground bus, unless otherwise directed by the Designated Resident Engineer. This connection shall be arranged to be removable to allow testing of the electrical insulation between the control machine and ground.
  - 3. The Contractor shall make all ground connections in each Train Control Room to a prime ground bus bar furnished and installed by others. This prime ground bus bar will be a minimum of two feet in length and will be of sufficient length to accommodate all Train Control system related connections required. It will be

mounted on insulating stand-offs on a wall of the Train Control Room, approximately four feet above the floor. This prime ground bus bar will be connected to a number 4/0, six foot pigtail (provided by others) which is the lead to the main ground connection for the applicable room. Each ground wire connected to the room prime ground bus bar shall be identified by an embossed metal tag indicating the wire's origin.

4. Ground bus bars as installed shall be free from sharp edges. All joints shall be assembled with a uniform pressure of 200 pounds per square inch.
5. Items of Train Control equipment such as power supplies, which contain an external ground post, shall be grounded to their respective rack and not directly to the room prime ground. Train Control equipment which contains an internal connection to the ac distribution system neutral, shall not be grounded. All other individual apparatus not located on racks and shown on the Contract Drawings or herein specified to be grounded shall be connected to the room prime ground bus with individual insulated No. 6 AWG (or larger as necessary) extra-flexible soft drawn copper wire. These connections shall be designed to be of the shortest possible length consistent with good workmanship and the layout of the room.
6. If shielded cable is used as part of the Contractor's Train Control System, each electrically continuous segment of cable shielding shall be grounded at only one point.
7. The Contractor shall provide all labor and material for any special grounding which is required or necessary for his equipment over and above that specified herein, at no additional cost to the Authority.

### **3.03 LIGHTNING AND SURGE PROTECTION**

- A. Conform to all wiring and equipment installation methods and procedures known, and provide all types and levels of lightning arresters and surge protectors necessary, to protect the Train Control equipment from damage or operational interference. This coordinated protective system shall include, but not be limited to the following:
  1. Segregation of high voltage wiring from low voltage wiring;
  2. Segregation of TC control wiring from power/ operating wiring and communications wiring;
  3. Provision of short, direct, low resistance conductor paths, using a minimum number of long-radius bends in the grounding cable, for the grounding of equipment and protective devices;
  4. Provision of initial lightning protection and surge protection by means of low resistance (15 ohms, max.) earth grounds for outside Train Control equipment, and at the point where TC cables and wiring first enter the buildings housing the Train Control Rooms;
  5. Provision of primary, high-current-capacity, properly grounded arresters of characteristics and type(s) appropriate to the application(s);
  6. Provision of three-stage secondary surge protection, which shall consist of:
    - a. Stage 1 - Dual overvoltage devices, each containing a gas-filled surge arrester, a varistor-type overvoltage protection module, and zener-type suppression diodes;
    - b. Stage 2 - Fast-blow fuses rated at the maximum current capable of being delivered by the device(s) being protected, and;
    - c. Stage 3 - A duplication of Stage 1, all circuited as shown on the applicable page in the ATC Technical Appendix (Section 16996).

### **3.04 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. With the exception of ground rods, there will be no separate measurement for partial payments for lightning, surge protection or grounding of equipment specified herein. All costs

of furnishing, delivery, storage and proper installation of grounding and lightning protection equipment other than ground rods specified within this Section will be measured for payment as part of the cost of the work for which it is a part.

- B. Factors which will be considered when determining partial payments for ground rods will include, but not be limited to:
1. Delivery of the ground rods:
  2. Installation of the ground rods and approval of the installation by the Designated Resident Engineer.
  3. Testing of the ground resistance and satisfactory correction of all grounding installation and test discrepancies by the Contractor.
  4. Final approval of the grounding test results by the Designated Resident Engineer.

**END OF SECTION**

## SECTION 16923

### ATC MAINTENANCE TELEPHONE SYSTEM

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing and installation of telephone equipment to extend the existing METRO Train Control (TC) Maintenance Telephone System to certain equipment provided under this Contract and to certain equipment provided by others.
- B. Provide all telephone jacks and plugs, terminals, jack boxes, rotary selector switches, interconnecting twisted pair wiring and speaker phones to form a complete system compatible with the existing system. No instrument ringing shall be provided.
- C. Provide TC Maintenance Telephone jacks in or on each of the following pieces of equipment as applicable under this Contract:
  - 1. Power, Entrance, and Equipment Racks (2 per rack; front and back)
  - 2. Track and Alarm Indication Panels
  - 3. Large Junction Boxes (to include TC/COMM Interface Cabinets and DTS interface boxes or cabinets furnished by other disciplines, and Wayside Interface or Distribution Junction Boxes furnished by the Contractor)
  - 4. Signal Junction Boxes
  - 5. Wall Mounted Interlocking Control Panels
  - 6. Switch-and-Lock Movements
- D. TC Maintenance Telephone circuits shall conform to the requirements specified in Section 16916, Basic Circuit Requirements, and be as indicated on the Contract Drawings.

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:

1.	Section 16916	Basic Circuit Requirements
2.	Section 16941	Basic Electrical and Electronic Component Requirements
3.	Section 16949	Signal Wire and Cable
4.	Section 16965	Signal Layouts
5.	Section 16955	Track and Alarm Indication Panels
6.	Section 16956	Interlocking Control Panels
7.	Section 16969	Snowmelter Layouts
8.	Section 16971	Racks and Cable Trays
9.	Section 16972	Junction Boxes
10.	Section 16980	ATC Tests, Inspections and Quality Assurance

##### 1.03 QUALITY ASSURANCE

- A. Ten randomly selected telephone jacks and plugs out of every hundred of each furnished, shall pass a 1000-volt insulation breakdown test and a low voltage continuity test before shipment from the point of manufacture. The results of these tests shall be recorded by the Contractor and submitted to the designated Resident Engineer on a test form previously approved by the Engineer.
- B. Each speaker phone and its adaptor cord shall be factory tested. The factory test for speaker phones shall be the manufacturer's standard. Only those speaker phones and cords which have passed their factory test shall be shipped to the Authority.

- C. The rotary selector switches for the TC Maintenance Telephone System shall be factory tested prior to installation in the racks.

#### **1.04 SUBMITTALS**

- A. Prior to Purchase or Fabrication
  - 1. The Contractor shall not proceed with the purchase or fabrication of TC Maintenance Telephone equipment until he has received the designated Resident Engineer's written approval of the proposed equipment. The Contractor shall submit the following drawings and data for approval prior to the purchase or fabrication of TC Maintenance Telephone equipment:
    - a. Mechanical drawings for each type of plug and jack lay-out to be used, including mounting and fastening details. The drawings for telephone jacks shall show the details of mounting on the front and back of all entrance, power and equipment racks, on all types of control and indication panels and internal junction boxes, and the details of the proposed external weatherproof jack box for external housing and junction boxes.
    - b. Complete mechanical and electrical drawings and performance data for the proposed speaker phones.
    - c. Complete mechanical and electrical drawings including contact ratings for the proposed rotary selector switches.
- B. Prior to Shipment or Installation
  - 1. Submit properly filled out factory test report forms to the designated Resident Engineer prior to the shipment of speaker phones or the installation of rotary selector switches or TC Maintenance Telephone jacks.
- C. Prior to Acceptance
  - 1. Submit properly filled out field installation inspection report forms and field test reports to the designated Resident Engineer for approval before the TC Maintenance Telephone System will be considered for approval.

#### **1.05 DELIVERY, STORAGE AND HANDLING**

- A. Deliver the speaker phones and adaptor cords furnished under this Contract directly to the Authority at a location on WMATA property designated by the designated Resident Engineer.

### **PART 2 - PRODUCTS**

#### **2.01 TELEPHONE JACKS**

- A. Telephone jacks for the TC Maintenance Telephone System shall be Type NL-112B as manufactured by Switchcraft, Inc., or approved equal, except that Type N-112B may be used on racks in the TCRs or on thin sheet metal boxes. Springs shall be silver-plated, nickel silver. A nylon bushing shall be provided to insulate jack sleeves from mounting surfaces. Terminals at all telephone jack locations shall be arranged to accommodate at least two pairs of No. 16 AWG wires.

#### **2.02 EXTERNAL JACKS**

- A. All telephone jacks mounted on junction boxes or equipment housings outside of Train Control Rooms shall be enclosed in wired entrance boxes or weatherproof housings and shall be equipped with spring-loaded jack-covers, Switchcraft No. 520, or approved equal.

### 2.03 TELEPHONE PLUGS

- A. All telephone plugs shall be Type 267 as manufactured by Switchcraft Inc. or approved equal. Plugs shall have solder terminals with built-in strain-relief clamp.

### 2.04 SPEAKER PHONES

- A. Furnish six speaker phones for each of the TCRs newly equipped under this Contract. Each speaker phone shall operate from either an internal power supply fed by external 120V ac, or a self-contained battery pack using conventional penlite batteries which shall be easily replaceable. Each speaker phone shall be equipped with a call button switch and a push-to-talk button switch.
- B. The speaker phones shall meet or exceed the following specifications:
  - 1. Receive Mode
    - a. Sensitivity: -30dBm
    - b. Impedance: 600 ohms, 300 Hz to 3kHz
    - c. Frequency Response:  $\pm 3$ dB from 300 Hz to 3kHz
    - d. Audio Power: 200mw
  - 2. Transmit Mode
    - a. Output:  $\pm 5$ dBm
    - b. Impedance: 600 ohms, 300 Hz to 3kHz
    - c. Frequency Response:  $\pm 3$ dB from 300 Hz to 3kHz
  - 3. Physical
    - a. Size: (Maximum) 8 inches x 5 inches x 4 inches
    - b. Weight: (Maximum) 24 oz. (including batteries)
  - 4. Battery
    - a. Type: Dry - Alkaline
    - b. Cell Size: AA (1.5V penlite)
    - c. Life: 125 hours minimum
  - 5. Protection
    - a. No damage to the speaker phone shall result from connection across 120V ac or 150V dc.
  - 6. Leads
    - a. Leads shall be six feet long and equipped with type 267 plugs; lead insulation breakdown voltage shall be 600V ac.
- C. An adaptor cable shall be provided with each speaker phone. The adaptor cable shall consist of a six foot length of extra flexible single-pair cable, with an insulated jack to accept the type 267 plug at one end and a pair of insulated alligator clips at the opposite end.
- D. Speaker Phones shall be "Nobelphone Portable Telephone Model P-11" as manufactured by Nobel Co., Ltd., Tokyo, Japan, or approved equal, modified to meet additional requirements specified above.

### 2.05 SELECTOR SWITCH UNITS

- A. A rotary, six-pole, six position wafer switch, wired as shown on the Contract Drawings, shall be furnished to select various combinations of TC Maintenance Telephone connections at each Train Control Room. This switch and a terminal strip of pressure-clamp type communications terminals shall be mounted on a metal plate suitable for installation in a standard size space on the entrance rack. The mounting plate shall be steel with a black or gray enamel finish, or anodized aluminum. The front of the plate shall be clearly and permanently marked to indicate the various connection combinations available for the various positions of the rotary switch, all as shown on the Contract Drawings. The back of the plate shall be marked to indicate the terminal coordinates for the switch plate wiring.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. External Jacks
  - 1. The weatherproof external jacks shall be so mounted on external cases, housings and junction boxes that the jacks may be used without opening the junction box, case or housing. The two wires from the telephone jack shall be terminated on terminals mounted inside the associated case, housing or junction box. The Contractor shall make twisted pair connections to other locations from these terminals.
  
- B. External Wiring
  - 1. The Contractor shall use No. 16 AWG twisted pair cable, as specified in the non-vital wire portion of Section 16949, Signal Cable and Wire, to connect all the external TC Maintenance Telephone jacks mounted on ATC equipment within the control limits of each TCR to the selector switch in that TCR as shown on the Contract Drawings. The Contractor shall install a separate twisted pair cable for each track in each direction from the TCR. Each cable shall connect all the TC Maintenance Telephone jacks mounted on ATC and support system equipment located along that particular track within the TCR area limits. The twisted pair installed along each track shall be extended to connect with the corresponding TC Maintenance Telephone pair from each adjacent TCR as shown on the Contract Drawings.
  - 2. The Contractor shall use one No. 19 AWG twisted pair out of each special control and indication cable to connect the TC Maintenance Telephone jack in each DTS Interface junction box to the TC Maintenance Telephone System in the Train Control Room as shown on the Contract Drawings.
  
- C. Internal Wiring
  - 1. The Contractor shall use No. 16 AWG twisted pair cable, unless otherwise directed on the Contract Drawings, to connect all of the TC Maintenance telephone jacks on panels, racks and junction boxes located within each TCR, to the selector switch in that TCR. Two individual single-conductor wires twisted together will not be acceptable.
  
- D. Jack and Plug Wiring
  - 1. All jacks and plugs shall be wired with white insulated wire on the tip side and black insulated wire on the ring side.
  
- E. In all instances, the TC Maintenance Telephone jacks shall be installed in such a manner that they are easily seen and easily accessible for use. A room-temperature vulcanizing adhesive sealant shall be applied to the threads of phone jacks to prevent them from loosening due to vibration and use.

### **3.02 FIELD TESTING**

- A. Test each TC Maintenance Telephone jack after the system has been installed in the field to assure a minimum resistance of one megohm between each jack and the equipment on which it is mounted.
  
- B. The TC Maintenance Telephone System provided under this Contract shall be tested to ensure that voice communications with a minimum signal-to-noise ratio of 15dB can be maintained through the extreme ends of all possible TC Maintenance Telephone circuits:
  - 1. Between TCRs located within the new route segment,

2. Between these TCRs and external wayside equipment jacks along each track within the new route segment,
  3. Between all the TCRs and wayside equipment jacks located within the route segment provided under this Contract and the nearest adjacent TCR originally equipped under previous contracts,
  4. Between all TCRs and DTS junction boxes newly connected under this Contract.
- C. The minimum resistance and minimum signal-to-noise ratio characteristics specified above shall be regarded as part of the criteria for acceptance of the TC Maintenance Telephone System. The Contractor shall provide whatever effort and material is required to meet these criteria at no additional cost to the Authority.
- D. Record the results of the above described field tests for submittal to the designated Resident Engineer.

### **3.03 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. There will be no separate payment for telephone jacks, jack boxes, plugs and the associated switching and wiring facilities. The cost of furnishing, installing and wiring all TC Maintenance Telephone jacks, jack boxes and selector switches will be included in the costs for the junction boxes, panels, housings, or racks on which these items are mounted.
- B. The cost of furnishing and installing external twisted pair cable for the TC Maintenance Telephone System will be measured for partial payments as indicated in Section 16949, Signal Wire and Cable.
- C. Speaker phones, complete with specified power supplies or batteries, leads and adaptor cords, will be measured for partial payments based upon the number of required units delivered to the Authority and accepted by the Authority.

**END OF SECTION**

## SECTION 16924

### ATC - NON-VITAL ATO & ATS PROCESSOR SYSTEMS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the requirements for providing a system of one or more equipment modules which constitute a microprocessor-based controller with the capability of operating certain non-vital ATO and ATS functions for each passenger station equipped for ATC under this Contract. This controller, or group of controllers, for each new passenger station location, shall be referred to herein as a Non-Vital Station Processor or, more simply, a Station Processor (STAP). This Section also specifies the requirements for certain interfacing equipment and circuitry to be provided along with the Station Processor, and for certain non-vital function logic to be provided by discrete components external to the Station Processor.
- B. Unless otherwise specified, the requirements of this Section shall supersede the Contract Drawings where the various passenger station functions are shown to be executed by relay and discrete electronic component types of equipment. The "discrete component" drawings are included to indicate how these non-vital ATO & ATS functions are achieved on other portions of the **current** METRORAIL SYSTEM, and are still correct insofar as the logic and results are concerned.
- C. The area of the WMATA right-of-way controlled or affected by the STAP shall be limited to the station platforms and the approaches thereto.

##### 1.02 BASIC STAP SYSTEM REQUIREMENTS

- A. It is recognized that a manufacturer of the STAP may supply more than one processor to properly accommodate the various station functions specified herein. This is acceptable under these Specifications. For the purposes of these Specifications, one or more non-vital processors will be referred to as a single entity, or as sections of a single entity. The STAP shall be completely separate from any processor specified in these Specifications for any other purpose. Functions or equipment of the STAP shall not interfere with the operation of other systems. The basic modular unit(s) of all STAPs provided under this Contract shall be interchangeable. The overall configuration for each STAP shall be determined by its internal programming and by its external wiring.
- B. The Contractor shall provide:
  - 1. One complete Station Processor for each passenger station newly equipped for ATO and ATS under this Contract,
  - 2. One complete Station Processor for use during training, which is to be delivered to the Authority upon completion of training.
- C. In the design of the logic for the STAP the Contractor shall comply with the requirements of this Article and to the logic design inherent in the descriptions of electronic equipment and relay-type circuits contained on the applicable related Contract Drawings of these Specifications. In the construction of the STAP, the Contractor shall comply with the requirements of all other related Articles included in these Specifications.
- D. The Contractor shall provide a parallel-data interface between the STAP and the DTS Remote Terminal Unit.

- E. The Station Processor shall be capable of performing the following subsystem tasks as specified:
1. Control of Programmed Station Stopping
    - a. The Program Stop subsystem to be provided shall be the wayside portion of a system which shall cause the trains of transit vehicles to decelerate smoothly to a stop at the desired location along each passenger station platform included under this Contract. This subsystem shall be fully compatible with the carborne program stop equipment currently in use.
    - b. The wayside Program Stop subsystem shall transmit codes from the TCR to appropriate track-mounted marker coils to cause two-car and four-car trains to stop with their front ends aligned with the platform centerline (Type A Stop); or with their front ends aligned with the leaving end of the platform (Type B Stop); or with their centerline aligned with the platform centerline (Type C Stop), all as determined by the presence or absence of special jumpers in the control circuitry. Six-car and eight-car trains shall always be caused to stop with their centerline aligned with the platform centerline. The codes required are specified in Section 16967, Marker Coil Layouts.
    - c. The wayside Program Stop subsystem shall also have the capability of transmitting to the wayside marker layouts the proper code to cause the trains to skip the station stop when so commanded by Central Control via the DTS. When Central Control sends a skip-stop control, this control signal will be present at the output interface relay of the DTS until the skip-stop command is transferred to the intended train. In the absence of a skip-stop signal from Central Control, the Program Stop subsystem shall send to the appropriate marker coils the three-wire code for the programmed train/platform alignment.
    - d. The wayside Program Stop subsystem shall provide inputs to the Platform Edgelight Control subsystem, specified herein, for use in controlling the flashing of the proper segments of the platform edgelights.
  2. Train-to-Wayside Communications (TWC)
    - a. The TWC subsystem to be provided shall expand the wayside portion of the current METRORAIL TWC System as described herein. The operation of the TWC subsystem specified herein shall be functionally compatible with the current TWC System installed under previous WMATA contracts or by the Authority. The TWC subsystem shall be interfaced in such a way that any frequency ranges of electrical noise from the surrounding environment shall not interfere with the normal operation of the TWC System. TWC signal input circuits shall be provided with security check circuitry or software which shall not allow electrical noise to be interpreted as a valid message.
    - b. The current TWC System is the digital communications link between trains and wayside for exchange of data. The following functional data is exchanged between the trains and the wayside equipment.
 

<u>Train-to-Wayside</u>	<u>Wayside-to-Train</u>
Train Destination	Train Destination
Train Number	Train Number
Manual Pushbutton Right	Platform ID
Manual Pushbutton Left	Passenger Station Check
Doors Closed Right	ATS Acceleration
Doors Closed Left	ATS Speed Limit
PSS Active	
ATP in Effect	
Train in ATO	
Passenger Station Check	
Train Ready	



	1	Mark)
	2	Space)
	3	Mark) - Message Start
	4-11	Data - Word 1 - Train Destination
	12	Parity - (odd)
	13	Mark)
	14	Mark)
	15	Mark) - Message End
2)	Train-to-Wayside "Long" Message	
	<u>Bit</u>	<u>Description</u>
	1	Mark)
	2	Mark)
	3	Mark) - Message Start
	4-11	Data - Word 1 - Train Destination
	12	Parity (odd)
	13-24	Data - Word 2 - Train Number
	25	Parity (odd)
	26	Data - Word 3 - Manual Pushbutton Right
	27	Data - Word 3 - Manual Pushbutton Left
	28	Data - Word 3 - Doors Closed Right
	29	Data - Word 3 - Doors Closed Left
	30	Data - Word 3 - PSS Active
	31	Data - Word 3 - ATP in Effect
	32	Data - Word 3 - Train in ATO
	33	Data - Word 3 - Spare
	34	Data - Word 3 - Spare
	35	Data - Word 3 - Spare
	36	Data - Word 3 - Spare
	37	Data - Word 3 - Spare
	38	Parity (odd)
	39	Data - Word 4 - Passenger Station Check
	40	Data - Word 4 - Train Ready
	41	Data - Word 4 - All Doors Closed
	42	Data - Word 4 - Train Berthed
	43	Parity (odd)
	44	Data - Word 5 - Motion Detection
	45	Data - Word 5 - Train Length 2
	46	Data - Word 5 - Train Length 4
	47	Data - Word 5 - Train Length 8
	48	Parity - (odd)
	49	Mark)
	50	Mark)
	51	Mark) - Message End
3)	Wayside-to-Train "Short" Message	
	<u>Bit</u>	<u>Description</u>
	1	Mark)
	2	Space)
	3	Mark) - Message Start
	4-7	Word 1 - ATS Speed Limit
	8	Parity - (odd)
	9	Mark)
	10	Mark)
	11	Mark) - Message End
4)	Wayside-to-Train "Long" Message	
	<u>Bit</u>	<u>Description</u>
	1	Mark)

2	Mark)
3	Mark) - Message Start
4-11	Data - Word 1 - Train Destination
12	Parity (odd)
13-24	Data - Word 2 - Train Number
25	Parity (odd)
26-33	Data - Word 3 - Platform ID
34-37	Data - Word 3 - Spares
38	Parity (odd)
39	Data - Word 4 - Passenger Station Check
40	Data - Word 4 - ATS Acceleration
41	Data - Word 4 - Door Close Warning
42	Data - Word 4 - Spare
43	Parity (odd)
44-47	Data - Word 5 - ATS Speed Limit
48	Parity (odd)
49	Mark)
50	Mark)
51	Mark) - Message End

3. Platform Edgelight Control

a. The Platform Edgelight Control subsystem shall provide the logic necessary to illuminate the platform edgelights in such a manner that the lighted sections indicate the stopping alignment and length of the next train to stop in the station. The Platform Edgelight Control subsystem shall make use of traffic direction, track occupancy, and the Program Stop subsystem circuits to provide this logic. Output from the Platform Edgelight Control subsystem shall consist of a control for each 75-ft. section of platform edgelights as shown on the Contract Drawings. The Contractor shall extend the outputs to the appropriate locations in AC service rooms.

b. The Platform Edgelight Control Subsystem shall operate as follows:

- 1) Four types of input information are required for the Platform Edgelight Control System to determine the proper platform segment output controls:
  - a) Traffic Direction on the applicable track - supplied by the appropriate traffic relays;
  - b) Length of the approaching train - supplied by the Program Stop Control subsystem;
  - c) Skip Stop (Yes or No) - determined by Central Control, and;
  - d) "Type of Stop" (for 2 and 4 car trains) if the stop is to be other than centerline-of-train to centerline-of-station. Jumpers shall be provided by the Contractor in the TCR to call for Type A (Short) Stop, or Type B (Long) Stop as instructed by Designated Resident the Engineer. Absence of jumpers shall result in a call for a Type C (Center) Stop.
- 2) The Platform Edgelight Control System shall include two methods of triggering the outputs. One method shall be by means of inputs from the RTU via the Program Stop Control subsystem. The alternate method of triggering the Platform Edgelight Control subsystem outputs shall be by track occupancy in approach to the station as shown on the Contract Drawings.
- 3) The Platform Edgelights shall be caused to cease flashing upon departure of a train from the platform track.

4. Train Door Operation and Dwell Time Control

a. The Door and Dwell Control subsystem shall provide independent door and dwell control for each platform.

- b. The Door and Dwell Control subsystem shall:
  - 1) Provide the controls necessary to hold a train in the station.
  - 2) Provide automatic door control commands.
  - 3) Control the length of time a train remains at a station platform with its doors either opened or closed.
  - 4) Control the removal and restoration of ATP speed commands for trains at the station platforms.
  - 5) Control the transmission and removal of open door commands to the platform impedance bonds.
  - 6) Provide the interface between the RTU, the dwell timing and the station ATP track modules.
- c. The Door and Dwell Control subsystem shall operate as follows:
  - 1) The Door and Dwell Control subsystem shall receive the TRAIN BERTHED signal from a train in the station via the TWC System. Upon receiving the TRAIN BERTHED signal the Door and Dwell Control subsystem shall simultaneously:
    - a) Start the operation of the appropriate dwell timer.
    - b) Inhibit the transmission of an ATP speed to the platform impedance bond and the next downstream bond.
  - 2) The Door and Dwell Control subsystem shall subsequently replace the ATO speed command with an OPEN DOOR command.
  - 3) The speed command selection circuits shall:
    - a) Determine on which side the doors are to open.
    - b) Apply the appropriate OPEN DOOR command to both platform impedance bonds in such a manner that all doors of the train must be within the platform limits in order for the train to be able to process the command.
  - 4) Under normal operating conditions, when the dwell timer has timed-out the Door and Dwell Control subsystem shall:
    - a) Remove the OPEN DOOR command from the platform impedance bonds.
    - b) Allow the restoration of ATP speed commands to the platform impedance bonds and the next downstream impedance bond.
  - 5) The removal of the OPEN DOOR command causes the train to send a TRAIN-NOT-BERTHED signal via the TWC station receiver. Reception of the TRAIN-NOT-BERTHED signal by the Door and Dwell Control subsystem shall simultaneously:
    - a) Cause a DWELL COMPLETE signal to be transmitted to the Program Stop subsystem which shall cancel the train length information stored there.
    - b) Cancel the TRAIN BERTHED signal which is stored in the Door and Dwell Control subsystem.
  - 6) The Door and Dwell Control subsystem shall receive and process inputs from the RTU which will permit Central Control to influence dwell times.
    - a) These controls are as follows:
      - (1) HOLD WITH DOORS OPEN
      - (2) HOLD WITH DOORS CLOSED
      - (3) TERMINATE DWELL
    - b) Receipt of a HOLD WITH DOORS OPEN command from the RTU shall cause the Door and Dwell Control subsystem to maintain an OPEN DOOR command as long as the HOLD WITH DOORS OPEN command is present, even after the dwell timer has timed-out.
    - c) Receipt of a HOLD WITH DOORS CLOSED command

- from the RTU shall cause the Door and Dwell subsystem to:
- (1) Remove the OPEN DOOR command
  - (2) Transmit a zero mph speed command to the train as long as the HOLD WITH DOORS CLOSED command is present, even after the dwell timer has timed out.
- d) Transmission of a TERMINATE DWELL command shall simultaneously:
- (1) Cancel the TRAIN BERTHED signal stored in the Door and Dwell Control circuits.
  - (2) Transmit a DWELL COMPLETE signal to the Program Stop subsystem.
  - (3) Remove the OPEN DOOR command from the platform impedance bond.
  - (4) Allow the restoration of ATP speed commands to the platform impedance bond and the next downstream bond.
- 7) The Door and Dwell Control subsystem shall be provided with wiring for a possible future local control switch for the following commands:
- a) HOLD WITH DOORS OPEN
  - b) HOLD WITH DOORS CLOSED
- 8) The effect of the possible future locally initiated "Hold With Doors ..." commands shall be the same as previously described.
5. Train Approach Warning Light Control(for TRAIN ARRIVAL INDICATION LIGHT SYSTEM) ("TAILS")
- a. Provide the circuitry/logic to initiate a "TRAIN APPROACH WARNING LIGHT" (TAWL) when an outbound train is in approach to, and within approximately 60 seconds of arriving at the station platform.
  - b. Provide an adjustable timing function output to maintain this "TAWL" indication for a certain period of time after the train first arrives at the station platform track. The "timer" shall initially be set for 120 seconds.
  - c. The Contractor shall also provide the necessary circuitry to carry this "TAWL" indication to a 28-volt, non-vital relay (by others) in the DTS Box (by others) in the applicable station AC Service Room, as indicated on the Contract Drawings.
- F. The Station Processor shall include all non-vital internal timing functions necessary for the subsystems which it is executing.
- G. The Station Processor shall include the "Performance Level Translator" logic necessary to convert the two-bit performance level control received from Central Control into a four-bit binary code which identifies the ATS speed limit required to achieve the desired performance level. (See Section 16904, Current ATC System.) The two bit Performance Level Translator shall be programmable from external hardwire program plug couplers. Modifications of Software to change performance levels will not be allowed.
- H. The Contractor shall provide training courses for personnel maintaining the STAP. The training courses shall be in accordance with the requirements of this Section and Section 16993, ATC Training Courses.
- I. The Contractor shall provide circuitry for the control of "NEXT TRAIN SIGN" lights furnished by others at terminal locations, as shown on the Contract Drawings. The "automatic" logic for this control circuitry shall be based on "First In/First Out" principals, but provision for manual override control from the Dispatcher's Interlocking Control Panel shall also be included. This logic shall not be included in the STAP.

### 1.03 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
1. Section 16998 Correction of ATC Deficiencies
  2. Section 16904 Current Automatic Train Control System
  3. Section 16911 Scope of ATC Work
  4. Section 16914 Environmental Requirements
  5. Section 16915 Basic ATC Equipment Requirements
  6. Section 16916 Basic ATC Circuit Requirements
  7. Section 16918 Special ATC Requirements for Specific Locations
  8. Section 16925 Data Transmission System (DTS)
  9. Section 16926 Microprocessor System for Non-Vital Interlocking Functions
  10. Section 16927 ATC Microprocessor Support Systems
  11. Section 16928 Interlocking Vital Processor Systems
  12. Section 16931 ATC Maintenance and Test Facilities
  13. Section 16932 Spare ATC Equipment and Selectable Items
  14. Section 16941 Basic ATC Electrical and Electronic Components
  15. Section 16942 Printed Circuit Cards
  16. Section 16945 Plugboards and Cabinets for Relays and PC Cards
  17. Section 16948 Plug Connectors
  18. Section 16949 Signal Wire and Cable
  19. Section 16953 ATP Track Modules
  20. Section 16961 Audio Frequency Track and Loop Circuit Layouts
  21. Section 16962 Impedance Bond Layouts
  22. Section 16967 Marker Coil Layouts
  23. Section 16971 Racks and Cable Trays
  24. Section 16977 Tagging and Marking
  25. Section 16980 ATC Tests, Inspections and Quality Assurance
  26. Section 16990 TC Documentation and Training
  27. Section 16996 ATC Technical Appendix
  28. Section 16997 RTU Scan Sheets
  29. Section 16998 Correction of ATC Deficiencies

### 1.04 QUALITY ASSURANCE

- A. The Contractor shall provide "Type Acceptance Testing" for the Station Processor if its design differs in any respect from a STAP previously accepted for regular use on the WMATA METRORAIL SYSTEM. This Type Acceptance Testing shall be performed at the manufacturer's factory. The testing may be under the surveillance of the designated Resident Engineer and shall be thoroughly documented.
- B. The Type Acceptance Testing shall including, but not be limited to, the following tests:
1. For the STAP, complete with its I-O Interface:
    - a. Full Temperature Sequence
    - b. Full Humidity Sequence
    - c. Full Vibratory Sequence
    - d. Full Power Voltage Variation
    - e. Electrical Transient Withstand (all external connections)
    - f. Proof of Correct Software Operation
    - g. Broad-band Radio Frequency Interference-Output Limits and Withstand Capability
    - h. Proof of Diagnostic Operation.

- C. All of the STAP modules and the software programs which are to be installed under this Contract shall be factory tested as a complete system in accordance with a factory test procedure. This procedure shall be generated by the Contractor in accordance with the guidelines set forth in another part of this Section. The procedure shall be approved by the Designated Resident Engineer before the start of factory testing.
- D. The factory test for the system complete with all TCR equipment shall include:
  - 1. All field tests which can be performed in the factory;
  - 2. Simulation of train movements at, and in approach to, the station platforms.
- E. The Contractor shall record the results of these tests on the specified Factory Test Report forms. Items for which Factory Test Reports have not been approved by the Designated Resident Engineer may be shipped to the job site only at the Contractor's risk.
- F. Each item of equipment shall be inspected by the Contractor immediately prior to installation. Only those items which have suffered no damage during shipment and subsequent handling shall be installed.
- G. All of the STAP modules and their software program which have been installed under this Contract shall be field tested after installation in accordance with a field test procedure. This procedure shall be generated by the Contractor in accordance with the guidelines set forth in another part of this Article. Field testing of the STAP shall not start until this procedure has been approved by the Designated Resident Engineer.
- H. The Contractor shall provide and maintain up-to-date, a Station Processor Diary or Log containing a detailed write-up of any and all changes made to the system hardware and software from the time of their approval by the Engineer until final acceptance by the Authority, at which time the Log shall be delivered to the Designated Resident Engineer. This record shall conform to the requirements more fully described in the documentation section of Part 3 of this Article.
- I. The STAP system shall be capable of meeting the Mean-Time-To-Restore requirements shown in the ATC Technical Appendix (Section 16996) of these Specifications.
- J. The Contractor shall provide Operation and Maintenance Manuals for the STAP. These manuals shall be prepared during the initial phases of the Contract so that they may be approved and delivered to the Authority before field testing commences. These manuals shall be prepared according to guidelines set forth in another part of this Article and in Section 16992, ATC Instruction Manuals.

#### **1.05 SUBMITTALS**

- A. The Contractor shall furnish within 60 calendar days of receipt of Notice to Proceed a submittal consisting of the following four explanatory items. These explanations shall be fully detailed and written in plain English. Simple diagrams may be used for clarity. All such diagrams shall be fully explained. A glossary of definitions shall be included to thoroughly define any absolutely necessary technical or unusual words, otherwise, such words shall not be used. Buzzwords, slang, computer jargon and telegraphic writing style not be used. The explanatory items are:
  - 1. The Contractor shall explain the method by which he obtains reliability in the system which he intends to provide for this Contract. With this explanation, he shall explain his understanding of the word reliability and his method of quantifying the reliability of the system.
  - 2. The Contractor shall provide a detailed explanation of the method by which he intends to implement the diagnostic requirements of this Section. This explanation

- shall describe the techniques of schemes to be utilized to verify the correct operation of every step of every process included in the information processing.
3. The Contractor shall provide a general explanation of the method by which he intends to implement the maintenance requirements of this Section. This explanation shall describe the features of the proposed maintenance program and the test equipment to be supplied for use with the maintenance procedures.
  4. The Contractor shall describe in detail the provisions he has made for repairing the printed circuit boards which are part of the STAP. This description shall address the following items:
    - a. Confirm that the Contractor will provide PC board service for at least 24 months as specified in Section 16998, Correction of ATC Deficiencies.
    - b. The procedure the Contractor plans to follow to allow continued Authority servicing when the 24 months have expired.
    - c. Which boards or devices will be kept in stock at the Contractor's factory, and for how many years.
    - d. The guaranteed maximum factory turn-around time from the receipt of a request for a new board or device to the shipment of its replacement.
    - e. The Contractor's board replacement policy.
    - f. Whether replacement boards are new or repaired.
    - g. Whether replacement boards would be from Authority returned boards or a general stock.
    - h. The present cost of replacement for each board type.
    - i. The present cost of repair for each board type.
- B. The Contractor shall furnish, within 60 calendar days of receipt of Notice to Proceed, any Type Acceptance Testing documentation which may be required for the STAP systems. This documentation shall include, but not be limited to, the details of the simulations for the functions to be executed by the STAP, the diagnostic routines and equipment, and the tests to be utilized in proving to the satisfaction of the Engineer that the STAP and the related system to be supplied will meet all of the applicable requirements of these Specifications.
- C. The Designated Resident Engineer will review the documentation for all equipment to be furnished under this Article before the equipment is delivered. The Designated Resident Engineer recommends that the Contractor not manufacture equipment for this Contract which has not been approved. Therefore, prior to component purchase, or fabrication of the equipment to be supplied under this Section, the Contractor shall deliver to the Designated Resident Engineer for approval, the following:
  1. Drawings of the proposed equipment modules, and test and diagnostic fixtures, including schematic diagrams, arrangement plans, assembly drawings, complete parts lists keyed to the drawings, ordering information, mounting details, internal and external wiring circuits and details, and mechanical and electrical component descriptions to the component level.
  2. The complete field test procedures for the installed and programmed STAP system.
  3. An outline of the course to be provided for Authority class instruction on the STAP.
  4. An outline of the organization of the system documentation for the STAP which the Contractor plans to supply according to these Specifications.
- D. The Factory Test Procedures for the assembled and programmed equipment modules for the applicable TCR locations shall be in conformance with the requirements specified in Section 16980, ATC Tests, Inspections and Quality Assurance. Approval of the procedures shall be obtained prior to manufacture of the modules. Manufacture without this approval shall be at the Contractor's risk. These test procedures shall include the testing of all operational aspects of each proposed system. The procedures shall show that the factory tests will be made on the complete system with all of the racks interconnected and with a complete simulation of the field inputs and outputs.

- E. Factory Test Reports as stipulated by the approved Factory Test Procedures shall be submitted to the Designated Resident Engineer for approval as quickly as possible after the factory tests. These test reports shall bear the signature of the Designated Resident Engineer's representative attesting to the witnessing of the test and its successful conclusion. There shall be a test report for each of the boards (including spares) comprising the STAP furnished under this Contract for initial Type Acceptance Testing.
- F. For the Design Review of the equipment to be supplied under this Section, the Contractor shall submit to the Designated Resident Engineer, for approval, the following:
  - 1. A listing of all inputs and outputs for each system with easily understood designations of their functions.
  - 2. A complete and detailed program printout of all software, including equivalent circuit drawings, for each STAP. The program shall be easily related to its associated equivalent circuits and modularized in a logical and easily understood manner. Each module of the program shall be fully documented with plain-English explanations of its purpose and the method by which it accomplishes that task, the modules to which it is related, and the module(s) of which it is a part.
  - 3. A description of the program functions and details with flow charts, a programming manual and a key sheet which lists and defines all symbols, abbreviations and other aspects of the program. This shall be one of the first items submitted for review.
  - 4. A description of, and documentation for, the compiler.
  - 5. Full documentation for the class of instruction including a course outline, course instruction manual, list of course training aids, list of class facility requirements, and class schedule.
- G. The Contractor shall revise the circuits of the Contract Drawings as necessary to show the circuitry external to the STAP and accomplish the functions described by the Drawings and Specifications with the equipment he plans to provide under this Contract. These revised circuits shall be submitted as part of the Design Review. These circuits shall be complete and continuous from the point of origin to the point of destination. They shall show all interface terminal connections between the various pieces of equipment. No conductor shall be ended or terminated without some note or reference as to its physical location or continuation at some other place. Twisted pair and/or shielded wiring shall be shown and noted wherever it is used.

## **PART 2 - PRODUCTS**

### **2.01 BASIC STAP EQUIPMENT REQUIREMENTS**

- A. The STAP equipment furnished by the Contractor under this Contract shall perform all of the functions listed in Part 1.02 E.
- B. The STAP equipment shall meet the physical and environmental requirements listed in these Specifications.

### **2.02 MECHANICAL REQUIREMENTS**

- A. The STAP shall make use of plug-in circuit boards. Each board shall be labeled with its function, a means of application identification, a serial number, and a model or drawing number.
- B. The program of the STAP shall reside in Erasable Programmable Read Only Memory (E-PROM) located on the processor board, or on a separate "memory" board. The memory devices shall be erasable and reprogrammable. The Contractor shall provide sockets on the boards for the memory devices. The memory devices shall be removable, and each memory

device shall have a complete and unique identification marking.

- C. Electro-mechanical memories such as magnetic-media tape and disk drives shall not be used in the STAP, except as may be necessary for programming and testing purposes.
- D. The printed circuit boards of the STAP shall be housed in rigid frames containing a motherboard for the mounting of the printed circuit board receptacles. This motherboard may be either a printed circuit board or a hard-wired plane. The frame shall contain full-length board guides to assure that the plug-in contacts of each plug-in board correctly mate with their motherboard receptacle.
- E. Each plug-in location of the STAP shall be labeled with the identity of the board type intended for that location.
- F. The Contractor shall provide some form of interlocking device to ensure that plug-in boards of the STAP cannot be mechanically or electrically damaged by plugging them into an incorrect location.
- G. The board frame of the STAP shall be constructed and mounted in a manner which allows the free movement of air over the equipment by convection to prevent local hot-spots which would degrade the life and operation of the assembled and mounted equipment and prevent it from meeting the physical and electrical environmental requirements of this Section and Section 16914. No fans or blowers will be approved for these purposes.
- H. The printed circuit boards or the printed circuit board frame which houses the STAP shall be provided with electromagnetic shielding if necessary for the system to meet the electrical environmental requirements of these Specifications.
- I. The Contractor shall provide a dust-resistant cabinet to house the STAP. This cabinet shall have dust-resistant doors or removable covers on both the front and back. The front shall be supplied with a safety glass or fire-resistant plastic panel which allows observation of the operation indicators which may be located on the front of the boards. The equipment shall be immune to the ambient dust accumulation. TCR dust consists mostly of residues of the train brake wear.
- J. This cabinet shall be of sufficient volume to allow the removal of heat from the boards by internal convection and the removal of heat from the cabinet by radiation and external convection. Fans shall not be employed in the heat removal process.
- K. The board frame shall be located within a zone which does not allow the bottom of the frame to be any closer to the floor than 2 feet or the top of the frame to be any higher than 6 feet from the floor. This requirement is for ease of viewing indicators or working on the STAP modules. Items of support equipment such as power supplies may be mounted in rack locations outside of this zone.
- L. At the time of the qualification test of the STAP, the printed circuit board frame shall be installed in this cabinet and the door or cover shall be in place.
- M. The Contractor shall provide compiler software maintenance for a period of 5 years.

## **2.03 ELECTRICAL REQUIREMENTS**

- A. The STAP and its associated equipment shall be powered by conservatively rated power supplies or inverters provided as part of its support equipment. These supplies or inverters shall meet the electrical, mechanical and environmental requirements of these Specifications.

These supplies or inverters shall operate either from the 120 Vac line or the 28 Vdc local power system specified elsewhere in these Specifications. In either case, these supplies or inverters shall be equipped with sufficient transient protection to provide immunity from power line transients as high as six kilovolts (1.5/40 microsecond standard wave).

- B. The input and output signal connections of the STAP shall be fully isolated from the power supply of the processor. This isolation shall be adequate to provide protection from the transient levels encountered in the installation. The Contractor shall be cognizant of the various sources of transient interference that may be encountered in the TCR such as those listed in Section 16914. It shall be the Contractor's responsibility to assess and provide protection from this interference.
- C. The output signal potential shall be 28 Vdc nominal and the outputs shall have an adequate and conservatively rated power capability suitable for each application.
- D. The impedance of the input channel shall be low enough to draw sufficient current for the circuitry to ignore false high resistance voltage applications at the input terminal. This low input impedance shall also serve to reduce "noise" interference. The input circuit shall be read as permissive only when sufficient current is present.
- E. All inputs shall be provided with de-bounce circuitry so that momentary voltage changes at the time of initial external contact closure will be ignored.
- F. One or more ports shall be provided for the transfer of coded input and output information. These ports shall make maximum use of industry standard communications standards and protocol except as necessary to promote reliability and security. These ports shall be for the purpose of system expansion, connection of test equipment and other such uses.
- G. All input and output boards utilized in the STAP system shall be constructed with a minimum of 1/8 inch creepage distance between all conductors exposed to the external electrical environmental, and shall be capable of withstanding a 1500 volt dc breakdown test. The voltage shall be applied between adjacent isolated circuits as well as from the isolated circuits to ground.
- H. All printed circuit boards utilized in the STAP shall have a properly applied conformal coating to minimize the effects of moisture.
- I. All printed circuit boards utilized for inputs or outputs in the STAP shall be designed so that there is minimal capacitive coupling between the circuitry on either side of the isolation devices. Consideration shall be given by the Contractor to the use of a grounded copper track between circuitry on either side of the isolation devices to further decrease the capacitive coupling which bypasses the isolation device.
- J. Visual indicators, such as LEDs, shall be provided on each input and output board to indicate when each of the associated inputs or outputs is active. A Key chart which identifies the function which each LED represents, shall be mounted inside the cover of the STAP module.
- K. All appropriate, relatively short timing functions shall be field adjustable without software modification, via jumpers on printed circuit boards in the processor or by some other means approved by the Designated Resident Engineer. The adjustable range of the timers shall be at least 0.1 to 30 minutes. The timers shall have a timing error of not more than plus or minus 5 percent of the setting.

## **2.04 ENVIRONMENTAL REQUIREMENTS**

- A. The following requirements shall take precedence over any other applicable environmental requirements:
1. Physical
    - a. The STAP assembly shall function in accordance with the Specifications in the physical environmental conditions described for the TCRs in Section 16914.1.02.
    - b. The various STAP system modules shall be shock mounted to provide the required vibration suppression.
    - c. Cooling of the STAP modules shall be accomplished by radiant plus natural convection means only. (No fans shall be used for this purpose.)
  2. Electrical
    - a. The STAP assembly shall work in the electrical environment of the TCR. The Contractor shall assess this environment, considering the factors stated in Section 16914.1.03 of these Specifications, and the characteristics of the equipment he is providing under this Contract. All inputs, outputs, power connections and communications lines, if any, shall be immune to the effects of lightning (except in the case of a direct stroke to the building which houses the STAP) and to surges or transients to which they may be subjected.
    - b. The Contractor shall pay special attention to the design and implementation of adequate protection for both ends of all input, output and metallic communications lines which are connected at their far end to equipment referenced to an independent ground.
    - c. The equipment to be provided under the terms of this Section shall conform to the following requirements:
      - 1) Conducted and radiated radio frequency energy at all frequencies shall be attenuated to a level which will not interfere with the operation of an adjacent radio transceiver with a self-contained antenna operating at any of the usual communications frequencies.
      - 2) The operation of a radio transceiver, transmitting radio frequency energy at any of the usual communications frequencies with ten (10) watts of power into an attached antenna, shall not cause malfunction of the microprocessor or the I/O devices. This and the previous requirement shall be met when the end of the transmitting antenna is within three inches of any external part of the STAP equipment.
      - 3) The STAP, if operating from an AC supply, shall be capable of operating without loss of continuity during power outages of up to three times the transfer time of the transfer switch provided by the Contractor.
      - 4) The STAP shall be immune to electrostatic discharges to all devices and surfaces exposed to human touch during operation or adjustment. This requirement does not apply to repair procedures to the printed circuit boards.

## **2.05 PROGRAMMING HARDWARE AND SOFTWARE**

- A. The Contractor shall exercise special care in the design of the program for the STAP to select an order of processing which does not cause any unwanted results.
- B. The Contractor shall provide a means of programming the STAP system, initially and as any subsequent changes, improvements, and replacements may require. This means of programming shall take the form of test and program fixtures and, if necessary to operate a fixture, a test program. See Section 16927, ATC Microprocessor Support Systems. The application software shall be written in Boolean expression, i.e., \*, +, etc.

- C. The Contractor shall provide a user-friendly software program to generate equivalent relay logic circuits for the STAP logic systems. This program may be combined with a program to create equivalent circuits for the NVIP systems. See Section 16926, Microprocessor System for Non-Vital Interlocking Functions.

## **2.06 PROGRAM STOP SUBSYSTEM EQUIPMENT AND LOGIC**

- A. The wayside Program Stop subsystem shall consist of the following equipment and logic:
  - 1. Equipment and logic located in the TCR which shall interface properly with the DTS and with the other passenger station subsystems, and which shall translate Skip-Stop commands and train/platform alignment data into a three-wire, 28 volt polarity code for transmission to track-mounted marker coils. This code shall be as shown on the Contact Drawings.
  - 2. Track-mounted marker assemblies to house the marker coils, tuning units, and related hardware required to transfer program stop data to the carborne recognition equipment. These marker assemblies shall meet the requirements specified in Section 16967, Marker Coil Layouts.
  - 3. All necessary interconnecting cable and wire for the equipment specified above.

## **2.07 TWC SUBSYSTEM EQUIPMENT AND LOGIC**

- A. The wayside TWC subsystem shall consist of the following basic equipment and logic:
  - 1. Equipment and logic located in the TCR which shall interface properly with the DTS and with ATP track modules and the TCR circuitry as specified, for each station platform and for each TWC flyby transmitter, flyby receiver and dispatch receiver location indicated on the Contract Drawings.
  - 2. Circuitry necessary to provide LED system status maintenance indications as specified. The LED indicators shall be mounted and identified on the system module such that they will be visible at all times without the need to remove covers or open the module.
  - 3. All interconnecting cable, wires and miscellaneous hardware and software required to provide the operating system specified herein.
- B. TWC Transmitters
  - 1. The equipment and logic for each TWC transmitter shall consist of:
    - a. Logic circuitry necessary to convert parallel ATS codes received from the RTU to serial binary codes for use by the Carborne TWC System.
    - b. Circuitry necessary to generate the required timing pulses.
    - c. An FSK oscillator which operates in a sine wave mode and is capable of generating three output frequencies (center 9800 Hz; mark 9950 Hz; space 9650 Hz) when digitally keyed by the logic circuitry.
    - d. A line driver (linear amplifier) which shall interface the oscillator and a power amplifier which is shared with the ATP System. The output of the power amplifier is connected to the track-mounted impedance bonds.
    - e. Circuitry necessary to provide LED maintenance indicators. The system status signals to be indicated shall include, but not be limited to, the following:
      - 1) For Station TWC Transmitters:
        - a) DTS Operational
        - b) DTS Strobe Pulse Present
        - c) Memory Load Pulse
        - d) Receiver Inhibit
        - e) Parity Check
        - f) Key On Transmitter

- 2) For Flyby Transmitters:
  - a) DTS Operational
  - b) DTS Strobe Pulse Present
  - c) Receive Carrier Detected
  - d) ATS Speed Bit 1
  - e) ATS Speed Bit 2
  - f) Key On Transmitter
- f. An externally mounted programmable plug coupler which shall translate ATS speed bits from the RTU into the ATS speed required for each location.
- 2. The TWC transmitter shall have the following characteristics:
  - a. Frequency: 9800 Hz carrier frequency
  - b. Modulation: frequency shift keying ( $\pm 150$  Hz)(mark 9950 Hz; Space 9650 Hz)
  - c. Signal to Noise Ratio: 20 d
  - d. Output Impedance: 600 ohms
  - e. Bit Rate: 100 bps
  - f. Range: 450 feet
  - g. Output Power: 20 watts (Transmitter output shall be connected to the power amplifier shared with the ATP System. Output of the power amplifier is 60 watts; the TWC output is limited to 20 watts.)

C. TWC Receivers

- 1. Each TWC receiver shall consist of:
  - a. A receiver input network which limits the level of the receiver signals.
  - b. Logic necessary to decode serial data received from the Carborne TWC System for transmission to the RTU as parallel data.
  - c. A band pass filter to eliminate noise and harmonics. The Contractor shall provide a passive network band pass filter. No other type will be acceptable to the Authority.
  - d. A limiter amplifier.
  - e. A carrier detector and squelch circuit which provides the squelch feature to inhibit the receiver during transmitter operation.
  - f. A receiver which detects the mark and space signals.
  - g. Circuitry necessary to equalize and square signals before transmitting them to the RTU.
  - h. Circuitry necessary to provide LED maintenance indicators. The system status signals to be indicated shall include, but not be limited to, the following:
    - 1) For Station TWC Receivers:
      - a) Receive Carrier Detected
      - b) Data Strobe
      - c) Word 1
      - d) Word 2
      - e) Word 4
      - f) Word 5
    - 2) For Flyby TWC Receivers:
      - a) Receiver Carrier Detected
      - b) Data Strobe
      - c) Receive Mark Bit
      - d) Word 1 Parity Check
      - e) 1.6 K Hz Clock
      - f) Shift Register Clock
- 2. The TWC receiver shall have the following characteristic:
  - a. Receiver Band: Passive network; 9800 Hz
  - b. Pass Filter: center frequency; bandwidth  $\pm 250$  Hz at

- c. Receiver Limiter Amplifier: 3dB down.  
Full limiting with input signal of .016V rms.  
Dynamic limiting range of 54 dB minimum.
- d. Carrier Detector Amplifier: Gain 42 dB. Adjustable 0-42 dB.
- e. Squelch: Carrier operated; adjustable threshold.
- f. Receiver Detector: 2 parallel tuned circuits: f1 is 9650 Hz, f2 is 9950 Hz, each with bandwidth of  $\pm 70$  Hz.
- g. Receiver Sensitivity: Adjustable without using a train.
- h. Size: No larger than 15x18x6 inches.
- i. Weight: Maximum: 15 pounds.

D. TWC Monitor

1. The Contractor shall provide for each TWC installation, wired card connectors in the STAP cabinet for the temporary installation of a TWC monitor.
2. The TWC monitor shall consist of one or more plug-in printed circuit boards in the STAP cabinet for the temporary installation of a TWC monitor.
3. The TWC monitor shall provide an indication for each of the functions listed in Part 1.02-E.2.b. Train length, train destination and train number shall be displayed on multi-segment numerical indicators.
4. The Contractor shall provide one TWC monitor for each route segment in the Contract.
5. The TWC monitor shall not interfere with the operation of the system, nor require movement or replacement of any part of the installed system.
6. The Contractor shall provide a complete instruction manual covering the installation and use of the TWC monitor.

E. TWC Data Logging Device

1. The Contractor shall provide, for each TWC installation location, a notebook-size data logging device.
2. The data logging device shall interface with the STAP by means of a portable, plug-in/out, serial-connected communications cable.
3. The data logging device shall enable a Signal Maintainer to retrieve recorded data from the STAP, or to observe real-time operation of the STAP on an integral CRT.
4. The data logging device shall not interfere in any way with the normal operation of the STAP.
5. This device can be used to satisfy certain requirements of Part 2.09-B of this Section.

## 2.08 PASSENGER STATION SUBSYSTEMS EQUIPMENT AND LOGIC

A. Platform Edgelight Control Subsystem

1. The Platform Edgelight Control subsystem shall consist of equipment and logic necessary to interface properly with the Program Stop subsystem and to control the platform edgelights in the manner specified in Part 1.02-E.3., and as shown on the Contract Drawings.

B. Door and Dwell Control Subsystem

1. The Door and Dwell Control subsystem shall consist of the following equipment and logic:
  - a. Equipment and logic necessary to interface properly with the DTS, ATP track circuit modules, the TWC and Program Stop subsystems, and dwell timer equipment, or, as an alternative, to generate electronically the adjustable timing intervals necessary for the control of dwell time for each station platform.
  - b. An equipment panel, suitable for mounting on a standard 19-inch EIA

- c. equipment rack, on which the local dwell timers shall be mounted.  
All interconnecting cables, wires, and miscellaneous hardware necessary to provide the operating system specified herein.

## 2.09 DIAGNOSTICS

### A. Internal

- 1. The Contractor shall provide the STAP system with one or more Diagnostic Routines as outlined herein. The degree or refinement of such routines is at the discretion of the Contractor who is reminded that the diagnostics he furnished will be instrumental in meeting the time-to-restore requirements shown in the Technical Appendix of these Specifications. The minimum requirements follow, but the Contractor shall be alert for ways to extend these requirements in any way practicable to make the system more reliable and easier to maintain. The minimum diagnostic requirements are:
  - a. The Contractor shall provide one or more Diagnostic Routines which shall continuously monitor the operation of the STAP and shall "remember" and indicate both on-going and intermittent failures until manually reset in the field. The diagnostic Routine(s) may be implemented in any way the Contractor selects, providing that the results meet the requirements of these Specifications and providing that the methodology meets with the approval of the Designated Resident Engineer.
  - b. One output of the STAP shall operate a slow-release relay, named the Station Passenger Check relay (STAPCHK), by means of recurring pulses which indicate that the processor is correctly meeting the requirements of all of the internal diagnostic tests. These tests shall be designed to require the proper operation of as many of the STAP facilities as possible. (The Contractor may employ some other means of obtaining the operation of this relay, but it must have the prior approval of the Designated Resident Engineer.) In the de-energized position, the opening of the front contacts of the relay shall open a circuit to the RTU. The opening of this circuit shall cause an indication to be received at Central Control called PROCESSOR FOR STATION PROBLEM.
  - c. The Contractor shall provide diagnostic indicator lights (LEDs) on the visible edge of the printed circuit boards. One of these lights shall be provided to indicate a failure for each individual diagnostic routine, and one additional light shall be provided which shall be illuminated whenever energy is not being provided to the Station Processor Check Relay.

### B. External

- 1. In addition to the internal diagnostic capability of the STAP, the Contractor shall provide an external plug-in diagnostic device and associated software. This external device shall have some form of data memory capability and a CRT display. The software for this device shall be user friendly and menu driven. See Part 2.07-E of this Section.

- C. The Diagnostic Routines (both Internal and External) shall be thoroughly documented in the maintenance manual provided by the Contractor and described elsewhere in this Section.

## 2.10 SPARE EQUIPMENT

- A. See Section 16932, Spare ATC Equipment and Selectable Items.

## 2.11 TEST FIXTURES

- A. Board Test Fixtures
1. The Contractor shall provide one complete set of printed circuit board test fixtures for each of the following:
    - a. The route segment equipped under this Contract;
    - b. The Central Maintenance Facility, and;
    - c. The Training Courses (combined).
  2. Each of these board test fixture sets shall include all individual test fixtures necessary to (collectively) test every printed circuit board in all parts of the working STAP system. Included with each of these complete test fixture sets shall be any test device which is necessary or desirable to set-up, inspect, monitor, maintain or facilitate the restoration of the STAP system.
  3. The Contractor shall not include as part of the equipment furnished for this requirement any instrument or test device duplicated in response to the requirements of another Section of these Specifications. Equipment for maintenance or actual repair of printed circuit boards shall not be considered part of this requirement.
- B. System Test Fixture
1. In addition to the PC board test fixtures required in the preceding paragraphs, the Contractor shall furnish two STAP System (Shop) Test Fixtures, one for training and one for maintenance purposes. Each of these fixtures shall consist of a board frame (or frames) complete with power supplies, printed circuit boards, diagnostic routines, and any other equipment or programs needed to simulate a complete and operable wayside system. Each of these STAP System test fixtures shall be equipped with a 120 Vac line cord and simulated input and output facilities consisting of a minimum of 10 input switches and 10 output indicators located on a suitable Indication Panel. The System (Shop) Test Fixtures shall be designed to allow electronic technicians access to working boards in a working system through the use of extender boards. The STAP System (Shop) Test Fixtures shall also be designed for use as a training aid in the training course described in Part 3.05 of this Section.
  2. Each STAP System Test Fixture shall be installed in a dust-resistant cabinet of the same type as specified in Part 2.02 I of this Section. Suitable supports shall be provided to floor-mount the cabinet on casters. Two complete sets of extender boards shall be provided for use with these STAP System (Shop) Test fixtures.
  3. The two STAP System (Shop) Test Fixtures shall be considered to be Specific ATC Test Devices, as specified in Section 16931.1.01 H., Item 10.

## **2.12 SUPPLY MATERIALS**

- A. The Contractor shall provide, if necessary for the operation of equipment supplied under this Article, paper, ribbon and any other consumable supplies sufficient for one year of operation. Unless the supplies are readily available, the name and address of the source of further supplies shall be furnished to the Designated Resident Engineer as a separate document.

## **2.13 INSTRUCTION MANUALS**

- A. The Contractor shall provide Maintenance and Programming Manuals for the STAP. Together, these manuals shall include a complete description, to the board level, of the setup, programming, operation, maintenance and trouble-shooting of the STAP system and all items of hardware and software included therein. These manuals shall be prepared according to guidelines set forth in this Section and in Section 16992, ATC Instruction Manuals. Manuals which do not meet these requirements will not be approved.
- B. The first type of manual which the Contractor shall provide shall be the Engineer's STAP Programming Manual. It shall consist of detailed instruction in the use of all the documentation for the STAP System software. This manual shall also provide all information

on the use of the equipment and software provided with the Microprocessor Support Systems to program and re-program the STAP System. (See Section 16927.) This documentation is meant for engineers with experience in the design of signal systems.

- C. Documentation describing the programming of the STAP System shall be provided 45 days prior to the Type Acceptance Testing. Six copies of this manual shall be provided.
- D. The second type of manual which the Contractor shall provide shall be a Field Maintainer's STAP Manual, intended for the signal maintainer. It shall be written for instruction of Authority personnel with an educational equivalent of 12th grade plus two years in a general electrical technical school. The Contractor shall not consider the technical school training as being two years in a computer programming school. The Field Maintainer's STAP Manual shall be clearly organized into two maintenance levels. They are:
  - 1. Level 1 - This level shall cover the detection of problems occurring in the field, TCR wiring, equipment modules and the input and output boards of the processor. This level is intended for the use of general maintenance personnel, and the manual shall so state.
  - 2. Level 2 - This level shall cover the detection and replacement of a malfunctioning board other than the input and output boards. It shall describe how this can be accomplishing using the facilities of the Board Test Fixtures which the Contractor has furnished as well as simple devices such as voltmeters and ohmmeters. This level is intended for specially trained maintenance personnel and their supervisors and the manual shall so state.
- E. The Field Maintainer's STAP Manuals shall be prepared during the initial phases of the Contract so that they may be approved and delivered to the Authority before field testing commences.

### **PART 3 - EXECUTION**

#### **3.01 DELIVERY, STORAGE AND HANDLING**

- A. The Contractor shall take whatever measures may be necessary to protect the STAP module from damage or marring during shipment, installation and testing and until the Authority accepts the system. If the equipment suffers any damage, from whatever cause, during this period, the Contractor shall replace or repair it to a like-new condition, to the satisfaction of the Designated Resident Engineer at no additional cost to the Authority.

#### **3.02 INSTALLATION**

- A. The Contractor shall install the STAPs in TCRs provided by the Authority for this purpose. The equipment shall be installed on equipment racks as required in these Specifications and as shown on the Contract Drawings.
- B. The Contractor shall install each STAP, complete with its program and all appliances necessary to provide a complete, local wayside ATO and ATS system which operates as required by these Specifications and is readily maintained.
- C. The STAP subsystems shall be interconnected with each other and with their applicable external equipment as specified herein and as shown on the Contract Drawings.
  - 1. STAP passenger station TWC transmitter and receiver circuitry and logic shall be connected to impedance bonds equipped with TWC coils, installed at both ends of each passenger station platform on each passenger station track.
  - 2. STAP TWC Dispatch Receiver circuitry and logic shall be connected to impedance bonds equipped with TWC coils, installed at certain train dispatching points other

than passenger station platforms as indicated on the Contract Drawings. (May not be used in some Contracts.)

3. STAP Program Stop subsystem circuitry and logic shall be connected to the appropriate track-mounted Middle (No. 2) and Inner (No. 3) program stop marker coil layouts, and to the TCR entrance rack. The Contractor shall provide all necessary jumpers on the TCR entrance rack to call for the desired train/platform alignment at the station unless otherwise instructed by the Designated Resident Engineer.
4. Track mounted equipment for the Program Stop subsystem shall be installed as specified in Section 16967, Marker Coil Layouts, and as shown on the Contract Drawings.
5. TWC flyby transmitter and receiver circuitry and logic shall be connected to impedance bonds equipped with TWC coils, installed at the "Flyby Transmitter" and "Flyby Receiver" locations indicated on the Contract Drawings.
6. An "Inclement Weather" Flyby Transmitter (Type 5 for Track 1, or Type 4 for Track 2) shall be installed at the first impedance bond more than 1000 feet upstream from the station platform centerline, on each normal direction (right-hand-running) station approach track which is exposed to the weather. The Type 4 and/or Type 5 Flyby Transmitter(s) for applicable locations shall be activated by the receipt of an ENABLE RETARDED PERFORMANCE LEVEL "Command" from Central. See the Contract Drawings and the RTU Scan Sheets.

### **3.03 TESTING**

- A. The Contractor shall perform a Type Acceptance Test on the first complete STAP furnished if its design differs in any respect from a STAP previously accepted for regular use on the WMATA METRORAIL SYSTEM. This test may be witnessed by the Engineer. The Contractor shall notify the Engineer in writing at least two weeks prior to the time this test is to take place.
- B. The Contractor shall factory test each completed STAP according to a test procedure which has been prepared in accordance with Section 16980 of these Specifications and previously approved by the designated Resident Engineer. Field conditions shall be simulated for this test. This test may be witnessed by the designated Resident Engineer. This test shall be successfully completed and the results approved by the designated Resident Engineer before the equipment is shipped from the factory.
- C. The Contractor shall field-test the installed STAP according to a series of field tests described in these Specifications, prepared by the Contractor and approved by the designated Resident Engineer.
- D. The Contractor shall notify the designated Resident Engineer at least one week before the commencement of each of the specified factory and field tests unless otherwise directed by the designated Resident Engineer.
- E. At the conclusion of the factory testing of the STAP, the Contractor shall deliver to the Authority three copies of the complete program documentation. The program documentation shall bear revision numbers to reflect any necessary changes in the program.
- F. The final revised program shall be entered into the memories of the spare equipment and the spare equipment shall be installed in the working system. When approval of the test has been received, the Contractor shall install the regular equipment in the system and repeat the tests. This equipment shall then be left in the system.
- G. If, once the final field testing has been approved, any change in the program is deemed necessary by the Contractor, the designated Resident Engineer shall be informed, and with his approval, the change shall be made. When the change has been completed and the log

filled out, the Contractor shall repeat the cycle of testing described in the previous paragraph.

### **3.04 DOCUMENTATION**

- A. The Contractor shall produce the required tracings, program listings, drawings and aperture cards at the times required by these Specifications and keep them up-to-date during installation.
- B. The Contractor shall produce the required maintenance manuals and training course submittals at the times required by these Specifications.
- C. The Contractor shall provide a Station Processor Software Configuration Logbook which shall be utilized commencing with the approval of the design submittal and continuing until Final Acceptance of the installation. This book shall be used (only for the STAP) to register dated entries describing every change made to the STAP program or equipment and the reason the change was made. It shall be written in a detailed, step-by-step narrative, and shall include cross-references to all program changes. Failure to provide and utilize this logbook will delay and may prevent, the approval of all the test reports associated with the field testing of the processor. At final acceptance, this logbook shall become the property of, and be delivered to, the Authority.

### **3.05 TRAINING**

- A. The Contractor shall provide two training courses, described in B. and C. below. One shall be called the Field Maintainer's STAP Training Course and the other shall be called the Engineer's STAP Training Course. Training aides shall be liberally employed in these courses where helpful to illustrate the devices and principles being described. Firmware such as flip charts, transparencies and slides shall become the property of the Authority at the conclusion of the final presentation of each course. The Contractor's instructor shall cooperate with the Authority in the videotaping of the course presentations.
- B. Field Maintainer's STAP Training Course
  - 1. The Contractor shall provide on the Authority's premises, for its signal maintenance personnel, four presentations of a course of classroom and hands-on instruction in the operation and maintenance of the STAP System. Each course shall be not less than 3 days nor more than 5 days in length. Each presentation of the course shall accommodate 12 persons designated by the Authority.
    - a. The first two presentations of this course shall occur consecutively during the final installation stages of the STAP. The third and fourth presentations shall be at later dates within one year from the date of the first two; the exact dates to be determined at the mutual consent of the Authority and the Contractor. These instruction courses shall be at no additional cost to the Authority.
    - b. This instruction shall be based on the second Instruction Manual described in Part 2.13-D.
    - c. This instruction shall cover all aspects of operation and maintenance of the wayside and TCR equipment pertaining to the STAP. It shall include but not be limited to the following:
      - 1) All Station Facilities operated by the STAP
      - 2) All Modules of the STAP and its programsProcessors
      - 3) Trouble shooting
      - 4) Diagnostic routines
      - 5) Maintenance procedures
      - 6) Preventive maintenance
    - d. This course shall be designed for an educational level of 12th grade plus 2 years in a technical school.

- e. This course shall include "hands-on" instruction for each participant in identifying and replacing defective boards through the use of the Board Test Fixtures provided by the Contractor. The Contractor shall supply, at no additional cost to the Authority, a set of printed circuit boards with various defects for use in this test. There shall be enough boards and variations in defective components so that successive course participants are not bored by locating the same defective board.
- C. Engineer's Station Processor Training Course
- 1. The Contractor shall provide on the Authority's premises, for certain engineering personnel, one presentation of a course of classroom and hands-on instruction in the programming, maintenance, and reprogramming of the STAP system to the board level. The course shall be not less than 5 days nor more than 10 days in length. The presentation of the course shall accommodate up to 5 persons designated by the Authority; 3 from Operations, and 2 from Engineering.
    - a. The presentation of this course shall occur during the final installation stages of the STAP and shall be made at no additional cost to the Authority.
    - b. This instruction shall be based on the first Instruction Manual described in Part 2.13-B.
    - c. This instruction shall cover all aspects of setup, programming, operation and maintenance of the STAP equipment. It shall include, but not be limited to the following:
      - 1) Programming Techniques
      - 2) Compiling
      - 3) Setting and Erasing Memory Devices
      - 4) Locating Defective Board Components
      - 5) System Operation
      - 6) Reliability Considerations
      - 7) Trouble Shooting
      - 8) Diagnostic Routines
      - 9) Maintenance Procedures
    - d. This course shall be designed for an educational level of 12th grade plus a Bachelor's Degree in Engineering or its equivalent.
    - e. This course shall include "hands-on" instruction for each participant in programming, reprogramming and identifying and replacing defective board components through the use of the Contractor's test fixtures (made available by the Contractor at no additional cost to the Authority), and the STAP unit provided to the Authority by the Contractor for training purposes. The Contractor shall supply, at no additional cost to the Authority, a set of boards with various defective components for use in this test.
- D. These training courses shall be organized in accordance with the requirements of this Section and Section 16993, ATC Training Courses.

### **3.06 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. No separate payment will be made for Non-Vital Station Processors (and their PC Board Test Fixtures) as such. The cost of the STAPs shall be included in the Design Engineering, Material and Fabrication and Installation costs for this Contract. The STAPs will be measured for partial payments based upon the number of complete required systems installed and accepted, relative to the total number required.
- B. For purposes of measurement for partial payments, Non-Vital Station Processor Systems shall include all mounting hardware, interconnecting wiring and STAP PC Board Test Fixtures.

- C. The following conditions will be considered when measuring the STAPs for partial payments:
1. Delivery by the Contractor of the STAPs, provided approval has been given of their Factory Test Reports.
  2. Installation of the STAPs and all interconnecting wiring by the Contractor, provided approval of the installation has been given by the designated Resident Engineer.
  3. Level "C" partial system acceptance of the location involved.
  4. Completion by the Contractor of Level "F" testing of the location involved, approval of the Level "F" testing and test reports by the designated Resident Engineer, and delivery of the TWC Monitor(s) to the Authority.
  5. Delivery by the Contractor of the approved as-built drawings, aperture cards and program listings.
  6. Approval by the designated Resident Engineer, and receipt by the Authority of the applicable Maintenance Manuals.
  7. Approval by the designated Resident Engineer of the documentation of the applicable classes of instruction and the satisfactory completion of each presentation.
  8. Delivery of the board test fixtures and system test fixtures, and final acceptance of these devices by the Authority.
- D. System (Shop) Test Fixtures for the Non-Vital Station Processor Systems will be measured for payment as specified in Section 16931.3.02 C.

**END OF SECTION**

## SECTION 16925

### ATC - DATA TRANSMISSION SYSTEM (DTS)

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION

- A. This Section specifies the furnishing and installation of additions and modifications to the current WMATA Data Transmission System (DTS). (The DTS transfers control information, status indications, and other information relating to train control, electrification, and support facility functions, between the Central Control Computer and all Train Control Rooms, passenger stations and other specified remote locations via the communications Carrier Transmission System (CTS) which is provided by other disciplines.)
- B. It is the intent of this Section that the Contractor shall provide all required, complete, and fully compatible operational DTS additions and modification work for the WMATA (**Project Name**). This work shall include, but not be limited to, the following:
1. Provision of new Remote Terminal Units (RTUs) and final, As-Built RTU Scan Sheets for the new Train Control Room(s).
  2. Provision of all interface wiring and equipment to connect the new RTUs to the ATC and ancillary devices and functions to be controlled and monitored, and to the Carrier Transmission System (CTS), provided by other disciplines.
  3. Provision of Computerized Analyzer Units (CAUs) for the new and currently used RTU(s).
  4. Provision of additions and modifications to the interface wiring of the current RTU(s) at the tie-in location(s), and updated Scan Sheets for same. (Where applicable). As an alternative, the Contractor shall provide a complete, new RTU and associated wiring, interfacing, and scan sheets for the tie-in location(s). This alternative shall be at the discretion of the designated Resident Engineer.
  5. Furnishing and installation of final AS-BUILT Wiring Diagrams for all new or revised DTS junction boxes (cabinets) furnished and installed by other disciplines, or by the Contractor.
- C. This Section specifies the requirements for the Remote Terminal Unit(s) (RTUs) to be provided by the Contractor. A cardinal requirement is that the new RTUs be completely and interchangeably compatible with the data message format generated by the existing equipment (channel processor) at the Operations Central Control. The equipment supplied for the RTU functions shall be capable of operating with the same inputs and outputs as the equipment currently in use on the WMATA Metrorail Data Transmission System. The original Model 9600 RTUs (as manufactured by TRW Controls of Houston, Texas) are no longer commercially available. The Contractor shall therefore provide RTUs of the "Outpost" Model 409 type (as manufactured by ABB Network Management of Sugar Land, Texas), or RTUs approved as equal by the designated Resident Engineer. See Part 2.02 of this Section.
- D. The new RTU(s) shall be microprocessor based, but shall be completely and interchangeably compatible in all respects with the existing Data Transmission System and its message format, bit structure, and functionality. They shall also meet the requirements of this Section, and be acceptable to the designated Resident Engineer. The Contractor shall determine the type(s) of PC cards and appropriate energization wiring to be used for certain applications for these new units, as noted on the RTU Scan Sheets. The energization and card type(s) actually used shall be fully documented in the RTU circuits and Scan Sheets submitted by the Contractor. The types of Control PC cards and their energization requirements shall be as follows:

<u>Control Card Type</u>	<u>Energization Required</u>
Electronic	Strobe
Relay Pair	Strobe
Relay Single	Strobe and Common B28G

- E. This Section specifies the requirements for Computerized Analyzer Units (CAUs) to be furnished by the Contractor.
- F. This Section specifies the requirements for DTS junction box wiring diagrams to be furnished and installed by the Contractor.

## 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  1. Section 16904 Current Automatic Train Control System
  2. Section 16914 Environmental Requirements
  3. Section 16918 Special ATC Requirements for Specific Locations
  4. Section 16921 ATC Power Distribution Systems
  5. Section 16923 TC Maintenance Telephone System
  6. Section 16928 Interlocking Vital Processor Systems
  7. Section 16930 ATC Facilities And Spare Equipment
  8. Section 16944 Non-Vital Relays and Timers
  9. Section 16948 Plug Connectors
  10. Section 16949 Signal Wire and Cable
  11. Section 16971 Racks and Cable Trays
  12. Section 16980 ATC Tests, Inspections and Quality Assurance
  13. Section 16992 ATC Instruction Manuals
  14. Section 16993 ATC Training Courses
  15. Section 16997 RTU Scan Sheets

## 1.03 QUALITY ASSURANCE

- A. The Contractor shall, within 90 days of issuance of N.T.P., successfully complete Type Acceptance Testing which proves, to the satisfaction of the designated Resident Engineer, that the proposed Data Transmission System equipment meets all of the operational, functional, environmental (physical and electrical) and configurational requirements of these Specifications. This testing shall be done in the Contractor's facilities under the surveillance of the designated Resident Engineer's representative. This testing shall include, but not be limited to, a full-range temperature and humidity test of an operational prototype of the completely configured system, housed in its dust-proof cabinet. Temperature sensors shall be mounted inside to determine when the temperature of the internal equipment has reached and maintained its stabilized value for at least twenty minutes. The equipment shall be in continuous operation during this test and means shall be provided for determining that the operation is within the specified tolerances. During this test the temperature shall be stabilized at increments of not more than thirty degrees. Readings of several critical temperature-dependent values shall be taken at each stabilized increment. The Contractor shall provide to the designated Resident Engineer a two-week minimum advance notice of the date of testing. If the Contractor-proposed RTU equipment fails to meet the specified requirements during Type Acceptance Testing, the Contractor shall provide "Outpost" 409 Units of the required configuration as specified.
- B. In addition to proving that the proposed Data Transmission System equipment meets all of the operational, functional, environmental (physical and electrical) and configuration requirements of these Specifications, a System Performance Test shall be successfully completed, to the satisfaction of the designated Resident Engineer, within 120 days of

issuance of N.T.P., to prove that the equipment functions properly when connected to the WMATA Central Control equipment and to either the existing TRW Model 9600 Portable Analyzer Unit (PAU), the CAU provided for Outpost Model 409 RTUs, or the computerized analyzer unit (CAU) provided under the requirements of this Section. At the Contractor's option, through arrangement with the designated Resident Engineer, and at no additional cost to the Authority, the System Performance Test shall either be conducted on the WMATA premises or it shall be conducted by means of Contractor-furnished telephone lines. If the Contractor-proposed RTU equipment fails to meet the specified requirements during the Systems Performance Testing, the Contractor shall provide "Outpost" 409 Units of the required configuration as specified.

- C. Each RTU provided under this Contract shall be factory tested in accordance with a factory test procedure provided by the Contractor and approved by the designated Resident Engineer. The Factory Test shall be a subset of the Type Acceptance Test, providing proof, through the testing of key operational factors, that each RTU is operating as well as the prototype. Each module may be tested separately, but the test shall prove that the module has operated a minimum of 100 hours without failure at the usual ambient temperature of the factory. One hundred percent of the RTU modules shall be so tested.
- D. Following installation, the Data Transmission System for each Train Control Room area of control shall be field-tested according to the basic test and inspection requirements specified in Section 16981, Basic ATC Test & Inspection Requirements, and the specific requirements specified in Section 16985 for DTS Interface Testing.

#### **1.04 SUBMITTALS**

- A. The Contractor shall submit the following to the designated Resident Engineer for approval within 60 calendar days of receipt of Notice-to-Proceed, and prior to purchase or fabrication of Remote Terminal Units:
  - 1. Complete internal circuits and wiring diagrams for the proposed RTUs.
  - 2. Drawings showing the physical dimensions and characteristics of the proposed RTUs.
  - 3. Complete performance data for the proposed RTUs.
  - 4. Complete logic diagrams and software for the proposed RTUs.
  - 5. Complete parts listing for all major components of the proposed RTUs.
  - 6. Complete installation, wiring and maintenance requirements and instructions for the proposed RTUs.
  - 7. A complete testing procedure for the Type Acceptance Test which proves that the proposed equipment meets all of the operational, functional, environmental (physical and electrical) and configurational requirements of these Specifications.
  - 8. A complete testing procedure for the System Performance Test which will prove that the proposed equipment is in every way compatible with the WMATA DTS system and with the PAU. Specifically, the tests shall include, but not be limited to, procedures concerning the message carrier frequency, carrier amplitude, format, bit structure and functioning, and timing.
- B. The Contractor shall give the designated Resident Engineer two weeks advance notice of when he expects to be ready to perform the Type Acceptance Testing on a prototype unit so that the designated Resident Engineer may witness the testing.
- C. Upon approval of the RTU design and prototype unit(s) by the designated Resident Engineer, the Contractor shall, within 30 calendar days, submit a System Performance Test procedure and a factory test procedure for the new Remote Terminal Units.
- D. The Contractor shall submit, and obtain approval of, factory test reports for each RTU prior to shipment of the unit.

- E. Upon approval of the RTU design, but prior to proceeding with the DTS interface wiring, the Contractor shall submit, and obtain approval from the designated Resident Engineer for, the following items, as applicable:
  - 1. Complete, updated RTU Scan Sheets showing terminal and board assignments for all RTUs to be provided under this Contract.
  - 2. Complete, updated RTU Scan Sheets showing terminal and board assignments for all existing RTUs to be modified under this Contract.
- F. Upon approval of the Contractor's RTU Scan Sheets by the designated Resident Engineer, the Contractor shall commence interface wiring and submit complete interfacing circuits and wiring diagrams for the proposed new RTU(s) (and for the revised portions of the current RTU(s) to be modified, where applicable).
- G. The Contractor shall submit, and obtain approval by the designated Resident Engineer for, an Installation Inspection Procedure for Remote Terminal Units at least 120 calendar days prior to the scheduled installation of the first new RTU. This procedure shall be in conformance with the requirements specified in Section 16981.
- H. The Contractor shall submit a complete RTU Installation Inspection Report within the 30 calendar day period following the installation of each new RTU.
- I. The Contractor shall submit the schedules and documents required for the associated training courses (as listed in Section 16993, Training Courses) for the new RTU and CAU equipment within 45 calendar days after approval of such equipment by the Authority.

## **PART 2 - PRODUCTS**

### **2.01 BASIC COMPONENTS**

- A. The additions to the wayside Data Transmission System shall consist primarily of the following basic components:
  - 1. One or more Remote Terminal Units.
  - 2. Interfacing equipment and wiring between the RTU(s) and the Train Control equipment, support system DTS interface junction boxes, and communications system equipment.
  - 3. Wiring diagrams for the DTS interface junction boxes.
  - 4. Computerized Analyzer Units (CAUs).

### **2.02 REMOTE TERMINAL UNITS**

- A. Each Remote Terminal Unit (RTU) shall consist of the following basic sections and components:
  - 1. Communications Line Interface.
  - 2. Receiving, Processing and Transmitting Logic.
  - 3. Control Output Interface.
  - 4. Status Input Interface, (to include converting analog 4-to-20 milliamp signals to digital signals, where applicable).
  - 5. Power Supply and Interface.Rack or Cabinet for Equipment Modules.
  - 6. Monitoring Interface for the internal 5 volt energy supply bus.
- B. Communications Line Interface Requirements
  - 1. The communications line interface shall contain a modem which provides all facilities necessary for reliable two-way communications between Central Control and the RTU. The interface shall also include surge protection and other features designed to protect the RTU from the hostile electrical environment of the communications line. The interface shall be accomplished by means of optical isolators. The modem shall be equipped with indicator lights for all critical functions. For a modem of the

204, 205 or 207 type to be considered by the designated Resident Engineer for "approved equal" status to the 201B type currently in use, the Contractor shall provide both ends of the modem at no additional cost to the Authority.

2. This interface shall perform properly under the following conditions and conform to the following requirements:

- |    |                                  |  |
|----|----------------------------------|--|
| a. | Line signal to noise ratio:      | 18 dB  |
| b. | Data interchange mode:           | Serial, Binary, Full Duplex  |
| c. | Interface Protocol:              | EIA Standard RS232C  |
| d. | Communications Channel:          | Voice grade  |
| e. | Modem Compatibility:             | AT&T (Bell) 201B Data Set  |
| f. | Modem Configuration:             | Synchronous  |
| g. | Modem Sensitivity Adjustment:    | Automatic  |
| h. | Modem Receive Level:             | 0 dBm to -40 dBm   |
| i. | Modem Transmit Level:            | -10 dBm to 0 dBm   |
| j. | Modem input impedance:           | 600 ohms, transformer isolation  |
| k. | Modem frequency response:        | 900 to 2700 Hz @ -2 to +6 dB   |
| l. | Modem transmit delay:            | Switchable, delay-for-quiet-line or immediate-transmit                 |
| m. | Error Rate (maximum) @ 2400 BPS: | 1x10E-09 @ 18dB S/N ratio (1x10E-08 @ 15 dB)                           |
| n. | Scan Mode:                       | Continuous   |
| o. | Scan Rate - All locations:       | Once per Second  |
| p. | RTU locations per line (max.):   | Seven (0,0,0 is "All Location Call")                                   |
| q. | Baud Rate:                       | 2400 bits per second   |
| r. | Clock Frequency:                 | 384 kHz  |
| s. | Distortion - max. time delay:    | ±50 nanoseconds  |
| t. | Delay correction (maximum):      | 3 nanoseconds  |
| u. | Delay of envelope (nanoseconds): | 1800 @ 700 to 2700 Hz  |
| v. | Distortion - Amplitude:          | ±1 dB  |
| w. | Line input protection:           | Adequate for ±10,000 v o l t p e a k 8 / 2 0 microsecond standard wave |

C. Receiving Processing & Transmitting Logic Requirements

1. The Receiving Processing and Transmitting Logic section of the RTU shall contain the necessary logic and circuitry for detection of a proper incoming data message from the central control computer including preamble address, data synchronization, and bit security as specified herein. The Receiving Processing and Transmitting Logic shall convert the serial data received from the Central Control Office to parallel form for use by the control output interface. It shall also convert the parallel data from the status input interface to a serial form for use in generating the outgoing message to the Central Control Office. The requirements for the organization of the equipment are as follows:

- |    |  |   |
|----|--|---|
| a. | Control capability (min.) per location:    | 836 controls                                      |
| b. | Indication capability (min.) per location: | 892 indications                                   |
| c. | Dataframe count:                           | 31 (total of 15 control and 16 indication frames) |
| d. | Words per dataframe:                       | 4   |
| e. | Bits per dataframe, Total:                 | 76  |
| f. | Assignable bits per dataframe:             | 52 (first frame), 56 (successive frames)          |
| g. | Bits per word:                             | 16  |

h. Bits per word - assignable:

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D. Data Format Requirements

1. The data format of the incoming message received by the RTU and the outgoing message generated by the RTU shall be as follows:

a. Incoming Message (to RTU):

1) CONTROL FRAME ONE:

- a) Bits 1 to 9 - PREAMBLE Nine 1s (1,1,1,1,1,1,1,1,1)
- b) Bits 10 and 11 - SYNC PATTERN Fixed (0,1)
- c) NOTE 1 - The above 11 bits are checked for validity. If not valid, the incoming message is locked out. If only seven 1s are received before the 0, the message being received is from another RTU and is also locked out.
- d) Bits 12 to 67 (56 bits) - FIRST CONTROL DATA FRAME - Consists of:
- e) Bits 12 to 14 (3 bits) Code 0,0,0 is used as RTU ADDRESS "All Location Call"
- f) Bits 15 (1 bit) NO RESPONSE BIT Inhibits the return of the status message if 1; allows the return if 0
- g) Bits 16 to 67 (52 bits) CONTROL DATA Assignable; 1 for "Control On" 0 for "Control Off"
- h) Bits 68 to 74 (7 bits) SECURITY CHECKWORD BCH Encoded, transmitted inverted
- i) NOTE 2 - The received checkword is compared to a locally generated checkword which is developed using the same BCH (Bose-Chaudhuri-Hocquenghem) coding method as was used in the office to generate the transmitted checkword. If the received and locally generated checkwords are the same, the first frame of data is accepted and a strobe pulse is generated to execute the controls. If they are not the same, the frame control message is aborted and the scan continues on to the next frame. The BCH code consists of the 7-bit remainder from a sequential division calculation utilizing the polynomial  $x^7+x^6+x^2+1$ .
- j) Bits 75 to 76 (2 bits) FRAME SYNC Binary code (0,1) - MORE DATA (advances frame counter); (0,0) - END OF DATA (initiates status transmission); (1,0) or (1,1) - ERROR (locks out control changes)
- k) NOTE 3 - Code (0,0) indicates the last frame being transmitted. It resets the error latches and initiates the status transmission. If codes (1,0) or (1,1) occur in the first frame, they lock out changes in the RTU controls. If they occur after the first valid frame, they lock out further control changes and immediately initiate a status transmission with its ERROR bit set to (1).

2) CONTROL FRAME TWO (and succeeding frames):

- a) Bit 77 (and successive 75 bits) Message bits for frame 2
- b) NOTE 4 - The succeeding frames are the same as the first, EXCEPT they lack the three ADDRESS bits and the NO

RESPONSE bit. This allows 4 more bits to be used for controls, bringing the number of assignable control data bits in the succeeding frames to 56, while keeping the total number of bits at 76.

- 3) LAST CONTROL FRAME:
  - a) The FRAME SYNC code of (0,0) in the last control frame being transmitted signals the end of the control message and initiates the indication (status) transmission from the RTU to the Office.
  - b. Outgoing Message (from RTU):
    - 1) The outgoing message is identical to the incoming message described above EXCEPT that:
    - 2) the PREAMBLE contains only seven "ones" (1,1,1,1,1,1,1) instead of nine, and:
    - 3) the NO RESPONSE bit is replaced by an ERROR bit which is described in NOTE 3 above.
    - 4) The assignable data bits are utilized for transmitting field status information to Central Control.

E. Other Requirements for incoming data:

1. Loss of the modem carrier, malfunction of the modem, or malfunction of the RTU shall cause all control output registers to be reset to zero.
2. If no valid data is received from the central control computer for a period of five seconds, all control output registers shall be reset to zero.
3. No data shall be acted upon unless preceded by a valid preamble word.
4. Updating of the outgoing data points (controls) shall not take place if the BCH checkword is invalid.
5. The receiver shall return to its quiescent state after the receipt of sync bits indicating end of message.

F. Other Requirements for outgoing data:

1. Under no condition shall a malfunction of the Remote Terminal Unit place any constraints on the external data point circuits, or interfere in any way with the normal conditions on the communication line.

G. Control Output Interface Requirements

1. The Control Output Interface shall provide bi-stable (latching) relays or electronic outputs to accept data from the incoming message and control the external equipment as listed in the control section of the Contractor's RTU Scan Sheets. Each individual output interface shall be equipped with a light emitting diode indicator which shall be lighted when the output is energized. This interface shall protect the RTU from the hostile electrical environment of the external equipment and the accidental application of external voltages. This interface shall conform to the following requirements:
  - a. Output type: Relay and transistor
  - b. Relay configuration: Form A, bistable (latching)
  - c. Relay type: Dry contact reed
  - d. Relay operating time (max.): 3 milliseconds
  - e. Contact capacity: 15 volt-amps, @ 28 Vdc
  - f. Contact surge capacity: 15 volt-amps, @ < 400 Vdc
  - g. Contact current rating: 1 amp dc maximum, supplied by external circuit
  - h. Contact open resistance (min.): 100 megohms
  - i. Contact closed resistance (max.): 100 milliohms

j.	Contact common return:	One only, and two contacts
k.	Transistor type. (electronic):	Open collector, latching
l.	Transistor current:	100 milliamp sink, limited self-protecting, supplied by external circuit
m.	Transistor common:	Negative 28 volts, dc grounded
n.	Read-status window-pulse output:	For quieting external device for reading by strobe
o.	External strobe pulse output:	Initiates external device status reading
p.	Contact surge suppression:	±2000V. peak, 8/20 micro-second standard wave

#### H. Status Input Interface Requirements

1. The Status Input Interface shall accept data from the external equipment listed in the Scan Sheets and organize it for use by the RTU in generating the outgoing message. This interface shall protect the RTU from the hostile electrical environment of the external equipment and the accidental application of external voltages in excess of the normal operating voltage. Each individual input interface shall be equipped with a light emitting diode which shall be lighted when the input is energized. Each individual input interface shall be equipped with a pushbutton or switch which is circuited to simulate an input, but which does not energize the external input circuit. Each individual input interface shall be capable of connection to a mechanical contact or an electronic output. This interface shall conform to the following requirements:
  - a. External (driving) Circuit:
    - 1) Contact closure, isolated
  - b. External voltage for contact indications:
    - 1) 30 Vdc maximum, 10 Vdc minimum
  - c. External circuit indicating current:
    - 1) Maximum Steady Application: 20 milliamps, from RTU Supply
    - 2) Noise Rejection Threshold: 5 milliamps
  - d. External contact bound immunity:
    - 1) 12 to 20 milliseconds
  - e. Input circuit configuration Optional:
    - 1) latching and
    - 2) non-latching
  - f. External contact operation (non-latching):
    - 1) Bit transmitted if contact closed during RTU scan
  - g. External contact operation (latching):
    - 1) Bit transmitted subsequent to 20 millisecond contact closure
    - 2) External suppression surge limit:
      - a) 15 volt-amps, @ < 400 Vdc
2. The Status Input Interface shall also accept data from external equipment in the form of a 4 to 20 milliamp current loop. This analog data shall be converted to digital 7-bit status and placed in the appropriate frame/word of the RTU response message. The accuracy of the Analog to Digital Converter shall be +/- 0.15% full scale.
3. Each RTU that is required to accept 4 to 20 milliamp analog current loop inputs shall have the capacity to handle a minimum of 16 analog inputs. This may be done by multiplexing.

#### I. Spare Point Requirements

1. Remote Terminal Units shall be provided with more points (spares) than the maximum number of points required for outputs (controls) and inputs (status). The arrangement and number of spare points shall be determined by the RTU Scan Sheets as shown in Section 16997 for each specific RTU location.

- J. Power Supply Interface Requirements
1. The Power Supply Interface contained within the RTU cabinet shall take its power from the 28 Vdc supply in the TCR. One or more power supplies shall convert this power to the voltages and currents required by the devices with which the RTU is implemented. The capacities of these internal power supplies shall be adequate for a full complement of input and output equipment. This interface shall protect the RTU from the hostile environment and normal variation of the external power source. This interface shall conform to the following requirements:
    - a. External supply voltage: Local System Vdc  $\pm$  8% or 120 Vac  $\pm$  15%
    - b. External supply load: Less than 500 volt-amperes
    - c. Ripple tolerance (dc supply):  $\pm$  7%
    - d. Power transient immunity:  $\pm$  2000V peak, 8/20 micro-second standard wave
    - e. Power failure or interruption: Cancels ongoing cycle, does not affect control memory
  2. Adequate power and ground buses shall be provided to transfer the power from the supply to the modules without loss and without introducing electrical interference.
  3. Surge protection shall be provided as part of the RTU's internal power supply input interface.
- K. Power Panel
1. A panel on the RTU shall be arranged to hold equipment which will serve the following functions:
    - a. Provide facilities for monitoring (on pin jacks or the equivalent) the power supply input and output voltages from the front of the panel.
    - b. Provide space for mounting power supply indicators and fuses, both of which shall be of the style that allows replacement from the front of the panel without rack or panel disassembly.
- L. I/O Interface Requirements
1. Control outputs and status inputs shall be interfaced from the external equipment to the RTU through plug connectors and optical isolators. The optical isolators shall protect the RTU internal circuitry and equipment from the application of ac or dc voltages up to 150 volts.
  2. All connections to the RTU shall be through the top of the rack or cabinet where it is mounted unless otherwise authorized by the designated Resident Engineer.
- M. Internal Circuitry Requirements
1. All active internal circuitry shall be comprised of solid state silicon devices. The circuitry shall be configured utilizing CMOS technology with board layout and component selection arranged for minimum heat generation, maximum heat dissipation and maximum immunity from interference. The copper layout of interface boards shall minimize (through adequate spacing and intervening grounded conductors) the electrical coupling between the internal and the external circuitry. The wiring harness of the interface boards shall provide for a separation of the wires of the internal and external circuits. The power wiring and the external circuits shall be wired with either twisted pair or twisted triple. The internal RTU circuitry shall withstand without damage or false operation, the interfering effects of induced lightning surges in the external interface wiring and the operation of the external interface relays at their maximum ratings.
  2. Proper grounding procedures shall be utilized throughout the system to ensure that ground loops are not established and EMI is not propagated or conducted to sensitive internal circuits.
  3. Circuitry shall be included which shall check and validate each requested output before it is activated, i.e., prevent the execution of false "commands."

- N. Rack Requirements
1. The RTU shall be composed of one or more dust-resistant modules mounted on a single, standard 19" rack, not exceeding 7 feet in height. The depth of the equipment modules and rack shall not exceed 33 inches.
  2. Modules containing indicators or controls shall be located as close to eye-level as practicable.
- O. Dust-Resistant Module Requirements
1. The individual modules of which the RTU is composed shall be gasketed and dust-resistant. They shall also meet the temperature requirements of these Specifications. This shall be accomplished without the use of fans or outside air by making the module enclosure large enough to dissipate its internally generated heat by internal convection and external radiation. The modules shall be immune to the predominant type of dust present in the TCR which results from train brake wear.
- P. Cabinet Requirements
1. If necessary to meet the temperature and dust-resistant requirements, the Contractor may elect to enclose the entire rack in a steel cabinet of approved construction, rather than to enclose each module. The interior of the cabinet shall be accessible from both front and rear by means of removable panels, or doors and shall be large enough to allow easy expansion of the inputs and outputs to the full specified capacity. The doors and their mountings shall allow the removal of the modules without restriction.
- Q. Cabinet Equipment Arrangement
1. The equipment within the cabinet shall be arranged (with ducting where necessary) to encourage air movement within the cabinet by natural convection. The air movement shall remove heat from the heat-producing components in the modules and transfer it to the exterior of the cabinet where it can be dissipated by radiation. The air movement shall be largely unimpeded in an upward flow, through all of the various modules mounted on the 19-inch rack to the top of the cabinet; then downward along the outside sheet metal housing (where the heat is removed by radiation) to the bottom of the cabinet, where it is ducted inward, to return upward again, to cool the modules. The "chimney" formed by the stack of uniformly sized module housings shall be continuous from the bottom of the module stack to the top. This "chimney" shall be free of gaps or openings larger than 1/8-inch where heated air currents rising inside the stack can escape and interfere with cooling air currents falling outside the stack, thus reducing circulation. Baffles shall be utilized as necessary to prevent the rising air currents from entering non-heat-producing sections of the modules and bypassing the critical components. The modules shall be designed so that the baffle of one module does not interfere with the air movement through the critical areas of an adjacent module.
- R. Environmental Requirements
1. Physical
    - a. The RTU assembly shall work in the physical environment of the TCR. These environmental requirements are:
      - 1) Operating temperature range -22 to +158 degrees F. (-30 to +70 degrees C.)
      - 2) Operating humidity range 5 to 95 percent R.H., non-condensing
      - 3) Vibration suppression Shock mounted
      - 4) Cooling system Radiant plug natural convection (no fans)
  2. Electrical

- a. The RTU assembly shall work satisfactorily in the electrical environment of the TCR. The Contractor shall assess this environment considering the factors stated in Section 16914.1.03 of these Specifications and the characteristics of the equipment the Contractor is providing under this Contract.
  - b. Conducted and radiated radio frequency energy in the bands 150-160 MHz, 460-500 MHz and 850-950 MHz shall be attenuated to a level which will not interfere with the operation of a radio transceiver with a self-contained antenna. Further, the operation of a radio transceiver, transmitting radio frequency energy at any frequency with ten (10) watts of power into a self-contained antenna, shall not cause malfunction of the microprocessor, its related equipment, or the I/O devices. These requirements shall be met when said antenna is within three inches of any external part of the RTU assembly.
- S. Maintainability
  - 1. The RTU and its mounting shall be designed to possess a high degree of maintainability, facilitated by the use of modular construction to allow easy removal and replacement of modules, subassemblies and components. Modules shall be removable without tilting them. Modules shall have sufficient cable slack to facilitate their removal without having to open additional covers.
- T. Operational Accuracy
  - 1. The RTU shall operate accurately, i.e., without generating erroneous controls or indications, over the entire range of operating voltage tolerances specified by its manufacturer.
- U. Fabrication or Procurement
  - 1. The RTUs provided under this Contract shall be of the "Outpost" type, similar to Model 409 (as manufactured by ABB Network Management, Inc., 1601 Industrial Blvd., Sugar Land, Texas 77478) except for the additional rack dimensional requirements, optical isolator interface requirements, and internal 5 volt power supply monitoring and interface requirements specified herein. These additional features shall be provided by the Contractor. The Contractor shall also provide, at no additional cost to the Authority, all necessary new-type(s) of printed circuit boards, plus 20 percent spares, which may be required at the WMATA Operations Control Center (OCC) location and the new wayside TCR locations if a different type of RTU, which accurately emulates the WMATA protocol, is approved.

## **2.03 INTERFACE JUNCTION BOX WIRING DIAGRAMS**

- A. DTS interface junction box (cabinet) wiring diagrams shall show the box designation, the final configuration for all wires and terminals in the box and the nomenclature for each wire terminated in the box. Where the nomenclature of external wires by other disciplines differs from the Contractor's nomenclature, the Contractor shall show both wire designations. The Contractor shall reduce these wiring diagrams in size (as necessary), laminate them (when approved) between sheets of clear moisture-proof material, and mount them inside the junction box covers. The lettering of these diagrams shall still be legible when so mounted. A copy of the approved arrangement (as-built) drawing shall be maintained in each DTS Junction Box until the laminated drawing is installed.

## **2.04 RTU EXTERNAL CONNECTIONS**

- A. Control outputs to all equipment or systems external to the ATC system shall be at the local system dc voltage (independently fused by function) switched over the contacts of the output interface relays, as specified in Section 16944, Non-Vital Relays and Timers. Suppression

for inductive loads shall be provided in the external equipment or system such that the instantaneous volt-amp load on the interface relays shall never exceed 15 volt-amperes and the voltage shall never exceed 400 Vdc.

- B. Inputs (Status Indications)
  - 1. On/off indication inputs from equipment or systems external to the ATC system shall be provided by dry contacts meeting the contact requirements of non-vital general purpose interfacing relays as specified in Section 16944.
  - 2. Analog indication inputs from systems external to the ATC system will be provided by 4 to 20 milliamp current loops. The RTU field Interface shall include 250 ohm radial lead, 0.01 percent tolerance, 2ppm/Degree C temperature coefficient or better, resistors.
- C. The wiring of the external circuits as they approach the RTU Input or Output interface device shall be twisted pair of appropriate gauge (twisted triple shall be used for relay outputs with one common per relay pair). This wiring shall be kept physically separate from the internal circuitry of the RTU. Mutual inductance and capacitance between the internal and the external wiring shall be minimized throughout; printed circuit layout of the interface shall conform to this requirement.
- D. Wire and cable for DTS wiring shall be as specified in Section 16949, Signal Wire and Cable.

## **2.05 COMPUTERIZED ANALYZER UNIT**

- A. The Contractor shall furnish (*number*) Computerized Analyzer Units (CAUs) for the route segment included in this Contract (i.e., one for each new station TCR), plus two CAUs for the Engineer Systems Engineering (ENSE) and one CAU for Operations (OPER) training. (A total of (*number*) CAUs).
- B. Each CAU shall be complete with all the equipment, manuals and supplies necessary to connect it to the system, perform the required tests, and to service all of the RTUs previously installed by others and the RTUs provided under this Contract.
- C. The CAU shall be a notebook style, pentium MMX™ microcomputer and visual display for monitoring all RTU functions. It shall include a minimum of 16 MB RAM, Active Matrix SVGA Monitor, 1.44" floppy drive, 28.8 baud modem and an external modem to interface with the RTU modem, internal 4X CD-R Drive with sound card, 2 type II PCMCVI slots, one parallel port and one serial port, an additional battery and battery charger, latest Windows software including latest Procomm Plus (pre-loaded with backup floppies) and a carrying case. It shall be useful in both the initial setup of RTUs and in the field and shop maintenance of RTUs. It shall have the capability of serving as a Local Storage Monitor for data messages. The microcomputer shall have an internal battery allowing at least three hours of operation without connection to any external power source. The display shall be active matrix color. If space limitations prohibit the installation of the necessary RTU interface equipment, a piggy-back type enclosure shall be provided which conforms to the physical characteristics of the microprocessor. If an external enclosure is provided, it shall be equipped with a suitcase style carrying handle.
- D. The CAU shall include, as a minimum, all of the facilities of the TRW Model 9600 Portable Analyzer Unit (PAU). These facilities shall provide the CAU operator with information which will enable him to successfully analyze the performance of the existing RTUs, the new RTUs furnished under this article, and the existing SIMPACT Boards. The CAU shall provide for the analysis of each of these units on a bit-by-bit basis to readily recognize and isolate trouble to a specific section.
- E. The CAU shall be capable of simulating for the RTU, the functions normally performed by the

SIMPACT Boards in the Front End processors located at Central Control.

- F. The CAU shall be connectable, either directly to the transmitter and receiver of the RTU or the SIMPACT Boards, or indirectly to these units via its internally provided modem. The CAU shall be capable of testing through its internal modem.
- G. Means shall be provided on the CAU for manually setting the transmitted bits of the data message described in this article and utilized in the existing and future system.
- H. The CAUs furnished for the Central Maintenance Facility shall be additionally equipped with plug couplers, cables, manuals, programs and other devices necessary to service the other CAUs. Alternatively, each CAU shall have the capability of a self-diagnostic program or test.
- I. The CAU, when acting as a simulator, shall adapt its data format depending upon whether it is simulating an RTU or a SIMPACT Board.
- J. Indicators or Flags on the visual display screen shall display the status of data message being processed. These indications shall include, but not be limited to, the following:
  - 1. Receive
  - 2. Transmit
  - 3. Frame Bits
  - 4. Address Bits
  - 5. Security CheckwordError
  - 6. Frame Sync.
  - 7. Carrier Level
- K. The CAU shall have a menu driven capability to store the control and status data bit information of an average RTU configured for a diamond interlocking location for not less than a 48 hours on a circular (write-over) basis. The menu shall provide the capability of selecting the required information bits to be stored. The stored memory shall be retrievable on the CRT and a typical laser jet printer. A program shall be included to highlight changes in the data. The data shall be transferable to a floppy diskette in ASCII (DOS) Text format.
- L. The CAU shall have a self-contained power supply operating from 120V ac. The power supply and the internal modem shall contain adequate transient protection.
- M. Each CAU shall be furnished with a durable, light- weight carrying case with provision to carry the CAU and all cables, adapters and external devices except the external modem.

## **2.06 SPARE REQUIREMENTS**

- A. See Section 16932, Spare ATC Equipment and Selectable Items.

## **2.07 INSTRUCTION MANUALS**

- A. For the RTU the Contractor shall submit, in accordance with the provisions of Section 16992, ATC Instruction Manuals, the specified documentation for the following manuals:
  - 1. Field Maintenance Manual
    - a. For maintenance of the RTU in the field to the board level.
  - 2. Shop Maintenance Manual
    - a. For maintenance of the RTU boards in the shop to the component level.
- B. For each CAU provided, the Contractor shall submit, in accordance with Section 16992, ATC Instruction Manuals, the specified documentation for the following manuals:
  - 1. Operator Training Manual
    - a. The "operator" will be a field maintainer or a shop maintainer.

2. Field Maintenance Manual
    - a. For maintenance of the CAU in the field to the board level.
  3. Shop Maintenance Manual
    - a. For maintenance of the CAU in the shop to the component level.
- C. The Contractor shall provide necessary field maintenance, shop maintenance, and operator training instruction manuals for the A/D Converter and Multiplexer equipment.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. The Contractor shall mount the Remote Terminal Unit for each TCR at the location shown on the approved TCR arrangement plan for that room in a manner similar to that used to mount the ATC racks. Signs displaying the RTU system voltage followed by the word "ONLY", all in 2-inch high letters, shall be affixed to the outside of each exposed side of the Remote Terminal Unit modules, and to the sides and cover of each DTS Interface Junction Box.
- B. RTU interfacing circuitry shall be installed in conformance with the typical RTU control and indication circuits shown on the Contract Drawings and connected to the RTU as indicated on the RTU Scan Sheets submitted by the Contractor and approved by the Engineer. (See Section 16997, RTU Scan Sheets.)
- C. Ancillary Location Interface
1. The Contractor shall provide the interface connections between the RTUs and all ancillary facilities in their respective areas. These facilities shall include, but not be limited to, the following, as applicable:
    - a. AC Service Rooms (AC)
    - b. Substations (SS)
    - c. Tiebreaker Stations (TBS)
    - d. Drainage Pumping Stations (DPS)
    - e. Vent Shafts (VS)
    - f. Fan Shafts (FS)
    - g. Sewage Ejectors (SEJ)
    - h. Communications Equipment Rooms (COMM)
    - i. Special Sump Pumps (SP) (where applicable)
    - j. Jet Fan Control Rooms (JFC) (where applicable)
  2. This interfacing shall be accomplished by furnishing, installing and terminating sufficient Special Control and Indication cables, of the type and at least the minimum capacity specified in Section 16949, between the TCR and the standard DTS junction boxes (cabinets) provided by others at certain wayside, non-ATC facilities external to the Train Control Rooms, as indicated on the Contract Drawings.
  3. As an alternative to direct conductor RTU interface for each ancillary data bit, and subject to the prior approval of the designated Resident Engineer, the Contractor shall provide small, satellite RTUs at selected ancillary locations. These satellite RTUs shall be connected to the local DTS interface junction boxes in the standard, specified manner, but shall be connected to the main RTU by one or more twisted-pair cables of appropriate size(s). The satellite RTUs shall be subject to the same limitations as specified for the primary RTUs, and the whole satellite RTU subsystem shall be subject to Type Acceptance Testing. If satellite RTUs are used, the CAU shall be equipped to interface with the satellite RTUs.
- D. The Contractor shall furnish, install and terminate a special control and indication cable, of the minimum size and type required as specified for external cable in Section 16949,

Signal Wire and Cable, between the RTU in each TCR and its associated TC/COMM Interface Cabinet (furnished by other disciplines in the Communications Room) to pick up, among other things, Fire and Intrusion indications for the various rooms and buildings specified. The Contractor shall tag and terminate this cable in the TC/COMM interface cabinet as indicated on the Contract Drawings, and make the appropriate corresponding terminations on the RTU.

- E. The Contractor shall provide a reed relay, energized by the internal 5 volt power supply of the RTU, and the necessary interface to use a contact of this relay in the applicable TCR power failure alarm system to indicate failure of the RTU internal 5 volt power supply.
- F. The Contractor shall furnish and install a two-pair telephone-type cable between the RTU in each TCR and the associated Main Distribution Frame (MDF) (furnished by other disciplines in the Communications Room) leaving sufficient wire at the MDF end for proper termination by other disciplines. Each pair in this cable shall be individually shielded. This cable shall be tagged "DTS". The shielded pair carrying information from Central Control shall be tagged "REC" and another shielded pair carrying the return information to Central Control shall be tagged "TRANS". The shields of these shielded pairs shall be grounded at one end only, to prevent interference from ground currents of the ac power. The Contractor shall terminate this cable on the appropriate terminals in the RTU and advise the appropriate other disciplines when this has been accomplished. Other disciplines will terminate this cable in the MDF cabinet and perform tests on the DTS channel from the MDF as part of the CTS System test. The other disciplines will advise the Contractor when the DTS channel has been tested and is operational and when the cable between the MDF and the RTU has been terminated in the MDF.
- G. The Contractor shall exercise the DTS channel from the RTU to ensure proper operation. It shall be the responsibility of the Contractor to coordinate with the appropriate other disciplines to locate and correct faults identified as carrier transmission faults within the Data Transmission System. The other disciplines will cooperate fully with the Contractor in accomplishing this interface.
- H. The Contractor shall inform the designated Resident Engineer when the RTU and all of its field connections are complete. The Authority will then, within a two-week period, make the appropriate connections at Central Control.
- I. Unless otherwise specified, the Contractor shall design and install the data point wiring as follows:
  - 1. The RTU wiring shall be installed in a manner and configuration having the prior approval of the designated Resident Engineer.
  - 2. The Contractor shall provide wiring from all active and spare data points to terminals or plug connectors located on an appropriate equipment or entrance rack in the Train Control Room.
  - 3. The Contractor shall provide no printed circuit card for the locations designated as "NO CARD" on the RTU Scan Sheets. Positions which are indicated by a "NO CARD" within the CONTROL FRAMES shall be wired to accept either a "RELAY PAIR CARD" or a "RELAY SINGLE CARD," as indicated on the approved Scan Sheets. (A "RELAY PAIR CARD" has one common brought out for every two control points and a "RELAY SINGLE CARD" has a common brought out for every control point.) Positions which are indicated by a "NO CARD" within the STATUS FRAMES shall be wired to accept any status input card and the wiring shall extend to plug couplers or terminals on an appropriate equipment or entrance rack.
  - 4. Where a card cage position is indicated as "VACANT SLOT" on the RTU Scan Sheet, no internal wiring shall be provided for that cage position, and no PC card shall be provided.

- J. The Contractor shall prepare and install Interface Junction Box Wiring Diagrams for all interface junction boxes (cabinets) in which ATC or DTS wiring provided under this Contract is terminated. This shall include a wiring diagram for each TC/COMM Interface Cabinet located in Communications Rooms. One copy of each box wiring diagram shall be inserted in each "Room Book of Plans" for the associated TCR, and another copy shall be laminated between layers of clear, moisture-proof material and mounted inside the applicable box.

### 3.02 SCAN SHEET DATA FORMAT

- A. The RTU Scan Sheets included in these Specifications are listings, as determined by information available at the time these Specifications were prepared, of the input (status), output (control), and spare data points to be provided or modified by the Contractor at each RTU location affected by this Contract. Modifications to the Scan Sheets must be approved before implementation. The Contractor shall provide RTU Scan Sheets which have the same format as those included in the Contract Documents, but which also contain additional columns showing RTU termination points.
- B. The Scan Sheets for each control and status "frame" contain four "words" (WD 0 through WD 3). Each word contains 16 bits, of which 14 are assignable as data bits (Bits 0 through Bit 13). The proposed arrangement of frames, words, and bits for each RTU location is shown in the RTU Scan Sheet section of these Specifications.
- C. Where an equipment function may be added or activated in the future, the notation "(FUTU)" in the Scan Sheet following the function name has the following meaning:
1. (FUTU) = Inactive now, but all DTS hardware and wiring shall be provided by the Contractor under this Contract at "New" locations to facilitate possible future use.
- D. Revised functions, PC card types, or energy feeds for the existing Tie-In location RTUs are indicated by an alphabetical character in the Scan Sheet column preceding the function names. The characters used, and their meanings, are as follows:
1. The old (**current**) names for the functions, PC cards and energy feeds at the point location revised are shown in brackets following the new names.
    - a. A = ADD
    - b. C = CHANGE
    - c. D = DELETE
    - d. E = ENERGIZE (a pre-wired point)
    - e. R = RESERVE or REMOVE
    - f. M = MOVED (point or card) (May include a CHANGE)
- E. The Contractor shall check the RTU Scan Sheets included in these Specifications and make any additions, corrections or revisions necessary to provide complete control and indication coverage of all Train Control and support facilities within the respective RTU control areas, based on the latest information available. For example, the Contractor shall modify the name and number of track occupancy indication data points as necessary to reflect the final, approved block design.
- F. The Contractor's RTU Scan Sheets shall also indicate the types of printed circuit cards actually used, together with appropriate common signal or energy bus wiring, and the arrangement for those printed circuit cards within the card cages of each RTU.
- G. The Contractor shall wire all RTUs affected by this Contract in conformance with the arrangement specified in the Contractor's RTU Scan Sheets which have been approved in writing by the designated Resident Engineer. The Contractor shall include

documentation of all termination points for data point wiring of the RTUs in the Scan Sheets he furnishes.

### **3.03 DELIVERY, STORAGE AND HANDLING**

- A. The Contractor shall take whatever measures may be necessary to protect the RTU, CAU, and A/D Converter equipment from damage or marring during shipment, installation and testing and until the Authority accepts the system. If the equipment suffers any damage, from whatever cause, during this period, the Contractor shall replace or repair it to a like-new condition, to the satisfaction of the Engineer and at no additional cost to the Authority.

### **3.04 TRAINING REQUIREMENTS**

- A. The Contractor shall provide three types of DTS training courses, for different groups of Authority employees. One course, (described in 1. below) shall be called the DTS Field Maintainer's Training Course. The second course, (2. below) shall be called the DTS Shop Maintainer's Training Course. The third course, (3. below) shall be called the Engineers' DTS Training Course. Training aids shall be liberally employed where helpful to illustrate the devices and principles being described. Firmware such as flip charts, transparencies and slides shall become the property of the Authority at the conclusion of the presentation of each course by the Contractor. The Contractor's instructor shall cooperate with the Authority in the videotaping of the course presentations.
  - 1. DTS Field Maintainer's Training Course
    - a. The Contractor shall provide on the Authority's premises, for its signal maintenance personnel, four identical presentations, each a minimum of five days duration. Each presentation shall be a complete course of classroom and hands-on instruction in the operation and maintenance of the RTU, CAU, and, where applicable, the A/D Converter and Multiplexer equipment and circuitry. Each presentation shall accommodate 12 persons designated by the Authority.
      - 1) The first two presentations of this course shall occur successively during the final installation stages of the RTU. The second two presentations shall be at later dates within one year from the date of the first two; the exact dates to be determined by the mutual consent of the Authority and the Contractor. All of these instruction courses shall be at no further cost to the Authority.
      - 2) This instruction shall be based on the Field Maintenance Manuals described above in Section 16992.2.07.
      - 3) This instruction shall cover all aspects of operation and maintenance of the RTU and CAU equipment, and, where applicable, the A/D Converter and Multiplexer equipment.
  - 2. DTS Shop Maintainer's Training Course
    - a. The Contractor shall provide two complete and identical presentations of a five-day course of instruction for the Authority's electronic technicians. This course shall provide hands-on training to enable these technicians to locate defective board components in the RTU and CAU systems, and defective A/D Converter and Multiplexer equipment. Each presentation of this course shall be held for eight Authority-designated persons. This course shall be based on the Shop Maintenance Manuals described in Section 16992.2.07.
    - b. The first presentation of this course shall be held on the Authority's premises at a mutually acceptable date during the installation phases of the Contract. The Authority will be responsible for the personal expenses of the participants during the time of course presentation.
    - c. The second presentation of this course shall be held on the Authority's

premises on a date mutually acceptable within one year of the date of the first presentation.

d. The Contractor shall provide at no further cost to the Authority, the copies of required manuals and all materials for these courses. These materials shall include but not be limited to defective boards for comparison with properly-operating boards. The Contractor shall be responsible for the repair or replacement of all boards inadvertently damaged during these courses.

3. Engineers' Data Transmission System Training Course

a. The Contractor shall provide on the Authority's premises, for certain engineering personnel, one presentation of a course of classroom and hands-on instruction in the operation of the DTS, the programming and reprogramming of the Remote Terminal Units, and the maintenance of the RTUs and other DTS equipment to the board level. The course shall be three days in length. The presentation of the course shall accommodate up to 12 persons designated by the Authority.

1) The presentation of this course shall occur during the final installation states of the DTS and shall be made at no additional cost the Authority.

2) This instruction shall be based on the Instruction Manuals described in Section 16992.2.07.

3) This instruction shall cover all aspects of setup, programming, operating and maintenance of the DTS equipment. It shall include, but not be limited to the following:

a) Programming Techniques

b) Compiling

c) Setting and Erasing Memory Devices

d) Locating Defective Board Components

e) System Operation

f) Reliability Considerations

g) Trouble Shooting

h) Diagnostic Routines

i) Maintenance Procedures.

4) This course shall be designed for an educational level of 12th grade plus a Bachelor's Degree in Engineering or its equivalent.

5) This course shall include "hands-on" instruction for each participant in programming, reprogramming and identifying and replacing defective board components through the use of the Contractor's test fixtures (made available by the Contractor at no additional cost to the Authority), and the Remote Terminal Unit provided to the Authority by the Contractor for training purposes. The Contractor shall supply, at no additional cost to the Authority, a set of boards with various defective components for use in this test.

B. These training courses shall be organized in accordance with the requirements of this Section and Section 16992, ATC Training Courses.

### 3.05 MEASUREMENT FOR PARTIAL PAYMENTS

A. The Data Transmission System additions provided under this Contract will be measured for partial payments based upon:

1. Approval by the designated Resident Engineer of the Type Acceptance and System Performance testing;
2. The number of required Remote Terminal Units furnished, installed and accepted
3. The number of required DTS junction box wiring diagrams properly furnished and

- installed;
4. (Where applicable): The number of A/D Converters and Multiplexers furnished, installed and accepted.
  5. (Where applicable): The number of Satellite Remote Terminal Units (SRTUs) furnished, installed and accepted.
- B. The Computerized Analyzer Units (CAU) will be measured for payment under Section 16931, ATC Maintenance and Test Facilities.

**END OF SECTION**

## SECTION 16926

### ATC - MICROPROCESSOR SYSTEMS FOR NON-VITAL INTERLOCKING FUNCTIONS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing and installation of systems of one or more equipment modules, which constitute a microprocessor-based controller with the capability of supervising the non-vital functions of interlockings, and monitoring both the vital and non-vital interlocking functions. The requirements of this Section shall supersede those shown on the Contract Drawings or given in other Sections of these Specifications where the non-vital interlocking functions are shown or described as being performed by "discrete component" and relay-type equipment.

##### 1.02 DESCRIPTION

- A. This controller shall be referred to herein as a Non-Vital Interlocking Processor System, or more simply, as an NVIP.
- B. The area of the WMATA right-of-way supervised and monitored by each NVIP shall be limited to interlockings and to the adjacent mainline area, but only to the distance that a "stop" aspect of an interlocking signal has an effect.
- C. It is recognized that a manufacturer of a non-vital interlocking processor controller system may supply separate modules, each possibly consisting of more than one processor, for "non-vital" interlocking processing. This is acceptable under these Specifications. Alternatively, a manufacturer may utilize only one processor module for the combined processing of all the interlocking non-vital tasks. For the purposes of these Specifications, the non-vital processors will be referred to as a single entity, or as sections of a single entity. Functions or equipment of the non-vital processor (or portions of a processor) shall not interfere with the safe operation of the vital logic system controlling and operating the interlocking.
- D. The basic modular units of all NVIPs provided by the Contractor under this Contract shall be interchangeable. The overall configuration of each NVIP shall be determined by its internal programming and by its external wiring.
- E. In the design of the logic for the NVIPs the Contractor shall comply with the applicable requirements of Section 16917, (Basic Interlocking Requirements) of these Specifications, and to the logic design inherent in the relay-type Circuit Drawings accompanying these Specifications. In the construction of the NVIPs, the Contractor shall comply with the requirements of all applicable articles included in these Specifications except as necessary to accommodate the vital relay logic controlling and operating the interlockings.
- F. The Contractor shall provide non-vital microprocessor logic to the greatest extent practicable to perform the functions of all the interlocking circuits classified as "Non-Vital" in Section 16916, Basic ATC Circuit Requirements. In addition, the Contractor shall provide non-vital processor logic to monitor both vital and non-vital interlocking functions as specified herein.

- G. The Contractor shall interface the processor to the Local Interlocking Control Panel, the TCR Track and Alarm Indication Panel, and the Remote Terminal Unit, providing non-vital inputs and outputs for interconnection to the indicators and manual controls thereon.
- H. The processor shall be capable of performing the following non-vital interlocking tasks and functions within the interlocking area specified in 1.02 B. above:
  - 1. Replace all non-vital relays and non-vital timers utilized in performing the interlocking non-vital supervisory and indication tasks set forth in these Specifications wherever possible and practical.
  - 2. Drive a non-vital relay referred to in these Specifications, as the NVIP Check Relay (NVIPCHK). Control of this relay is specified in PART 2 of this Section.
- I. The Contractor shall supply one complete Non-Vital Interlocking Processor System for each of the new Interlocking Train Control Room locations included in the area of this Contract as delineated in Section 16911, Scope of ATC Work, and Section 16918, Special ATC Requirements for Specific Locations of these Specifications, and one complete NVIP System for use during training, which is to be delivered to the Authority upon completion of training. See Section 16932.
- J. The Contractor shall provide a training program for personnel maintaining the NVIPs. The program shall be in accordance with the requirements of this Section and Section 16993.

### **1.03 RELATED SECTIONS**

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16904 Current Automatic Train Control System
  - 2. Section 16911 Scope of ATC Work
  - 3. Section 16914 Environmental Requirements
  - 4. Section 16916 Basic ATC Circuit Requirements
  - 5. Section 16917 Basic Interlocking Requirements
  - 6. Section 16918 Special ATC Requirements for Specific Locations
  - 7. Section 16924 Non-Vital ATO & ATS Processor Systems
  - 8. Section 16925 Data Transmission System (DTS)
  - 9. Section 16927 ATC Microprocessor Support Systems
  - 10. Section 16928 Interlocking Vital Processor Systems
  - 11. Section 16931 ATC Maintenance and Test Facilities
  - 12. Section 16932 Spare ATC Equipment and Selectable Items
  - 13. Section 16941 Basic ATC Electrical and Electronic Component Requirements
  - 14. Section 16942 Printed Circuit Cards
  - 15. Section 16945 Plugboards and Cabinets
  - 16. Section 16948 Plug Connectors
  - 17. Section 16949 Signal Wire and Cable
  - 18. Section 16955 Track and Alarm Indication Panels
  - 19. Section 16956 Interlocking Control Panels
  - 20. Section 16961 Audio Frequency Track and Loop Circuit Layouts
  - 21. Section 16971 Racks and Cable Trays
  - 22. Section 16977 Tagging and Marking
  - 23. Section 16980 ATC Tests, Inspections and Quality Assurance
  - 24. Section 16992 ATC Instruction Manuals
  - 25. Section 16993 ATC Training Courses

### **1.04 QUALITY ASSURANCE**

- A. All of the NVIP modules and the software programs which are to be installed under this

Contract shall be factory tested as a complete system in accordance with a factory test procedure. This procedure shall be generated by the Contractor in accordance with the guidelines set forth in another part of this article. The procedure must have the approval of the designated Resident Engineer before factory testing is started.

- B. The Contractor shall record the results of these tests on the specified Factory Test Report forms. Items for which Factory Test Reports have not been approved by the designated Resident Engineer, may be shipped to the job site only at the Contractor's risk.
- C. NVIP equipment modules shall be inspected by the Contractor prior to installation and only those items which have suffered no damage during shipment and subsequent handling shall be installed.
- D. All of the NVIP modules and their software program which have been installed under this Contract shall be field tested after installation in accordance with a field test procedure. This procedure shall be generated by the Contractor in accordance with the guidelines set forth in Part 1.05 (Submittals) of this Section. The Contractor shall submit this procedure for approval by the designated Resident Engineer, and must receive such approval before the start of field testing.
- E. The Contractor shall provide and maintain up-to-date, a diary or log containing a detailed write-up of any and all changes made to the NVIP system hardware and software from the time of their approval by the designated Resident Engineer until final acceptance by the Authority, at which time the log shall be delivered to the designated Resident Engineer. This record shall conform to the requirements more fully described in the documentation section of Part 3 of this Section.
- F. The Contractor shall provide Operation and Maintenance Manuals for the NVIPs. These manuals shall be prepared during the initial phases of the Contract so that they may be approved and delivered to the Authority before field testing commences. These manuals shall be prepared according to guidelines set elsewhere in this Section and in Section 16992 of these Specifications.
- G. The factory test for the NVIP system complete with all TCR equipment shall include:
  - 1. All field tests which can be performed in the factory
  - 2. Train movement simulations (all routes)

#### 1.05 SUBMITTALS

- A. The Contractor shall furnish within 60 calendar days of receipt of Notice to Proceed a submittal consisting of the following three explanatory items. These explanations shall be fully detailed and in plain English. Simple diagrams may be used for clarity. All such diagrams shall be fully explained. A glossary of definitions shall be included to thoroughly define any absolutely necessary technical or unusual words, otherwise, such words shall not be used. Buzzwords, slang, computer jargon and telegraphic writing style shall not be used. The Contractor shall explain the following:
  - 1. The Contractor shall present a detailed explanation of the method by which he intends to implement the diagnostic requirements specified in this Article. This explanation shall describe the techniques of schemes to be utilized to verify the correct operation of every step of every process included in the NVIP information processing.
  - 2. The Contractor shall present a general explanation of the method by which he

intends to implement the maintenance requirements specified in this Article. This explanation shall describe the features of the proposed maintenance program and the test equipment to be supplied for use with the maintenance procedures.

3. The Contractor shall describe in detail the provisions he has made for repairing the printed circuit boards which are part of the NVIP. This description shall address the following items:
  - a. The period of time for which the Contractor will provide PC board service for the NVIPs.
  - b. How and where the Authority may continue to receive NVIP PC board service when this time period expires.
  - c. Which boards or devices will be kept in stock at the Contractor's factory, and for how long.
  - d. The guaranteed maximum factory turn-around time from receipt of request for new board or device to shipment of its replacement.
  - e. The Contractor's replacement policy.
  - f. Whether replacement boards are new or repaired.
  - g. Whether replacement boards would be from Authority returned boards or a general stock.
  - h. The present cost of replacement for each board type.

B. The preceding three sections of the Contractor's submittal shall provide all of the information necessary to enable the designated Resident Engineer to make a reliability assessment. The Contractor shall assume that the designated Resident Engineer is familiar with basic computer terminology, but that he is not a programmer. The designated Resident Engineer will determine whether or not the equipment which the Contractor intends to supply for the NVIP system appears to be capable of performing the interlocking non-vital supervisory, monitoring and diagnostic functions in the desired manner. The results of the designated Resident Engineer's evaluation will be used as part of the design review. The outcome of this review shall be in no way construed as lessening the successful bidder's responsibility to provide a workable system.

- C. The Authority will review documentation for all equipment to be furnished under this Section before the equipment is delivered. The Authority also recommends that the Contractor not manufacture equipment which may not be approved for this Contract. Therefore, prior to component purchase, or fabrication of the equipment to be supplied under this Section, the Contractor shall deliver to the designated Resident Engineer for approval, the following:
1. Drawings of the proposed equipment modules and test fixtures, including schematic diagrams, arrangement plans, assembly drawings, complete parts lists keyed to the drawings, ordering information, mounting details, internal and external wiring circuits and details, and mechanical and electrical component descriptions to the component level.
  2. The complete field test procedures for the installed and programmed system.
  3. An outline of the course to be provided for Authority class instruction.
  4. An outline of the organization of the system documentation which the Contractor plans to supply according to these Specifications.
  5. A Critical Path Diagram which lists all of the major milestones set forth in these Specifications and any additional milestones which the Contractor deems appropriate. The diagram shall show as a minimum, the number of elapsed working days from Notice-to-Proceed to the listed milestone. All required submittals shall be listed as milestones.

- D. The NVIP Testing documentation shall include, but not be limited to, the details of the interlocking to be simulated, test durations, test equipment and test procedures for the tests to be utilized in proving to the satisfaction of the designated Resident Engineer that the NVIP system to be supplied will meet all of the requirements of these Specifications.
- E. The factory test procedures for the assembled and programmed equipment modules for the applicable TCR locations shall be in conformance with the requirements specified in Section 16980, ATC Tests, Inspections and Quality Assurance. Approval of the procedures shall be obtained prior to manufacture of the modules. Manufacture without this approval shall be at the Contractor's risk. These test procedures include the testing of all operational aspects of each proposed system, including the Interlocking Control Panels specified in Section 16956. The procedures shall show that the factory tests will be made on the complete system with all of the racks interconnected and with a complete simulation of the field inputs and outputs.
- F. Factory Test Reports shall be as stipulated by the approved Factory Test Procedures. These reports shall be submitted to the designated Resident Engineer for approval as quickly as possible after the completion of the factory tests. These test reports shall bear the signature of the designated Resident Engineer's representative attesting to the witnessing of the test and its successful conclusion. There shall be a test report for each of the PC boards (including spares) comprising the first NVIP furnished under this Contract.
- G. For the Design Review of the equipment to be supplied under this Section, the Contractor shall submit to the designated Resident Engineer, for approval, the following
1. A listing of all inputs and outputs for each system with easily understood designations of their functions.
  2. A complete and detailed program printout of all software, including equivalent circuit drawings, for each NVIP. The program shall be modularized in a logical and easily understood manner. Programming shall be easily related to circuit equivalents. Each module of the program shall be easily related to the associated equivalent circuits and be fully documented with plain-English explanations of its purpose and the method by which it accomplished that task, the modules to which it is related, and the modules of which it is a part.
  3. A description of the program functions and details with flow charts, a programming manual and a key sheet which lists and defines all symbols, abbreviations and other aspects of the program. This shall be one of the first items submitted for review.
  4. A description of, and documentation for, the compiler.
  5. Full documentation for the class of instruction including a revised course outline, course instruction manual, list of course training aids, list of class facility requirements, and class schedule.
- H. The Contractor shall provide drawings of all internal equivalent circuits, and circuits external to the NVIP, which are necessary to accomplish the functions described by the Drawings and Specifications with the equipment he plans to provide under this Contract. These circuits shall be submitted as part of the Design Review. These circuits shall be complete and continuous from the point of origin to the point of destination. They shall show all interface terminal connections between the portions at various locations and between the various pieces of equipment. No conductor shall be ended or terminated without some note or reference as to its physical location or continuation at some other place. All buses (including ground buses) shall be fully detailed. Twisted pair wiring shall be shown where utilized.

## **PART 2 - PRODUCTS**

### **2.01 BASIC REQUIREMENTS**

- A. The NVIP equipment, circuitry and software logic furnished by the Contractor under this Contract shall perform all of the functions designated in paragraph 1.01 and the paragraphs of PART 2 of this Section.
- B. The NVIP equipment shall meet the physical and environmental requirements listed in these Specifications.

### **2.02 MECHANICAL REQUIREMENTS**

- A. The NVIP shall make use of plug-in circuit boards. Each board shall be labeled with its function, a means of application identification, a serial number, and a model or drawing number.
- B. The program of the NVIP shall reside in a Programmable Read Only Memory located on the processor board, or a separate "memory" board. The memory devices shall be erasable and reprogrammable. A separate plugcoupler dedicated to this function may be provided on the board at a readily accessible location. This plugcoupler shall provide for the connection of suitable programming test fixtures which shall be provided by the Contractor. As an alternative, the Contractor may provide sockets on the boards for the memory devices. In this case, each memory device shall have a complete and unique identification marking. The placement of the wrong memory device on a board shall be detected by the system and power shall be removed from the outputs.
- C. Electro-mechanical memories such as magnetic-media tape and disk drives shall not be used in the NVIP, except for programming and testing purposes.
- D. The printed circuit boards of the NVIP shall be housed in rigid frames containing a motherboard for the mounting of the printed circuit board receptacles. This motherboard may be either a printed circuit board or a hard-wired plane. The frame shall contain full-length board guides to assure that the plug-in contacts of each plug-in board correctly mate with the motherboard receptacle.
- E. Each plug-in location of the NVIP shall be labeled with the identity of the board type intended for that location.
- F. The Contractor shall provide some form of interlocking device to ensure that plug-in boards of the NVIP cannot be mechanically or electrically damaged by plugging them into an incorrect location.
- G. The board frame of the NVIP shall be constructed and mounted in a manner that allows the free movement of air over the equipment by convection to prevent local hot-spots which could degrade the assembled and mounted equipment and prevent it from meeting the physical environmental and reliability requirements in Section 16914.1.02. No fans or blowers will be permitted for these purposes.
- H. The printed circuit boards or the printed circuit board frame which houses the NVIP shall be provided with electromagnetic shielding, if necessary to allow the system to meet the electrical environmental requirements of these Specifications.

- I. The Contractor shall provide a dust-resistant cabinet to house the NVIP. This cabinet shall have dust-resistant doors or removable covers on both the front and back. The front shall be supplied with a safety glass or fire-resistant plastic panel which allows observation of the indicators which may be located on the front of the boards. This equipment shall be immune to the ambient dust accumulation. TCR dust consists mostly of residues of the train brake wear.
- J. This cabinet shall be of sufficient volume to allow the removal of heat from the boards by internal convection and the removal of heat from the cabinet by radiation and external convection. Fans shall not be employed in the heat removal process.
- K. At the time of the initial factory test of the NVIP, the printed circuit board frame shall be installed in this cabinet and the door or cover shall be in place.
- L. The Contractor shall provide compiler software maintenance for a period of 5 years.

### **2.03 ELECTRICAL REQUIREMENTS**

- A. The NVIP and its associated equipment shall be powered by conservatively rated power supplies or inverters provided as part of its support equipment. These supplies or inverters shall meet the electrical and environmental requirements of these Specifications. At the Contractor's option these supplies or inverters shall operate either from the 120 Vac line or the 28 Vdc local power system specified elsewhere in these Specifications. In either case, these supplies or inverters shall be equipped with sufficient transient protection to provide immunity from power line transients as high as six kilovolts (1.5/40 microsecond standard wave), i.e., six kilovolts maximum voltage rise in 1.5 microseconds and decay in 40 microseconds.
- B. The input and output signal connections of the NVIP shall be fully isolated from the power supply of the processor. This isolation shall be adequate to provide protection from the transient levels encountered in the installation. The Contractor shall be cognizant of the various sources of transient interference that may be encountered in the TCR such as those listed in Section 16914. It is the Contractor's responsibility to assess and provide protection from this interference.
- C. The NVIP output signal potential shall be 28 Vdc nominal and the outputs shall have an adequate and conservatively rated power capability suitable for each application.
- D. All NVIP inputs shall be provided with de-bounce circuitry so that momentary voltage changes at the time of initial external contact closure will be ignored.
- E. One or more ports shall be provided for the transfer of coded input and output information. These ports shall make maximum use of industry standard communications standards and protocol except as necessary to promote safety and security. These ports shall be for the purpose of system expansion, connection of test equipment and other such uses.
- F. All components of the NVIP shall be conservatively rated so that the system is capable of meeting the Microprocessor Mean Time-To-Restore requirements shown in the Technical Appendix of these Specifications.
- G. All printed circuit boards utilized in the NVIP shall have a properly applied conformal

coating to minimize the effects of moisture.

- H. All printed circuit boards utilized for inputs or outputs in the NVIP shall be designed so that there is minimal capacitive coupling between the circuitry on either side of the isolation devices. Consideration shall be given by the Contractor to the use of a grounded copper track between circuitry on either side of the isolation devices to further decrease the capacitive coupling which bypasses the isolation device.

## **2.04 ENVIRONMENTAL REQUIREMENTS**

- A. Physical
  - 1. The NVIP assembly shall work in the physical environment of the TCR. These environmental requirements are:
  - 2. Operating temperature range: -22 to +158 degrees F. (30 to +70 degrees C.)
  - 3. Operating humidity range: 5 to 95 R.H., non-condensing
  - 4. Vibration suppression: Shock mounted
  - 5. Cooling system: Radiant plus natural convection (no fans)
- B. Electrical
  - 1. The NVIP assembly shall work in the electrical environment of the TCR. The Contractor shall assess this environment, considering the factors stated in Section 16914.1.03 of these Specifications, and the characteristics of the equipment he is providing under this Contract. All inputs, outputs, power connections and communications lines, if any, shall be immune to the effects of lightning (except in the case of a direct stroke to the building which houses the NVIP) and to surges or transients to which they may be subjected. In addition, the equipment to be provided under the requirements of this Section shall conform to the following requirements:
    - a. Conducted and radiated radio frequency energy at all frequencies shall be attenuated to a level which will not interfere with the operation of a radio transceiver with a self-contained antenna operating at any normal communications frequency.
    - b. The operation of a radio transceiver, transmitting radio frequency energy at any normal communications frequency with ten (10) watts of power into an attached antenna, shall not cause malfunction of the microprocessor or the I/O devices. This and the previous requirement shall be met when the end of the antenna is within three inches of any external part of the NVIP equipment.
    - c. The NVIP shall operate without loss of continuity during power outages lasting as long as three times the transfer time of the automatic transfer switch approved and provided for this Contract.
    - d. The NVIP shall be immune to electrostatic discharges to all devices and surfaces exposed to human touch during operation or servicing.

## **2.05 PROGRAMMING REQUIREMENTS**

- A. The Contractor shall provide a means of programming and testing the NVIP system, initially and as any subsequent changes, improvements, and replacements may be required. This means shall take the form of a test fixture and, if necessary to operate a fixture, a program. Both the fixture and the program shall become the property of the Authority when the installation is accepted. See Section 16927, ATC Microprocessor Support Systems. The application software shall be written in Boolean expression (i.e.; \*, +, etc.).

- B. The Contractor shall exercise special care in the design of the program to select an order of processing which does not cause any unwanted or unsafe results.
- C. The Contractor shall provide a user-friendly software program to generate equivalent relay logic circuits for the NVIP logic systems. This program may be combined with a program to create equivalent circuits for the STAP Systems. See Section 16924, Non-Vital ATO & ATS Processor Systems.

## 2.06 DIAGNOSTICS

- A. Internal
  - 1. The Contractor shall provide the NVIP system with one or more Diagnostic Routines as outlined herein. The degree or refinement of such routines is at the discretion of the Contractor who is reminded that the diagnostics he furnished will be instrumental in meeting the time-to-restore requirements shown in the Technical Appendix (Section 16996). The minimum requirements follow, but the Contractor shall be alert for ways to extend these requirements in any way practicable to make the system more reliable and easier to maintain. The minimum diagnostic requirements are:
    - a. The Contractor shall provide one or more Diagnostic Routines which shall continuously monitor the operation of the NVIP and shall "remember" and indicate both on-going and intermittent failures until manually reset in the field. The diagnostic Routine(s) may be implemented in any way the Contractor selects, providing that the results meet the requirements of these Specifications and providing that the methodology meets with the approval of the designated Resident Engineer.
    - b. One output of each NVIP module shall operate a uniquely identified, slow-release relay, named (X) Non-Vital Interlocking Processor Check relay ((X) NVIPCHK), by means of recurring pulses which indicate that the processor module is correctly meeting the requirements of all of the internal diagnostic tests. These tests shall be designed to require the proper operation of as many of the NVIP facilities as possible. (The Contractor may employ some other means of obtaining the operation of this relay, but it must have the prior approval of the designated Resident Engineer.) The opening of the front contacts of any applicable NVIPCHK relay shall energize an associated red LED alarm light on the Track and Alarm Panel and open a circuit to the RTU. This RTU circuit shall also include series front contacts of the Interlocking Vital Processor AVPCHKR and BVPCHKR vital relays. (See Section 16928 and the Contract Drawings.) The opening of this circuit shall cause an indication to be received at Central Control called PROCESSOR FOR INTLKG PROBLEM. For an example see drawing G4b-ATC-I-051.
    - c. The Contractor shall provide diagnostic indicator lights (LEDs) on the visible edge of the printed circuit boards. One of these lights shall be provided to indicate a failure for each individual diagnostic routine, and one additional light shall be provided which shall be illuminated whenever energy is not being provided to the NVIP Check Relay.
  - 2. External
    - a. In addition to the internal diagnostic capability of the NVIP, the Contractor shall provide an external plug-in diagnostic device and associated software. This external device shall have some form of data

memory capability and a CRT display. The software for this device shall be user friendly and menu driven. The diagnostic result(s) shall be displayed on the CRT in English language; no special code or number will be allowed.

- B. The Diagnostic Routines (both Internal and External) shall be thoroughly documented in the maintenance manual provided by the Contractor and described elsewhere in this Section.

**2.07 SPARE REQUIREMENTS**

- A. See Section 16932, Spare ATC Equipment and Selectable Items.

**2.08 TEST FIXTURE REQUIREMENTS**

- B. The Contractor shall provide a complete Shop Test Station to test and maintain all PC boards of the NVIP System to the component level.
  - 1. This NVIP Shop Test Station shall include all VXI based computer controlled test equipment, interfacing devices for all of the various NVIP units to be tested, and associated test programs capable of providing stimulus and measurement facilities necessary to fully test and diagnose faults in the various NVIP units. Self test programs shall be included to diagnose faults in the interface devices.
  - 2. The Shop Test Station shall be capable of providing fault isolation in the NVIP printed circuit boards to the following Ambiguity Levels:
    - a. For Active Element Groups (AEGs)

<u>No. of AEGs</u>	<u>Percent of the Time</u>
One (1)	80
Three (3) or less	90
Five (5) or less	100

- b. For Components Not Part of an AEG

<u>No. of Components</u>	<u>Percent of the Time</u>
One (1)	80
Three (3) or less	90
Five (5) or less	100

- 3. The NVIP Shop Test Station shall consist of a VXI Test Set, Part No. 9803-10000 as manufactured by RJO Enterprises, Inc., Hunt Valley, MD, and associated test programs and interfacing devices for the units to be tested, unless otherwise directed by the designated Resident Engineer. See Specific ATC Test Device Item 13 in Section 16931.1.01 H.
- 4. Equipment for repair of printed circuit boards shall not be considered part of this requirement. See Section 16927.
- C. The Shop Test Station for NVIP PC boards shall include one of each type of working PCBs (e.g., CPU, I/O) used in the NVIP, and shall have the capability necessary to test all NVIP PCBs, including the NVIP CPU provided under this Contract.
- D. In addition to the Shop Test Station for NVIP PC Boards specified in Part 2.08 A., the Contractor shall provide two Non-Vital Interlocking System (Shop) Test Fixtures. Each of these test fixtures shall include all devices necessary or desirable to set-up, inspect, monitor, maintain or facilitate the repair of the NVIP System. This shall include test devices

capable of troubleshooting the NVIP System by means of step-by-step sequential diagnostic operation. These two NVIP System (Shop) Test Fixtures shall be considered to be Specific ATC Test Devices, as specified in Section 16931.1.01 H., Item 11.

- E. The Contractor shall provide a complete set of Test EPROMs for the NVIP functions.
- F. The Contractor shall not include as part of the equipment furnished for this requirement any instrument or test device duplicated in response to the requirements of other Sections of these ATC Specifications.

## **2.09 SUPPLY MATERIAL REQUIREMENTS**

- A. The Contractor shall provide, if necessary for the operation of Train Control equipment supplied under this Contract, paper, ribbon and any other consumable supplies sufficient for one year of operation. Unless the supplies are readily available, the name and address of the source of further supplies shall be furnished to the designated Resident Engineer as a separate document.

## **2.10 INSTRUCTION MANUAL REQUIREMENTS**

- A. The Contractor shall provide three types of Maintenance Manuals which cover, to the board level, all items of hardware and software included as part of the working system and the maintenance system of the NVIP.
- B. These manuals shall comply with the special requirements of this section and the general requirements of Section 16992, ATC Instruction Manuals.
- C. The first manual which the Contractor shall provide shall be an Operator's Training Manual which covers the operation of the emergency control panel. It shall be written for an educational level limited to the 12th grade only.
- D. The second manual which the Contractor shall provide shall be a Field Maintainer's Manual intended for the signal maintainer. This manual shall contain basic information about the applicable computer processor systems as follows:
  - 1. Complete Memory Map and I/O Map. Table of addresses and data necessary to access all parts of the system.
  - 2. Complete theory of circuit operation for both the operational systems and the test devices.
  - 3. Complete description of a method of trouble-shooting the processor system kernel (microprocessor, address decoding, ram, DMA, etc.,) to be used when the system kernel fails.
  - 4. A listing of waveforms frequencies, voltages and other appropriate measured conditions when taken with PC board(s) in reset at major outputs of circuits. (With all signal lines labeled.)
  - 5. Complete System parts list with IC data sheets for both the operational equipment and the test device(s).
  - 6. Description of a power-on, self test which will display error code(s) indicating which "part" has failed, e.g., rom check sum, DMA, timer, serial, PPI, etc.
  - 7. Description of a diagnostic test either burnt into the operational EPROM or accessible by exchanging the operational EPROMs with diagnostic EPROMs.
  - 8. A complete listing of the code for the operational EPROMs.
  - 9. A complete listing of the code for the test and diagnostic EPROMs.
- E. The Field Maintainer's Manual shall be written for instruction of Authority personnel with an

educational equivalent of 12th grade plus two years in a general electrical technical school. (The Contractor shall not consider two years in a computer programming school as being equivalent to two years of electrical technical school training).

- F. The Field Maintainer's Manual shall be clearly organized into two maintenance levels. They are:
  - 1. Level 1 - This level shall cover the detection of problems occurring in the field, TCR wiring, equipment modules and the input and output boards of the processor. This level is intended for the use of general maintenance personnel, and the manual shall so state.
  - 2. Level 2 - This level shall cover the detection and replacement of a malfunctioning board other than the input and output boards. It shall describe how this can be accomplished using the facilities of the Alarm Panel and the diagnostic routines. This level is intended for specially trained maintenance personnel and their supervisors and the manual shall so state.
- G. The third type of manual which the Contractor shall provide shall be the Engineer's Programming Manual. It shall consist of all the documentation provided by the programming system manufacturer and shall provide all information on the use of the equipment and the software provided with the system. This documentation is meant for engineers with experience in the design of signal and interlocking systems. Documentation describing the programming of the NVIP system shall be submitted to the Engineer for approval at least 45 days prior to the factory testing of the first NVIP system. Six copies of this manual shall be provided.
- H. Manuals which do not meet these requirements will not be approved.

## **PART 3 - EXECUTION**

### **3.01 DELIVERY, STORAGE AND HANDLING**

- A. The Contractor shall take whatever measures may be necessary to protect the NVIP modules from damage or marring during shipment, installation and testing and until the Authority accepts the system. If the equipment suffers any damage, from whatever cause, during this period, the Contractor shall replace or repair it to a like-new condition, to the satisfaction of the designated Resident Engineer at no additional cost to the Authority.

### **3.02 INSTALLATION**

- A. The Contractor shall install the NVIPs along with their associated vital relay interlocking circuitry, in appropriate TCRs or TCERs provided by the Authority for this purpose. The equipment shall be installed on equipment racks as required in these Specifications and as shown on the Contract Drawings.
- B. Each NVIP installed shall be complete with its program and all appliances necessary to provide the non-vital portion of a complete interlocking system which operates as required by these Specifications and is readily maintained.
- C. The NVIP shall be interconnected and tested with its DTS interface equipment and associated vital relay interlocking circuitry as required elsewhere in these Specifications and as shown on the Contract Drawings.

### **3.03 TESTING**

- A. The Contractor shall factory test each completed NVIP according to a test procedure which has been prepared in accordance with Section 16980 of these Specifications and approved by the designated Resident Engineer. Field conditions shall be simulated for this test. This test may be witnessed by the designated Resident Engineer. This test shall be successfully completed and the results approved by the designated Resident Engineer before the equipment is shipped from the factory to the job site.
- B. The Contractor shall field-test the installed NVIP according to a series of field tests described in these Specifications, prepared by the Contractor and approved by the designated Resident Engineer.
- C. The Contractor shall notify the designated Resident Engineer at least one week before the commencement of each of the specified factory and field tests unless otherwise directed by the designated Resident Engineer.
- D. At the conclusion of the testing of the NVIP, the Contractor shall deliver to the Authority three copies of the complete program documentation. The program shall be labeled at this time as Revision 1. Subsequent changes, if necessary, shall bear subsequent revision numbers.
- E. The final revised program shall be entered into the memories of the spare equipment installed in the working system. When approval of the test has been received, the Contractor shall install the regular equipment in the system and repeat the tests. This equipment shall then be left in the system.
- F. If, upon completion of the final field testing, any change in the program is deemed necessary by the Contractor, the designated Resident Engineer shall be informed, and with his approval, the change shall be made. When the change has been completed and the log book filled out, the Contractor shall repeat the cycle of testing described in the previous paragraph.

### **3.04 DOCUMENTATION**

- A. The Contractor shall produce the required test procedures, program listings, test reports, drawings and aperture cards at the times required by these Specifications, and keep the drawings up-to-date during installation.
- B. The Contractor shall produce the required maintenance manuals and training course submittals at the times required by these Specifications.
- C. The Contractor shall provide a Software Configuration Log-book which shall be utilized commencing with the approval of the design submittal and continuing until Final Acceptance of the installation. This book shall be used to register dated entries describing every change made to the program or equipment and the reason the change was made. It shall be written in a detailed, step-by-step narrative, and shall include cross-references to all program changes. Failure to provide and utilize this logbook will delay, and may prevent, the approval of all the test reports associated with the field testing of the processor. At final acceptance, this logbook shall become the property of and be delivered to the Authority.

### **3.05 TRAINING REQUIREMENTS**

- A. The Contractor shall provide two training courses, (described in B. and C. below) which shall be called, respectively, the Maintainer's Training Course for Interlockings, and the Engineer's Training Course for Interlockings. Training aids shall be liberally employed

where helpful to illustrate the devices and principles being described. Firmware such as flip charts, transparencies and slides shall become the property of the Authority at the conclusion of the section presentation of each course. The Contractor's instructor(s) shall cooperate with the Authority in the videotaping of the course presentations.

B. Maintainer's Training Course for Interlockings

1. The Contractor shall provide on the Authority's premises, for its signal maintenance personnel, four presentations of a course of classroom and hands-on instruction in the operation and maintenance of complete interlocking signal systems. This course shall include special emphasis on the NVIP system. The course shall be not less than 5 days nor more than 10 days in length. Each presentation of the course shall accommodate 12 persons designated by the Authority.
  - a. The first two presentations of this course shall occur consecutively during the final installation stages of the NVIPs. The third and fourth presentations shall be at later dates within one year from the date of the first two; the exact dates to be determined at the mutual consent of the Authority and the Contractor. These instruction courses shall be at no additional cost to the Authority.
  - b. This instruction shall be based on the Field Maintainer's Manual, described in Section 16992.2.10, paragraphs D., E., & F.
  - c. This instruction shall cover all aspects of operation and maintenance of the wayside and TCR equipment related to the NVIPs. It shall include but not be limited to the following:
    - 1) Vital and Non-Vital Functions of Interlockings
    - 2) Track Circuits
    - 3) AF Track Modules
    - 4) Microprocessors
    - 5) Microprocessor programming and changes
    - 6) Trouble shooting
    - 7) Diagnostic routines
    - 8) Maintenance procedures
    - 9) Preventative maintenance
    - 10) Interlocking Control Panel Operation
    - 11) NVIP Alarm Panel Operation
  - d. This course shall be designed for an educational level of 12th grade plus 2 years in a technical school.
  - e. This course shall include "hands-on" instruction for each participant in identifying and replacing defective boards through the use of the test fixtures provided by the Contractor. The Contractor shall supply, at no further cost to the Authority, a set of defective boards for use in this test. There shall be enough boards so that successive course participants are not bored by locating the same defective board.
  - f. This course may be combined with a similar course for the Interlocking Vital Processor Systems. See Section 16928.

C. Engineer's Training Course for Interlockings

1. The Contractor shall provide on the Authority's premises, for certain engineering personnel, one presentation of a course of classroom and hands-on instruction in the programming, maintenance, and reprogramming of the NVIP system to the board level. The course shall be not less than five days nor more than 10 days in length. The presentation of the course shall accommodate up to 12 persons designated by the Authority.
  - a. The presentation of this course shall occur during the final installation stages of the NVIPs and shall be made at no additional cost to the

- Authority.
- b. This instruction shall be based on the Engineer's Programming Manual described in Part 2.10 G.
  - c. This instruction shall cover all aspects of setup, programming, operation and maintenance of the NVIP equipment. It shall include, but not be limited to the following:
    - 1) Programming Techniques
    - 2) Compiling
    - 3) Setting and Erasing Memory Devices
    - 4) Locating Defective Board Components
    - 5) System Operation
    - 6) Reliability Consideration
    - 7) Trouble Shooting
    - 8) Diagnostic Routines
    - 9) Maintenance Procedures
  - 2. This course shall be designed for an educational level of 12th grade plus a Bachelor's Degree in Engineering or its equivalent.
  - 3. This course shall include "hands-on" instruction for each participant in programming, reprogramming and identifying and replacing defective board components through the use of the Contractor's test fixtures (made available by the Contractor at no additional cost to the Authority), and the NVIP unit(s) provided to the Authority by the Contractor for training purposes. The Contractor shall supply, at no additional cost to the Authority, a set of boards with various defective components for use in this test.
- D. These training courses shall be organized in accordance with the requirements of this Section and Section 16993, ATC Training Courses.

### **3.06 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. No separate payment will be made for NVIPs as such. The cost of the NVIPs shall be included in the ATC Design Engineering, Material & Fabrication, and Installation costs for this Contract. The NVIPs will be measured for partial payments based upon the number of complete NVIP systems required by these Specifications which are delivered, installed, field tested, documented and approved.
- B. For purposes of measurement for partial payments, the NVIP systems shall include all mounting hardware inter-connecting wiring, and NVIP Test Fixtures.
- C. The following conditions will be considered when measuring the NVIPs for partial payments:
  - 1. Delivery by the Contractor of the NVIPs, provided approval has been given of their Factory Test Reports.
  - 2. Installation of the NVIPs and all interconnecting wiring by the Contractor, provided approval of the installation has been given by the designated Resident Engineer.
  - 3. Level "A" or Level "B" partial system acceptance of the location involved.
  - 4. Delivery by the Contractor of the approved NVIP as-built drawings, aperture cards and program listings.
  - 5. Approval by the designated Resident Engineer and receipt by the Authority of the Maintenance Manuals.
  - 6. Approval by the designated Resident Engineer of the documentation for: the NVIPs; the NVIP Test Fixtures; the various NVIP-related Training courses; and for the satisfactory completion of the various NVIP Training Course presentations.
  - 7. Delivery of the NVIP test fixtures and final acceptance of these devices by the Authority.

- D. The Shop Test Station for NVIP PCBs and the System (Shop) Test Fixtures for the Non-Vital Interlocking Processor Systems will be measured for payment as specified in Section 16931.3.02 C.

**END OF SECTION**

## SECTION 16927

### ATC MICROPROCESSOR SUPPORT SYSTEMS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing, installation, testing and documentation of microprocessor-based service systems to support the programming, maintenance and modifications for all ATC microprocessor systems provided by the Contractor under this Contract. These service systems are referred to as Microprocessor Support Systems (or more simply as MPS Systems), and Drawing Editor Systems.

##### 1.02 DESCRIPTION

- A. The MPS Systems shall be designed to be used with the required Training Courses to develop the Authority's engineering familiarity with the operating microprocessor system(s) provided under this Contract.
- B. Each of the MPS Systems shall include all of the equipment, fixtures, software and instructional information necessary to program, reprogram and maintain all of the microprocessor systems provided under this Contract.
- C. Provide six complete desktop type Microprocessor Support Systems: three for WMATA Design Engineering and three for WMATA Operations Engineering.
- D. Provide two portable Microprocessor Support Systems: one for WMATA Design Engineering, and one for WMATA Operations Engineering. Each of these portable MPSs shall be of the highest speed and maximum RAM commercially available, and shall include a 1.44 MB 3-1/2" internal Read/Write Floppy Drive, CD ROM drive with communication printer and USB port, modem, PROM Burner, an additional battery, and a carrying case.
- E. The Contractor shall provide two complete Drawing Editor Systems, one for WMATA Design Engineering, and one for WMATA Operations Engineering.

##### 1.03 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16911 Scope of ATC Work
  - 2. Section 16918 Special ATC Requirements for Specific Locations
  - 3. Section 16924 Non-Vital ATO & ATS Processor Systems
  - 4. Section 16926 Microprocessor Systems for Non-Vital Interlocking Functions
  - 5. Section 16928 Interlocking Vital Processor Systems
  - 6. Section 16992 ATC Instruction Manuals
  - 7. Section 16993 ATC Training Courses

##### 1.04 MPS SYSTEM DESIGN

- A. Each desktop MPS system shall consist of an IBM-type microprocessor complete with the programs and all necessary peripherals to analyze, program and reprogram the memory devices used with all the various microprocessor systems furnished as part of the ATC systems provided under this Contract. With the MPS System it shall be possible to program the various microprocessor systems from their relay circuits or from the Boolean equivalents

thereof. The process shall be "user friendly" and easily understood from reading the Instruction Manuals furnished by the Contractor with the respective operating microprocessor systems. (See Sections 16924, 16926, and 16928.)

- B. The Contractor shall provide, as part of each MPS System, a simulator program for each type of operating microprocessor-based system to be provided under this Contract. The simulator program(s) shall check the results of the individual system programming effort. These simulators shall be adequate to locate and identify logic errors in the "circuit" designs entered into the individual operating microprocessor system programs. The simulator program(s) shall also be "user friendly" and easily understood from reading the Instruction Manual for the applicable associated operating microprocessor system.
- C. The Contractor shall provide, as part of each MPS System, software programs that can generate equivalent, relay-style circuits represented by applicable WMATA nomenclature, from program logic provided under this Contract.
- D. Each MPS System shall be a complete system in itself, but the Contractor shall include all cables, connections and interface facilities necessary to allow the MPS System to be used in conjunction with the System Test Fixtures for all the related operating microprocessor systems provided under this Contract, at no additional cost to the Authority.

## **PART 2 - PRODUCTS**

### **2.01 EQUIPMENT AND SOFTWARE**

- A. The Microprocessor Support Systems shall be COMPAQ or DELL, with Intel processor, unless otherwise specified. All MPS equipment shall be of the latest generation, highest speed, and maximum capacity commercially available, at the time of delivery, unless otherwise directed by the designated Resident Engineer.
- B. Equipment for each MPS System shall include Universal EPROM burners with all available accessories to reprogram the various microprocessor systems provided under this Contract as well as the Authority's existing microprocessor systems.
- C. Each of the six MPS Systems to be provided shall include, in addition to items previously specified, the following new equipment and software or approved equal:
  - 1. Hardware
    - a. Latest generation with highest available clock cycle Intel Processor, minimum 2-level Cache of maximum size, minimum 100 Hz I/O Bus, and appropriate Power Supply in full Tower Case, with:
      - 1) Maximum RAM Memory offered by the manufacturer.
      - 2) Maximum capacity available Hard Drive with integrated PCI ULTRA-Fast-SCSI-2 or latest generation state-of-the-art Controller. (8 ms or better access time and 160 MB/sec minimum transfer rate). Mandatory partitioning of the disk will be indicated to the Contractor for implementation prior to delivery.
      - 3) Latest generation Video Graphics Card with maximum size WRAM with Graphic Accelerator.
      - 4) 17.3" diagonal, Low Emissions, 1600x1024 pixels at 60 Hz. 110 dpi (minimum resolution) Non-Interlaced, thin film transistor (TFT) active-matrix liquid crystal display (AMCLD) flat panel, digitally controlled, minimum 75 MHz refresh rate, 0.23 mm Dot Pitch Color Multiple Scan, Non-glare and Anti-Static screen monitor, for local bus system.
      - 5) 1.44 MB 3-1/2" internal Read/Write Floppy Drive with 720 MB

- Capability.
- 6) Latest generation with highest speed and transfer rate internal minimum 650 MB SCSI Read/Write CD Drive (with not to exceed 195 ms access time) capable of reading standard CD formats and read/write 650 MB re-writeable disc
  - 7) Latest generation internal DVD Drive.
  - 8) Latest generation with highest speed and transfer rate with minimum available access time, read only minimum 3 CD changer drive.
  - 9) Latest generation internal digital video disk player.
  - 10) 3-Button Mouse, Microsoft or compatible.
  - 11) Latest generation Windows compatible Keyboard.
  - 12) Latest generation business digital Audio Card (Sound Blaster or compatible) with necessary number of high quality, 55 watt, Base, Treble and Volume individually controllable, with surround sound speakers.
  - 13) Latest generation AWE 32 w/ASP chip set Internal SCSI, minimum 25 percent of Hard Drive capacity Tape Backup.
  - 14) Latest generation with highest speed V.42bis Internal Voice/Data/Fax Modem.
  - 15) Digital Video Camera port and additional two parallel and minimum four Comm. serial ports, four USB ports, fully equipped for Plotter, Scanner and PROM Burner connections.
  - 16) IBM Token Ring 16 mbps PCI Network Card.
  - 17) Latest generation HP Laser Jet Printer with minimum 600x600 DPI resolution, maximum internal memory, and applicable drivers, and optional accessories, such as software selectable dual paper trays, envelope feeder and straight through paper paths with complete mechanism.
  - 18) DOS/WINDOWS/OS2 Software Drivers for above mentioned equipments.
  - 19) Electronic A/B/C/D Switch and applicable equipment to connect furnished PROM burners.
  - 20) Latest generation HP ScanJet Scanner with paper feeder and optional accessories, such as OMNI Page Pro software and other drivers, or compatible full page, with complete mechanism.
  - 21) Latest generation 3½" Laser Stereo Diskette Drive with 720 KB, 1.44 MB and 120 MB Read/Write capability.
  - 22) Highest capacity, Min. 200MB Zip Drive.
  - 23) Latest generation Digitab with interface cursor and ACAD template compatible with AUTOCAD supplied.

2. Software:

- a. Software, with complete set of Manuals, for each Microprocessor Support System as follows:
  - 1) Latest version of MS-DOS (Minimum 6.2).
  - 2) Latest version of MS Windows for the desktops and portables.
  - 3) Latest version of MS Windows for the servers.
  - 4) Latest version of MS Windows compatible Sound System, with voice recognition and microphone.
  - 5) Latest version of PROCOMM PLUS for Windows.
  - 6) Latest version of Norton SYSTEMS WORKS.
  - 7) Latest version of DELRINA WINFAX Pro for Windows.
  - 8) Latest version of AUTOCAD and AUTOCAD Support software and Libraries for Electrical and Electronic design.
  - 9) AUTOCAD Lite software which is compatible with above AUTOCAD and other generic CAD systems.

- 10) Language Compiler compatible with Contractor's development software and Block Design software.
  - 11) Latest version of Corel Office Professional.
  - 12) Latest version of Corel Draw.
  - 13) Latest version of MS Office Pro for Windows.
  - 14) Latest version of MS Project Manager.
  - 15) Software Drivers for Drawing Editor Systems to be provided under this Contract.
  - 16) A state-of-the-art Boot Manager (e.g., "System Commander") capable of running multiple operating systems, selectable during boot time.
  - 17) All software shall be installed on site and debugged by the Contractor, with proper Hard Drive partitioning appropriate for DOS, Windows, OS/2 Boot Manager, OS/2, and DATA. All software shall be delivered in both diskette and CD ROM media, when available.
3. Magnetic Media
- a. The following items shall be furnished for each micro-processor system (8 sets total):
    - 1) 12 Back-up tape cassettes compatible with supplied tape back-up units.
    - 2) 50 Re-writeable disks for above CD Drive.
    - 3) 12 LS-120 Diskettes.
    - 4) 12 Zip Disks
- D. Drawing Editor Systems
1. The Contractor shall provide two complete ATC Drawing Editor Systems (Cadcam Computer Systems).
  2. Each Drawing Editor System shall include all items specified for an MPS system, with the following exception:
    - a. The monitor for the Drawing Editor System shall be 21 inch instead of 19 inch.
  3. Each Drawing Editor System shall also include the following:
    - a. Latest generation HP Color Design Jet Plotter (complete with paper roll holder stand and automatic paper cutter), with automatic switch and necessary cabling to provide remote access from up to six MPS Systems in addition to access from the Drawing Editor System.
  4. Latest generation HP Laser Color Printer with all optional accessories including , but not limited to, software selectable multiple paper trays (letter, legal, and 11"x17"), straight through paper paths and applicable drivers.
  5. One complete set of high quality computer furniture to house and store the equipment of the Drawing Editor System, and a swivel chair for the operator.

## **PART 3 - EXECUTION**

### **3.01 DELIVERY, STORAGE AND HANDLING**

- A. The Contractor shall deliver the equipment and software for the desktop and portable Microprocessor Support Systems, and the equipment, software and furniture for the Drawing Editor Systems, to the locations designated by the designated Resident Engineer approximately 30 calendar days prior to the ORD.
- B. The Contractor shall take whatever measures may be necessary to protect the MPS System equipment and furniture from damage or marring during shipment, installation and testing, and until the Authority accepts the systems. If the equipment or furniture suffers any damage, from whatever cause, during this period, the Contractor shall replace or repair it to

a like-new condition, to the satisfaction of the designated Resident Engineer, at no additional cost to the Authority.

### **3.02 INSTALLATION**

- A. The Contractor shall unpack all MPS and Drawing Editor System hardware and software, and set up and properly interconnect the various pieces of equipment comprising the MPS Systems and Drawing Editor Systems, and install all applicable software at the location(s) designated by the designated Resident Engineer.
- B. The Contractor shall arrange the System equipment and furniture in accordance with layouts previously approved by the designated Resident Engineer.

### **3.03 TESTING**

- A. The Contractor shall perform all initial testing of the various components of the MPS Systems and Drawing Editor Systems as recommended by the equipment manufacturers.
- B. The Contractor shall design, document and perform all other tests of the MPS Systems and Drawing Editor Systems which may be necessary to ensure proper operation of the Systems.

### **3.04 MAINTENANCE**

- A. Maintenance of the Microprocessor Support Systems and the Drawing Editor Systems shall be provided by the Contractor for the duration of the Contract, and for three years following formal acceptance of the Systems by the Authority.

### **3.05 INSTRUCTION AND TRAINING**

- A. The Contractor shall include training and instruction for the operation of the Microprocessor Support Systems and the Drawing Editor Systems in the training and instruction manuals and Training Courses required for the microprocessor-based systems included in this Contract. See Section 16924, Non-Vital ATO & ATS Processor Systems; Section 16926, Microprocessor Systems for Non-Vital Interlocking Functions, and; Section 16928, Interlocking Vital Processor Systems.

### **3.06 ACCEPTANCE**

- A. The MPS Systems and Drawing Editor Systems will not be formally accepted by the Authority until all of the following have been completed by the Contractor in a manner acceptable to the designated Resident Engineer:
  - 1. Delivery by the Contractor of all of the System hardware (and any applicable furniture) to the site designated by the designated Resident Engineer.
  - 2. Complete installation of the System and all interconnecting wiring by the Contractor, provided prior approval of the proposed installation layout has been given by the designated Resident Engineer.
  - 3. Delivery and on-site installation by the Contractor of the approved software and program listings for the System, and successful on-site testing of all required programs by the Contractor.
  - 4. Receipt by the Authority and approval by the designated Resident Engineer of the Instruction Manuals specified for the applicable type of System provided under this Contract.
  - 5. Approval by the designated Resident Engineer of the documentation for the applicable related classes of instruction and the satisfactory presentation of the applicable classes.

### **3.07 MEASUREMENT AND PARTIAL PAYMENTS**

- A. Payment for desktop and portable Microprocessor Support Systems, and Drawing Editor Systems will be based upon a unit price for each as specified in the CPM Price Schedule.
- B. The factors which will be considered when measuring an MPS System or Drawing Editor System for partial payments are those listed in Part 3.06, ACCEPTANCE.
- C. Partial Payments for desktop and portable Microprocessor Support Systems, and Drawing Editor Systems will be made as follows:
  - 1. Upon delivery of all individual System hardware and (if applicable) furniture to the designated site 15% of CPM Unit Price
  - 2. Upon installation and interconnection of each individual system by the Contractor 15% of CPM Unit Price
  - 3. Upon delivery, installation and satisfactory testing of all required software programs for the individual System 40% of CPM Unit Price
  - 4. Upon receipt by the Authority and approval by the designated Resident Engineer of the applicable related Instruction Manuals or the individual System 10% of CPM Unit Price
  - 5. Upon receipt by the Authority and approval by the designated Resident Engineer of the Documentation for the applicable related classes of instruction and the satisfactory presentation of the applicable classes 10% of CPM Unit Price
  - 6. Upon approval and formal acceptance of each individual System by the Authority 10% of CPM Unit Price

### **3.08 DISPOSITION**

- A. The equipment and software of the Microprocessor Support Systems and Drawing Editor Systems shall become the property of the Authority upon delivery to the Authority and formal acceptance of the Systems by the designated Resident Engineer.

**END OF SECTION**

## SECTION 16928

### ATC - INTERLOCKING VITAL PROCESSOR SYSTEMS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing and installation of systems of equipment modules, each of which constitutes a fail-safe, microprocessor-based, redundant controller with the capability of performing safely certain vital functions involved in the control of a vital interlocking. This controller system shall be referred to herein as an Interlocking Vital Processor (IVP) system, and shall contain two complete Vital Processor-I/O Systems configured as specified in Part 2 of this Section.

##### 1.02 DESCRIPTION

- A. Vital interlocking functions shall be performed electronically by the IVP Systems using logic equivalent to that shown on the Contract Drawings unless otherwise specified in this Section.
- B. The area of the WMATA right-of-way controlled by each IVP System shall be limited to one interlocking. The area influenced by the performance of the IVP shall be limited to an interlocking and the adjacent mainline area, but only to the distance that a "stop" aspect of that interlocking signal has an effect.
- C. It is recognized that a manufacturer of an Interlocking Vital Processor System may supply separate subsystems (each possibly consisting of more than one processor module) for "vital" and "non-vital" processing. This is acceptable under these Specifications. Alternatively a manufacturer may utilize two or more processors for the combined processing of both the "vital" and "non-vital" tasks. The non-vital functions shall be as specified in Section 16926, Microprocessor Systems for Non-Vital Interlocking Functions. Functions or equipment of the non-vital processor (or portions of a processor) shall not interfere with the safe operation of the Interlocking Vital Processor System (or portions of such a system).
- D. It is the intent of this Section that the Contractor shall provide one complete, safe, fully operational Interlocking Vital Processor System for each of the (*how many*) new interlockings included in the area of this Contract (as delineated in Section 16911, Scope of ATC Work, and Section 16918, Special ATC Requirements for Specific Locations, and one additional IVP system for use at the WMATA training facility.
- E. In the design of the logic for the IVP the Contractor shall comply with the requirements of Section 16917, Basic Interlocking Requirements, and to the logic design inherent in the relay-type Circuit Drawings included in these Specifications. In the design and fabrication of the IVP Systems, the Contractor shall comply with the requirements of all applicable Sections included in these Specifications except as necessary to accommodate the IVP Systems in a manner approved by the Designated Resident Engineer.
- F. The Contractor shall provide separate vital I/Os for the redundant vital, fail-safe processor units comprising each Interlocking Vital Processor System for all of the applicable circuits classified as "Vital" in Section 16916, Basic ATC Circuit Requirements. Non-vital processing, and non-vital inputs and outputs may be utilized for those circuits classified as "Non-vital" in Section 16916.
- G. The Contractor shall implement the circuits which are listed in Section 16916.1.05.B as being composed of both "Vital" and "Non-Vital" circuit components in a manner approved by the designated Resident Engineer.

- H. The Contractor shall interface the IVP System processors to the local Interlocking Control Panel (or Panels), Remote Terminal Unit and, where applicable, to the Wayside Pushbuttons, providing non-vital inputs and outputs for interconnection to the indicators and manual controls thereon.
- I. The Interlocking Vital Processor System shall be capable of performing non-vital interlocking tasks and functions within the geographical interlocking area specified in Part 1.02 C. above, and may replace non-vital relays and timers utilized in performing those interlocking tasks. See Section 16926.
- J. Each Interlocking Vital Processor System shall be configured, and function, as specified in Part 2.01, General Requirements, and as indicated on the Contract Drawings.
- K. The Contractor shall provide training courses for personnel maintaining the IVPs. The courses shall be in accordance with the requirements of this Section and Section 16993, ATC Training Courses.
- L. The intent of this Section is that the Contractor shall provide complete, fail-safe, redundant, vital processor systems, configured as specified herein, which operate to control interlocking areas of the WMATA METRO RAIL System in complete harmony with the current WMATA ATC System and all of its sub-systems.

**1.03 RELATED SECTIONS**

- A. Related work specified elsewhere shall include, but not be limited to:
  - 1. Section 16904 Current Automatic Train Control System
  - 2. Section 16911 Scope of ATC Work
  - 3. Section 16914 Environmental Requirements
  - 4. Section 16915 Basic ATC Equipment Requirements
  - 5. Section 16916 Basic ATC Circuit Requirements
  - 6. Section 16917 Basic Interlocking Requirements
  - 7. Section 16918 Special ATC Requirements for Specific Locations
  - 8. Section 16926 Microprocessor Systems for Non-Vital Interlocking Functions
  - 9. Section 16927 ATC Microprocessor Support Systems
  - 10. Section 16941 Basic ATC Electrical and Electronic Component Requirements
  - 11. Section 16942 Printed Circuit Cards
  - 12. Section 16945 Plugboards and Cabinets for Relays and PC Cards
  - 13. Section 16948 Plug Connectors
  - 14. Section 16949 Signal Wire and Cable
  - 15. Section 16955 Track and Alarm Indication Panels
  - 16. Section 16956 Interlocking Control Panels
  - 17. Section 16961 Audio Frequency Track and Loop Circuit Layouts
  - 18. Section 16971 Racks and Cable Trays
  - 19. Section 16977 Tagging and Marking
  - 20. Section 16980 ATC Tests, Inspections and Quality Assurance
  - 21. Section 16992 ATC Instruction Manuals
  - 22. Section 16993 ATC Training Courses

**1.03 QUALITY ASSURANCE**

- A. All of the IVP modules and the software programs which are to be installed under this Contract shall be factory tested as a complete system in accordance with a factory test procedure which has been furnished by the Contractor and approved by the designated

Resident Engineer. This procedure shall be generated by the Contractor in accordance with the guidelines set forth in another part of this Section. Factory testing shall not commence until this procedure has been approved by the designated Resident Engineer.

- B. The Contractor shall record the results of these tests on the specified Factory Test Report forms. Items for which Factory Test Reports have not been approved by the designated Resident Engineer, may be shipped to the job site only at the Contractor's risk.
- C. Each item of equipment shall be inspected by the Contractor immediately prior to installation and only those items which have suffered no damage during shipment and subsequent handling shall be installed.
- D. All of the IVP modules and their software programs which have been installed under this Contract shall be field tested after installation in accordance with a field test procedure. This procedure shall be generated by the Contractor in accordance with the guidelines set forth in another part of this Section. Field testing shall not commence until this procedure has been approved by the designated Resident Engineer.
- E. The Contractor shall provide and maintain up-to-date, a diary or log containing a detailed write-up of any and all changes made to the system hardware and software from the time of their approval by the designated Resident Engineer until final acceptance by the Authority, at which time the log shall be delivered to the designated Resident Engineer. This record shall conform to the requirements more fully described in the documentation section of Part 3 of this Section.
- F. The Contractor shall provide Operation and Maintenance Manuals for the IVP Systems. These manuals shall be prepared during the initial phases of the Contract so that they may be approved and delivered to the Authority before field testing commences. These manuals shall be prepared according to guidelines set forth in another part of this Section and in Section 16992 of these Specifications.
- G. The Contractor shall provide "Type Acceptance Testing" for the IVP Vital Processor modules. This Type Acceptance Testing shall be performed at the manufacturer's factory. The testing may be under the surveillance of the designated Resident Engineer and shall be thoroughly documented.
- H. The Type Acceptance Testing shall include, but not be limited to, the following tests:
  - 1. For the VP, complete with I-O Interface
    - a. Full temperature sequence
    - b. Full humidity sequence
    - c. Full vibratory sequence
    - d. Full power voltage variation
    - e. Electrical transient withstand (all external connections)
    - f. Proof of validity and accuracy of the executive or control software, and proof of the vitality of its execution
    - g. Artificial fault simulation of hardware and software (glitch) failures
    - h. Intentional clock frequency variation (plus and minus)
    - i. Broad-band radio frequency interference-output and withstand
    - j. Proof of diagnostic operation.
- I. The factory test for the system, complete with all TCR equipment shall include:
  - 1. All field tests which can be performed in the factory.
  - 2. Train movement simulations (all routes).

#### **1.04 SUBMITTALS**

- A. Furnish within 60 calendar days of receipt of Notice-to-Proceed a submittal consisting of the following four explanatory items. These explanations shall be fully detailed and in plain English. Simple diagrams may be used for clarity. All such diagrams shall be fully explained. A glossary of definitions shall be included to thoroughly define any absolutely necessary technical or unusual words; otherwise, such words shall not be used. Buzzwords, slang, computer jargon and telegraphic writing style shall not be used. The explanatory items are:
1. Explain the method by which vital interlocking safety is ensured in the system which he intends to provide for this Contract. With this explanation, the Contractor shall explain his understanding of the word "vital," and his method of quantifying the hazard rate.
  2. Present a detailed explanation of the method by which he intends to implement the diagnostic requirements of these Specifications. This explanation shall describe the techniques or schemes to be utilized to verify the correct operation of every step of every process included in the information processing.
  3. Present a general explanation of the method by which the maintenance requirements of these Specifications are to be implemented. This explanation shall describe the features of the proposed maintenance program and the test equipment to be supplied for use with the maintenance procedures.
  4. Describe in detail the provisions he has made for repairing the printed circuit boards which are part of the VP modules. This description shall address the following items:
    - a. The period of time for which the Contractor will provide board service.
    - b. What the Contractor plans to do with respect to board services when this time period expires.
    - c. Which boards or devices will be kept in stock at the Contractor's factory and for how long.
    - d. The guaranteed maximum factory turn-around time from receipt of request for new or replacement board or device to shipment of same.
    - e. The Contractor's board replacement policy.
    - f. Whether replacement boards are new or repaired.
    - g. Whether replacement boards would be from Authority returned boards or a general stock.
    - h. The present cost of replacement for each board type.
- B. The preceding four sub-sections of the Contractor's submittal shall provide all of the information necessary to enable the designated Resident Engineer to make a safety and reliability assessment. The Contractor shall assume that the designated Resident Engineer is familiar with basic computer terminology, but that he is not a programmer. The designated Resident Engineer will determine whether or not the equipment which the Contractor intends to supply for the Interlocking Vital Processor System appears to be capable of failing only in a safe mode and whether the diagnostics appear to be capable of detecting these failures. The results of the designated Resident Engineer's evaluation will be used as part of the design review. The outcome of this review shall be in no way construed as lessening the successful bidder's responsibility to provide a safe system.
- C. Submit to the Authority for review documentation for all equipment to be furnished under this Section. The Contractor shall not ship any IVP [TCVP] equipment, except at his own risk, until the review has been completed and the equipment approved. The Authority also recommends that the Contractor not manufacture equipment for this Contract which may not be approved. Therefore, prior to component purchase, or fabrication of the equipment to be supplied under this Section, the Contractor shall deliver to the designated Resident Engineer for approval, the following:
1. Drawings of the proposed equipment modules and test fixtures, including schematic diagrams, arrangement plans, assembly drawings, complete parts lists keyed to the drawings, ordering information, mounting details, internal and external wiring circuits and details, and mechanical and electrical component descriptions to the component level.

2. A detailed fault-tree analysis of the IVP system and its equipment.
  3. The complete field test procedures for the installed and programmed system.
  4. An outline of the course(s) to be provided for Authority class instruction.
  5. An outline of the organization of the system documentation which the Contractor plans to supply according to these Specifications.
  6. A Critical Path Diagram, as required in Section 2 of these Specifications, which lists all of the major milestones set forth in this Section and any additional milestones which the Contractor deems appropriate. The diagram shall show, as a minimum, the number of elapsed working days from Notice-to-Proceed to the listed milestone. All required submittals shall be listed as milestones.
- D. The Type Acceptance Testing documentation shall include, but not be limited to, the details of the interlocking to be simulated, test duration, test equipment and test procedures for the tests to be utilized in proving, to the satisfaction of the designated Resident Engineer, that the Vital Processor and the related system to be supplied will meet all of the requirements of these Specifications.
- E. The Factory Test Procedures for the assembled and programmed equipment modules for the applicable TCR locations shall be in conformance with the requirements specified in Section 16980, ATC Tests, Inspections and Quality Assurance. Approval of the procedures shall be obtained prior to manufacture of the modules. Manufacture without this approval shall be at the Contractor's risk. These test procedures include the testing of all operational aspects of each proposed system, including the emergency Interlocking Control Panels specified in Section 16956. The procedures shall show that the factory tests will be made on the complete system with all of the racks interconnected and with a complete simulation of the field inputs and outputs.
- F. The Factory Test Reports shall be as stipulated by the approved Factory Test Procedures. These reports shall be submitted to the designated Resident Engineer for approval as quickly as possible after the completion of the factory tests. These test reports shall bear the signature of the designated Resident Engineer's representative attesting to the witnessing of the test and its successful conclusion. There shall be a test report for each of the boards (including spares) comprising the VP furnished under this Contract for initial type acceptance testing.
- G. For the Design Review of the equipment to be supplied under this Section, the Contractor shall submit to the designated Resident Engineer, for approval, the following:
1. A listing of all inputs and outputs for each system with easily understood designations of their functions.
  2. A complete and detailed program printout of all software for each IVP System. The program shall be modularized in a logical and easily understood manner. Each module of the program shall be fully documented with plain-English explanations of its purpose and the method by which it accomplishes that task, the modules to which it is related, and the modules of which it is a part.
  3. A description of the program functions and details with flow charts, a programming manual and a key sheet which lists and defines all symbols, abbreviations and other aspects of the program. This shall be one of the first items submitted for review.
  4. A description of, and documentation for, the compiler.
  5. Full documentation for the class of instruction including a revised course outline, course instruction manual, list of course training aids, list of class facility requirements, and class schedule.
- H. Revise the circuits of the Contract Drawings as necessary to show the circuitry external to the VP necessary to accomplish the functions described by the Drawings and Specifications with the VP equipment he plans to provide under this Contract. These revised circuits shall be submitted as part of the Design Review. These circuits shall be complete and continuous

from the point of origin to the point of destination. They shall show all interface terminal connections between the portions at various locations and between the various pieces of equipment. No conductor shall be ended or terminated without some note or reference as to its physical location and specific continuation at some other place. All buses (including ground buses) shall be fully detailed. Twisted pair and shielded wiring shall be identified where utilized.

## PART 2 - PRODUCTS

### 2.01 GENERAL REQUIREMENTS

- A. The IVP System equipment shall meet all of the basic, special and environmental requirements listed in these Specifications.
- B. All application software programs shall be the equivalent of the existing WMATA relay logic.
- C. All application software source code shall be delineated in Boolean expressions.
- D. Each Interlocking Vital Processor System shall consist of two independent, virtually identical Vital Processor - I/O Systems, "A" and "B." Each of the two VP-I/O Systems composing an IVP System shall be capable of performing all of the specified vital interlocking functions for the interlocking controlled by that IVP. One of the VP-I/O Systems shall be "on-line," i.e., its outputs shall be connected (interfaced) to the Automatic Train Protection (ATP) system equipment, while the other VP-I/O System shall be running in "hot-standby" mode, i.e., with its outputs isolated from the ATP System, but ready to go "on-line" immediately and automatically if the other VP-I/O System fails or is removed. The VP-I/O System which is "on-line" shall drive a vital indication relay ("AVPOLR" or "BVPOLR") which shall in turn generate an applicable "PROCESSOR A FOR **INTLKG** ONLINE" or "PROCESSOR B FOR **INTLKG** ONLINE" indication to Central and to the local Track and Alarm Panel. (See the Contract Drawings.)
- E. Each VP-I/O System shall have an Executive (Diagnostic) Routine to monitor its own inputs, outputs and internal operations. Each of these Executive Routines ("A" and "B") shall drive its own Vital Check relay (AVPCHKR and BVPCHKR respectively), so long as no I/O errors or internal failures are detected. Each of these interfacing relays shall generate its applicable local "FAILURE" indication when deenergized. When the "on-line" VP System recognizes a problem, a failure, the IVP System shall immediately (if possible) transfer control to the other (hot-standby) VP System and remove the "problem" VP System from on-line status in such a manner that no problem is caused for the new on-line VP System or for the ATP System.
- F. If the "standby" VP-I/O System is also in a failure mode, or has been removed from service when the operating VP-I/O System experiences an internal failure, the IVP System shall immediately cancel all cleared routes and signals through its applicable interlocking.
- G. Each independent Vital Processor - I/O system in the Interlocking Vital Processor System shall be capable of being isolated and physically removed from its normal mounting in the TCR (for troubleshooting and maintenance purposes), without disturbing the continued normal operation of the other VP-I/O System, i.e., the on-line processor. When both VP-I/O Systems are in place and operating properly, it shall be possible to manually cause the IVP System to switch from one "on-line" VP System to the other.
- H. Each VP-I/O System shall include diagnostic systems as specified in part 2.05 of this Section.
- I. Track circuits shall not be operated or disabled by the IVP systems.

- J. The speed selection circuits for the applicable area of trackage shall be included in the IVP systems, but no speed commands shall be generated by the IVP System.
- K. Vital relays shall be used to interface vital control and indication circuits between the Train Control Room and the trackside equipment.
- L. All internally generated vital variables developed by the vital application logic shall be made available as output bits for future troubleshooting aids. Their status and identity shall be made distinguishable by specially identified LED indicators mounted on the applicable VP logic modules.

## **2.02 MECHANICAL REQUIREMENTS**

- A. Each VP-I/O System shall make use of plug-in circuit boards. Each board shall be labeled with its function, a means of application identification, a serial number, and a model or drawing number.
- B. The program of each VP-I/O System shall reside in a Programmable Read Only Memory located on the processor board, or a separate "memory" board. The memory devices shall be erasable and reprogrammable. A separate plugcoupler dedicated to this function may be provided on the board at a readily accessible location. This plugcoupler shall provide for the connection of suitable programming test fixtures which shall be provided by the Contractor. As an alternative, the Contractor may provide sockets on the boards for the memory devices. In this case, each memory device shall have a complete and unique identification marking. The placement of the wrong memory device on a board shall be detected by the system and power shall be removed from the outputs.
- C. Electro-mechanical memories such as magnetic-media tape and disk drives shall not be used in the VP Systems, except for programming and testing purposes.
- D. The printed circuit boards of the VP modules shall be housed in rigid frames containing a motherboard for the mounting of the printed circuit board receptacles. This motherboard may be either a printed circuit board or a hard-wired plane. The frame shall contain full-length board guides to assure that the plug-in contacts of each plug-in board correctly mate with the motherboard receptacle.
- E. Each plug-in location of the VP modules shall be labeled with the identity of the board type intended for that location.
- F. The Contractor shall provide some form of interlocking device to ensure that plug-in boards of the VP modules cannot be plugged into an incorrect location.
- G. The board frame of the VP shall be constructed and mounted in a manner which allows the free movement of air over the equipment by convection to prevent local hot-spots which could degrade the assembled and mounted equipment and prevent it from meeting the environmental and reliability requirements of these Specifications. No fans or blowers will be permitted for these purposes.
- H. The printed circuit boards or the printed circuit board frame which houses the VP shall be provided with electromagnetic shielding, if necessary to allow the system to meet the electrical environmental requirements of these Specifications.
- I. The Contractor shall provide a dust-resistant cabinet to house the VP. This cabinet shall have dust-resistant doors or removable covers on both the front and back. The front shall be supplied with a safety glass or fire-resistant plastic panel which allows observation of the indicators which may be located on the front of the boards. The equipment shall be immune

to the ambient dust accumulation. TCR dust consists mostly of residues of the train brake wear.

- J. This cabinet shall be of sufficient volume to allow the removal of heat from the boards by internal convection and the removal of heat from the cabinet by radiation and external convection. Fans shall not be employed in the heat removal process.
- K. The board frame shall be located within a zone which does not allow the bottom of the frame to be any closer to the floor than two feet or the top of the frame to be any higher than six feet from the floor. This requirement is for ease of viewing indicators or working on the VP modules.
- L. At the time of the type acceptance test of the IVP System, the printed circuit board frames shall be installed in these cabinets and the doors or covers shall be in place.
- M. The Contractor shall provide as part of the IVP Systems, three sets of all of the equipment and fixtures necessary to program, reprogram and maintain the systems. These fixtures shall include, but not be limited to, a microprocessor-oriented program system. This support system shall be IBM or IBM compatible and shall, as a minimum, include all the features of the computer system described in Section 16927, ATC Microprocessor Support Systems. The system shall include an EPROM burner to reprogram IVP system software.
- N. The Contractor shall provide compiler software maintenance for a period of five years.

## **2.03 ELECTRICAL REQUIREMENTS**

- A. Each VP-I/O System and its associated equipment shall be powered by conservatively rated power supplies or inverters provided as part of its support equipment. These supplies or inverters shall meet the electrical and environmental requirements of these Specifications. At the Contractor's option these supplies or inverters shall operate either from the 120V ac line or the 28V dc (or 12V dc) local power system specified elsewhere in these Specifications. In either case, these supplies or inverters shall be equipped with sufficient transient protection to provide immunity from power line transients as high as six kilovolts (1.5/40 microsecond standard wave).
- B. The input and output signal connections of the VP-I/O Systems shall be fully isolated from the power supply of the processor. This isolation shall be adequate to provide protection from the transient levels encountered in the installation. The Contractor shall be cognizant of the various sources of transient interference that may be encountered in the TCR such as those listed in Section 16914 of these Specifications. The Contractor shall assess and provide protection from this interference.
- C. The output signal potential shall be 28V dc (or 12V dc) nominal and the outputs shall have an adequate and conservatively rated power capability suitable for each application.
- D. Each vital output shall include provision for monitoring the current which flows in the external output circuit. This shall allow the program to check the output circuit to detect unexpected current when the output is supposed to be deenergized. The program shall produce an alarm and fail-safe response when this condition is detected.
- E. Input Monitoring
  - 1. Each vital input shall include provision for monitoring the current which flows into the input channel from the external circuit. The impedance of the input channel shall be low enough to draw sufficient current for the circuitry to ignore false high resistance voltage applications at the input terminal. This low input impedance shall also serve to reduce "noise" interference. The input circuit shall be read as permissive only

- when sufficient current is present.
2. As an alternative, each input shall be monitored in a vital manner.
- F. Outputs shall be provided by the VP-I/O Systems for the control of vital interfacing relays which shall control the illumination of the wayside signals. This circuitry shall be capable of withstanding without damage, the shorting of the output to ground or the opposite ac polarity. Such a short shall register an alarm.
  - G. Provide local system voltage dc output from the VP-I/O Systems for the vital relays which shall be provided for controlling the switch-and-lock movements. These relays shall minimize the amount of equipment to be maintained on the wayside. This shall also allow the use of the same types of switch-and-lock movements that are currently in use on the WMATA Metrorail System.
  - H. All vital inputs and outputs of the VP-I/O Systems shall be capable of being equipped or connected, and programmed in either a unipolar or bipolar mode.
  - I. All vital and non-vital inputs to the IVP Systems shall be provided with de-bounce circuitry so that momentary voltage changes at the time of initial external contact closure, will be ignored.
  - J. One or more ports shall be provided for the transfer of coded input and output information. These ports shall make maximum use of industry standard communications standards and protocol except as necessary to promote safety and security. These ports shall be for the purpose of system expansion, connection of test equipment and other such uses.
  - K. All components of the IVP Systems shall be conservatively rated so that the system is capable of meeting the Mean-Time-To-Restore requirements shown in the Technical Appendix (Section 16996) of these Specifications.
  - L. All vital inputs and outputs utilized in the VP-I/O Systems shall be constructed with a minimum of 1/4 inch creepage distance between all exposed conductors and shall be capable of withstanding a 3000 volt dc breakdown test. The voltage shall be applied between isolated circuits as well as from isolated circuit to ground.
  - M. All printed circuit boards utilized in the VP-I/O Systems shall have a properly applied conformal coating to minimize the effects of moisture.
  - N. All printed circuit boards utilized for inputs or outputs in the VP-I/O Systems shall be designed so that there is minimal capacitive coupling between the circuitry on either side of the isolation devices. Consideration shall be given by the Contractor to the use of a grounded copper track between circuitry on either side of the isolation devices to further decrease the capacitive coupling which bypasses the isolation device.
  - O. A visual indicator, such as a LED, shall be provided on each input and output board to indicate when each applicable input or output for that board is active.
  - P. All vital timing functions shall be field adjustable without software modification, but via jumpers on printed circuit boards in the processor, or jumpers on vital outputs. Means shall be provided for sealing the time setting. The adjustable range of the timers shall be 0 to 300 seconds.

## **2.04 ADDITIONAL ENVIRONMENTAL REQUIREMENTS**

- A. Physical
  1. The VP assembly shall work in the physical environment of the TCR. These environmental requirements are:

- a. Operating temperature range 22 to +158° F. (-30 to +70° C.)
- b. Operating humidity range 5 to 95 R.H., non-condensing
- c. Vibration suppression Shock mounting
- d. Cooling system Radiant plus natural convection (no fans)

B. Electrical

- 1. The VP-I/O assemblies shall work in the electrical environment of the TCR. The Contractor shall assess this environment, considering the factors stated in Section 16914.1.03 of these Specifications, and the characteristics of the equipment he is providing under this Contract. All inputs, outputs, power connections and communications lines, if any, shall be immune to the effects of lightning (except in the case of a direct stroke to the building which houses the VP) and to surges or transients to which they may be subjected. In addition, the equipment to be provided under the requirements of this Article shall conform to the following requirements:
  - a. Conducted and radiated radio frequency energy at all frequencies shall be attenuated to a level which will not interfere with the operation of a radio transceiver with a self-contained antenna operating at any normal communications frequency.
  - b. The operation of a radio transceiver, transmitting radio frequency energy at any normal communications frequency with ten watts of power into an attached antenna, shall not cause malfunction of the microprocessor or the I/O devices. This and the previous requirement shall be met when the end of the antenna is within three inches of any external part of the VP equipment.
  - c. The IVP Systems shall be capable of operating without loss of continuity and with complete safety, during power outages of up to three times the transfer time of the transfer switch provided by the Contractor.
  - d. The IVPs shall be immune to electrostatic discharges to all devices and surfaces exposed to human touch during operation or servicing.

**2.05 PROGRAMMING REQUIREMENTS**

- A. Provide a means of programming the IVP Systems, initially and as any subsequent changes, improvements, and replacements may require. This means shall take the form of test fixtures and, if necessary to operate a fixture, a program. Both the fixtures and the program shall become the property of the Authority when the installation is accepted.
- B. The Contractor shall exercise special care in the design of the VP programs to select an order of processing which does not cause any unwanted or unsafe results.
- C. Provide each VP-I/O System with three forms of diagnostic systems as outlined herein. The degree of refinement in each of these systems is at the discretion of the Contractor who is reminded that the diagnostics he furnishes will be instrumental in meeting the time-to-restore requirement described elsewhere in these Specifications. The three forms of diagnostics are; (1) Executive Routine, (2) Maintainer's Diagnostic System, (MDS) and (3) Engineer's Monitoring System (EMS). The minimum requirements for these systems follow, but the Contractor shall be alert for ways to extend these requirements in any way practicable to make the VP-I/O systems safer, more reliable and easier to maintain. The minimum requirements for these diagnostic systems are:
  - 1. Executive Routine
    - a. Provide an Executive Routine to continuously monitor the operation of each VP-I/O System, and to the greatest extent possible, its peripheral devices. This may be implemented in any way the Contractor selects, providing that the solution includes provisions to meet the requirements of these Specifications and providing that the solution meets with the approval of the designated Resident Engineer.

- b. As part of the Executive Routine, provide a method of verifying the integrity of the input and output circuits.
  - c. In the event that any part of the Executive Routine indicates that an unsafe condition exists within its VP-I/O System, vital provisions within that VP-I/O System shall:
    - 1) Cause the VP-I/O System to attempt to transfer control to the other VP-I/O System (if the troubled VP-I/O System was "on-line" at the time);
    - 2) Disconnect and/or remove energy from the VP-I/O System's vital outputs to the ATP System, and;
    - 3) Remove energy from the applicable Vital Processor Check Relay (VPCHKR).
  - d. The removal of energy from the VP Check Relay of one or both of the VP-I/O Systems shall result in the energization of an "NVIP PROBLEM" alarm LED on the Track and Alarm Panel in the TCR. (See the Contract Drawings.)
  - e. The removal of energy from the VP Check Relay of a VP-I/O System shall result in the energization of the applicable VP FAILURE alarm LED on the local Track and Alarm Panel, to alert the supervisor to call maintenance personnel. (See the Contract Drawings.)
  - f. Some examples of the type of events that shall cause the deenergization of a vital processor check relay are:
    - 1) Failure of the equipment to properly execute an internal diagnostic routine that checks the VP System clock and other normal routines or facilities.
    - 2) Failure of the equipment to properly execute an internal diagnostic routine checking wayside equipment.
  - g. The dropping of a VP ON-LINE relay or a VP CHECK relay shall be monitored by, and a descriptive alarm indication (identity, time and date of de-energization) entered into the memory of the Maintainer's Diagnostic System described below.
2. Maintainer's Diagnostic System (MDS)
- a. This system shall contain all of the information, processes and equipment necessary to enable the maintainer to audit the operation of the VP-I/O System equipment modules, and to determine the location of a problem so that he can make effective repairs as quickly as possible and within the time allotted by the requirements of these Specifications.
  - b. The MDS provided shall be capable of diagnosing VP-I/O System failures or intermittent conditions. Its equipment and software shall not affect the safety of the IVP System. If necessary to ensure safe operation, the MDS shall prevent energization of the applicable ("A" or "B") VPCHK Relay while the MDS is operative.
  - c. The MDS provided shall be designed to be activated at the TCR by maintenance personnel, and shall be capable of locating the source of problems such as those caused by defective printed circuit boards.
  - d. The MDS shall include an easily understood, hand-held display and test device having the ability to implement the test procedure, and to use built-in hand-step controls if necessary. The diagnostic displays on this unit shall be in simple text form and shall be unambiguous to the reader.
  - e. The MDS shall be thoroughly documented in the Maintenance Manuals provided by the Contractor. See Part 2.09 of this Section.
3. Engineer's Monitoring System (EMS)
- a. This system shall contain all of the individual TCR location wiring and logic, and all of the special, plug-in, notebook computers needed to monitor the operation of the IVP local application software in real time, or for up to 48 hours of such data in a store/playback mode, in the manner specified

- herein.
- b. Plugging in or unplugging an EMS monitor shall have no affect on the safety of IVP operation.
  - c. Data shall be displayed on the EMS monitor in English text form for the location being monitored.
  - d. The Contractor shall provide:
    - 1) All necessary local TCR EMS wiring and logic at each new TCR equipped with Vital Processor interlocking logic under this Contract.
    - 2) Two special EMS Monitor Units (plug-in notebook computers) complete with all necessary programming.
    - 3) Two complete extra sets of EMS software in the media format required by the designated Resident Engineer.
- D. FRA Test Facilities
- 1. The Contractor shall provide special programming and equipment necessary to allow maintainer's or other authorized personnel to conduct all applicable FRA Tests involving the IVP Systems in a safe and efficient manner which will not require other re-testing of the IVP Systems. The special FRA Test equipment must be easily applied and easily removed.
  - 2. The special software and hardware proposed for this purpose are subject to pre-approval by the designated Resident Engineer. The proposed designs must be submitted to the Engineer for approval at least 60 days prior to the start of construction/programming.

## **2.06 SPECIAL EQUIPMENT REQUIREMENTS**

- A. Provide, in addition to the equipment supplied for the working system of this Contract, two card frames with motherboards and two sets of printed circuit boards to be used as replacements for defective units. Each set shall contain one printed circuit board for every different board utilized to meet the requirements of the working systems supplied. Where many boards of the same type are utilized in the working systems, the Contractor shall provide either one board, or twenty percent of the total number of boards used in all of the working systems (rounded to the next higher whole number), whichever is greater.
- B. The replacement boards shall be identical to, and interchangeable with, the boards of the working system. This shall be demonstrated during field testing of the system by making a replacement of the working boards with the maximum number of replacement boards and repeating the tests.
- C. Rugged and portable carrying cases with hinged and latched covers and with a handle on top shall be provided to house and protect each set of replacement boards and memory devices. Guides shall be fitted to the interior of these cases to hold each board and prevent contact between the components of any two boards. The bottom of the inside of each case shall be fitted with a one inch thick foam pad (closed cell Neoprene) to protect the boards from impact during transit and storage. The maximum weight of any case with a full complement of boards installed shall be twenty-five pounds. If one case capable of holding a complete set of replacement boards exceeds this weight limit, more than one case shall be provided. Provide a means of safely storing spare replacement memory devices within these cases, possible in a compartment built into the case lid.

## **2.07 SHOP TEST FIXTURE REQUIREMENTS**

- A. The Contractor shall provide two each of every test fixture necessary to test and maintain all IVP PC boards of the IVP System to the component level. Equipment for actual repair of printed circuit boards shall not be considered part of this requirement.

- B. Each IVP PC board test fixture shall include one of each type of working PCBs (e.g., CPU, I/O) used in the IVP and shall have the capability necessary to test all IVP PCBs, including the IVP CPU provided under this Contract.
- C. In addition to the IVP PC board test fixtures required in the preceding paragraph, the Contractor shall provide two IVP System (Shop) Test Fixtures, each of which shall consist of a board frame complete with power supplies, printed circuit boards, diagnostic systems, and any other equipment or programs needed to simulate complete and operable wayside systems. Each of these test fixtures shall include all devices necessary or desirable to set-up, inspect, monitor, maintain or facilitate the repair of the IVP System. Each of these test fixtures shall be equipped with simulated input and output facilities interfaced to a minimum of 10 input switches, 10 output indicators (five for the 28v dc outputs and five for the 120v ac outputs), and a 120v ac line cord. The System Test Fixtures shall be designed to allow electronic technicians access to working boards in a working system through the use of extender boards. The system shall be installed in a dust-resistant rack or cabinet of the same type as specified in Part 2.02 I. of this Section. Suitable supports shall be provided to floor-mount the rack or cabinet on casters. A complete set of extender boards shall be provided for use with each of these test fixtures.
- D. The Contractor shall provide two complete sets of IVP Test EPROMS for the IVP functions.
- E. The two IVP System (Shop) Test Fixtures shall be considered to be Specific ATC Test Devices, as specified in Section 16931.1.01 H., Item 12.
- F. The Contractor shall not include as part of the equipment furnished for these requirements any instrument or test device duplicated in response to the requirements of another Section of these Specifications.

## **2.08 SUPPLY MATERIAL REQUIREMENTS**

- A. The Contractor shall provide, if necessary for the operation of equipment supplied under this Contract, paper, ribbon and any other consumable supplies sufficient for one year of operation. Unless the supplies are readily available, the name and address of the source of further supplies shall be furnished to the designated Resident Engineer as a separate document.

## **2.09 INSTRUCTION MANUAL REQUIREMENTS**

- A. The Contractor shall provide three types of Maintenance Manuals which cover, to the board level, all items of hardware and software included as part of the working system and the maintenance system of the VP.
- B. These manuals shall comply with the Special Requirements of Part 2.06 of this Section, and the general requirements of Section 16992, ATC Instruction Manuals.
- C. The first manual which the Contractor shall provide shall be an Operator's Training Manual which covers the operation of the Emergency Control Panel. It shall be written for an educational level limited to the 12th grade only.
- D. The second manual which the Contractor shall provide shall be a Field Maintainer's Manual intended for the signal maintainer. It shall be written for instruction of Authority personnel with an educational equivalent of 12th grade plus two year in a general electrical technical school. (Two years in a computer programming school will not meet this requirement). Manuals which do not meet these requirements will not be approved.
- E. The Field Maintainer's Manual shall be clearly organized into two maintenance levels. They

are:

1. Level 1 - This level shall cover the detection of problems occurring in the field, TCR wiring, equipment modules and the input and output boards of the processor. This level is intended for the use of general maintenance personnel, and the manual shall so state.
  2. Level 2 - This level shall cover the detection and replacement of a malfunctioning board other than the input and output boards. It shall describe how this can be accomplished using the facilities of the Alarm Panel and the diagnostic routines. This level is intended for specially trained maintenance personnel and their supervisors and the manual shall so state.
- F. The third type of manual which the Contractor shall provide shall be the Engineer's Programming Manual. It shall consist of all the documentation provided by the programming system manufacturer and shall provide all information on the use of the equipment and the software provided with the system. This documentation is meant for engineers with experience in the design of signal and interlocking systems. Documentation describing the programming of the VP System shall be provided 45 days prior to the type acceptance testing. Six copies of this manual shall be provided.

### **PART 3 - EXECUTION**

#### **3.01 DELIVERY, STORAGE AND HANDLING**

- A. The Contractor shall take whatever measures may be necessary to protect the VP modules from internal or external damage during shipment, installation and testing and until the Authority accepts the system. If the equipment suffers any damage, from whatever cause, during this period, the Contractor shall replace or repair it to a like-new condition, to the satisfaction of the designated Resident Engineer at no additional cost to the Authority.

#### **3.02 INSTALLATION**

- A. The Contractor shall install the IVPs in TCRs which have one or more interlockings located within their area of control. The equipment shall be installed on equipment racks as required in these Specifications and as shown on the drawings prepared by the Contractor and approved by the designated Resident Engineer.
- B. The Contractor shall install the VP-I/O modules, complete with their programs and all appliances necessary to provide a complete IVP System which operates as required by these Specifications and is readily maintained.
- C. The IVP Systems shall be interconnected and tested with their interface equipment as required elsewhere in these Specifications and as shown on the Contract Drawings.

#### **3.03 TESTING**

- A. The Contractor shall perform a Type Acceptance Test on the first complete IVP System available, according to the requirements of these Specifications.
- B. The Contractor shall factory test each completed VP-I/O module and each complete IVP System according to a test procedure which the Contractor has prepared in accordance with Section 16981 of these Specifications and which has been approved by the designated Resident Engineer. Field conditions shall be simulated for this test. This test may be witnessed by the designated Resident Engineer. This test shall be successfully completed and the results approved by the designated Resident Engineer before the equipment is shipped from the factory.

- C. The Contractor shall field-test each installed IVP System according to a series of field tests described in these Specifications, prepared by the Contractor and approved by the designated Resident Engineer.
- D. The Contractor shall notify the designated Resident Engineer at least one week before the commencement of each of the specified factory and field tests unless otherwise directed by the designated Resident Engineer.
- E. The final revised program shall be entered into the memories of the spare equipment and the spare equipment shall be installed in the working system for testing. When approval of the test results has been received from the designated Resident Engineer, the Contractor shall install the regular equipment in the system and repeat the tests. Upon approval by the designated Resident Engineer of the results of this second test, the regular equipment shall be left in the system.
- F. At the conclusion of the testing of each IVP System, the Contractor shall deliver to the Authority three copies of the complete program documentation. The program shall be labeled at this time as Revision 1. Subsequent changes if necessary shall bear subsequent revision numbers.
- G. If, upon completion of the final field testing, any change in the program is deemed necessary by the Contractor, the designated Resident Engineer shall be informed, and with the designated Resident Engineer's approval, the Contractor shall make the change. When the change has been completed and the log book filled out, the Contractor shall repeat the cycle of testing described in Part 3.03 E of this Section.

#### **3.04 DOCUMENTATION**

- A. The Contractor shall deliver the required tracings, program listings, drawings and aperture cards at the times required by these Specifications and keep them up-to-date during installation.
- B. The Contractor shall deliver the required maintenance manual and training course submittals at the times required by these Specifications.
- C. The Contractor shall provide a Software Configuration Logbook which shall be utilized commencing with the approval of the design submittal and continuing until Final Acceptance of the installation. This book shall be used to register dated entries describing every change made to the VP program and equipment, and the reason the change was made. It shall be written in a detailed, step-by-step narrative, and shall include cross-references to all program changes. Failure to provide and utilize this logbook will delay, and may prevent, the approval of all the test reports associated with the field testing of the processor. At final acceptance, this logbook shall become the property of and be delivered to the Authority.

#### **3.05 TRAINING REQUIREMENTS**

- A. The Contractor shall provide one training course, (described in B. below) which shall be called the Field Maintainer's ATC/IVP Training Course and one training course, (described in C below) which shall be called the Engineer's ATC/IVP Training Course. Training aids shall be liberally employed where helpful to illustrate the devices and principles being described. Applicable firmware, such as flip charts, transparencies and slides, shall become the property of the Authority at the conclusion of the first presentation of the courses. The Contractor's instructor(s) shall cooperate with the Authority in the videotaping of the course presentations.
- B. Field Maintainer's ATC/IVP Training Course

1. The Contractor shall provide on the Authority's premises, for its signal maintenance personnel, four presentations of a course of classroom and hands-on instruction in the operation and maintenance of the complete ATC system. This course shall include special emphasis on the IVP System. The course shall be not less than five days nor more than ten days in length. Each presentation of the course shall accommodate 12 persons designated by the Authority.
  2. The first two presentations of this course shall occur consecutively during the final installation stages of the VP. The third and fourth presentations shall be at later dates within one year from the date of the first two; the exact dates to be determined with the mutual consent of the Authority and the Contractor. These instruction courses shall be at no additional cost to the Authority.
  3. This instruction shall be based on the second Maintenance Manual described in Part 2.09.E. of this Section.
  4. This instruction shall cover all aspects of operation and maintenance of the wayside and TCR equipment including the VP. It shall include, but not be limited to the following:
    - a. Track Circuits
    - b. Interlockings
    - c. Passenger Facilities
    - d. TCR Modules
    - e. Processors
    - f. Processor programming and changes
    - g. Trouble shooting
    - h. Diagnostic routines
    - i. Maintenance procedures
    - j. Preventive maintenance
    - k. Emergency Interlocking Control Panel Operation
  5. This course shall be designed for an educational level of 12th grade plus two years in a technical school.
  6. This course shall include "hands-on" instruction for each participant in identifying and replacing defective boards through the use of the test fixtures provided by the Contractor. The Contractor shall supply, at no further cost to the Authority, a set of defective boards for use in this test. There shall be enough boards to that successive course participants are not bored by locating the same defective board.
  7. This course may be combined with a similar course for the Non-Vital Processor Interlocking Systems. See Section 16926.
- C. Engineer's Training Course for Interlocking Vital Processor Systems
1. The Contractor shall provide on the Authority's premises, for certain engineering personnel, one presentation of a course of classroom and hands-on instruction in the programming, maintenance, and reprogramming of the IVP Systems to the board level. The course shall not be less than three days nor more five days in length. The presentation of the course shall accommodate up to 12 persons designated by the Authority.
  2. The presentation of this course shall occur during the final installation stages of the IVPs and shall be made at no additional cost to the Authority.
  3. This instruction shall be based on the third Instruction Manual described in Part 2.09 F. of this Section.
  4. This instruction shall cover all aspects of setup, programming, operation and maintenance of the IVP equipment. It shall include, but not be limited to the following:
    - a. Programming Techniques
    - b. Compiling
    - c. Setting and Erasing Memory Devices
    - d. Locating Defective Boards
    - e. System Operation

- f. Reliability Considerations
  - g. Trouble Shooting
  - h. Diagnostic Routines
  - i. Maintenance Procedures
5. This course shall be designed for an educational level of 12th grade plus a Bachelor's Degree in Engineering or its equivalent.
  6. This course shall include "hands-on" instruction for each participant in programming, reprogramming and identifying and replacing defective boards through the use of the Contractor's test fixtures (made available by the Contractor at no additional cost to the Authority), and the IVP unit(s) provided to the Authority by the Contractor for training purposes. The Contractor shall supply, at no additional cost to the Authority, a set of boards with various defective components for this purpose.
- D. These training course presentations shall be organized in accordance with the requirements of this Section and Section 16993, Training Courses.

### **3.06 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. The Interlocking Vital Processor Systems will be measured for partial payments based upon the number of such required, complete systems which are designed, furnished installed and successfully tested by the Contractor.
- B. For purposes of measurement and payment, these systems shall include all mounting hardware, interconnecting wiring, and IVP PC Board Test Fixtures.
- C. The following conditions will be considered when measuring the IVPs for partial payments:
  1. Completion by the Contractor, and approval by the designated Resident Engineer, of the Interlocking Vital Processor System design.
  2. Delivery by the Contractor of the IVP systems, provided approval of their Factory Test Reports has been received from the designated Resident Engineer.
  3. Installation of the IVP system and all interconnecting wiring by the Contractor, provided approval of the installation has been received from the designated Resident Engineer.
  4. Level "A" or Level "B" partial system acceptance of the location involved.
  5. Delivery by the Contractor of the approved as-built drawings, aperture cards and program listings.
  6. Approval by the designated Resident Engineer and receipt by the Authority of the applicable Maintenance Manuals.
  7. Approval by the designated Resident Engineer of the documentation for the classes of instruction and the satisfactory completion of these presentations.
- D. System (Shop) Test Fixtures for the Interlocking Vital Processor Systems will be measured for payment as specified in Section 16931.3.03 C., and in the ATC Unit Price Schedule.

**END OF SECTION**

**SECTION 16930**

**ATC FACILITIES AND SPARE EQUIPMENT**

(Table of Contents)

**PART 1 - GENERAL**

**1.01 SECTION INCLUDES**

- A. This SECTION lists the various 16930-series ATC Facilities and Spare Equipment Specification Sections:
1. ATC Maintenance and Test Facilities (Section 16931)
  2. Spare ATC Equipment and Selectable Items (Section 16932)

**PART 2 - PRODUCTS**

NOT USED

**PART 3 - EXECUTION**

NOT USED

**END OF SECTION**

**SECTION 16931**

**ATC MAINTENANCE AND TEST FACILITIES**

**PART 1 - GENERAL**

**1.01 SECTION INCLUDES**

- A. This Section specifies the furnishing and installation by the Contractor of certain storage and maintenance facilities and equipment at Train Control Rooms, TCERs and Interlockings, and the furnishing of basic and specific ATC Test Equipment.
- B. Provide the following at each Train Control Room and TCER newly equipped under this Contract:
  - 1. A workbench and stool for reading plans.
  - 2. A wall-mounted storage cabinet for spare parts.
  - 3. A 6-foot fiberglass stepladder.
- C. At new Train Control Rooms and TCERs controlling interlockings, the Contractor shall also provide a floor-mounted steel locker.
- D. Furnish and install a "Gang Box" (storage bin) at each interlocking newly equipped under this Contract.
- E. Furnish maintenance tools and materials to enable Authority maintenance personnel to perform compression bolted negative return bonding.
- F. Furnish, in the quantity shown, the following Basic ATC Test Equipment. Each item shall be portable and furnished complete with all necessary cables, adapters and ancillary devices needed to perform the functions or tests for which it is designed. Each item shall be of the manufacturer indicated or equal.

<u>ITEM</u>	<u>QUANTITY</u>	<u>BASIC ATC TEST DEVICE</u>
1	2	Megger (BIDDLE No. 212159CL)
2	2	Digital Frequency Counter (FLUKE No. PM6669)
3	2	Function/Arbitrary Wave Form Generator (HEWLETT PACKARD No. HP-33120A) with Accessory Pouch (HEWLETT PACKARD No. HP 34161A)
4	5**	Inductive Ammeter (AMPROBE No. ACDC-1000)
5	3**	Digital Voltmeter (FLUKE No. 8060A)
6	2	Oscilloscope (TEKTRONIX Model TDS-340A w/Option 14: Interfaces and Printing)
7	2	Oscilloscope, Battery-Powered, hand-held (TEKTRONIX Model THS-720Aw/THS7CHG Battery Charger)
8	4	Shunt strap, .06 ohm with T-Handle Clamping (Safetran Model TS1)
9	2	AC Ammeter, Clamp-on (FLUKE No. 80I-600A)
10	2	DC Ammeter (FLUKE No. Y8100)
11	2	Volt-Ohmmeter with leads and case (SIMPSON Model No. 260-6XLPM)

ITEM    QUANTITY    BASIC ATC TEST DEVICE (Continued)

12	1	Digital Micro-ohmeter (ALBERENGINEERING No. RT-10)
13	2	RMS Voltmeter (DB)(HEWLETT-PACKARD No. 3400B)
14	1	TWC Receiver/Transmitter Test Set*#
15	2	ATP Track Module Test Set
17	2	Power Level Adjustment Unit for ATP module*
18	8	RTU Computerized Analyzer Unit (CAU)*
19	6	ATP Logic Card Extender*
20	10	Rail Audio Frequency Test Set (RAFTS)which can detect and individually identify each of the 14 ATC operating frequency signals in the running rails (RJO Part No. 9802-10000)
21	2	Marker Coil Test Unit*###
22	7	Data Logging Device*####
23	1	Insulated Joint Tester which can determine insulated joint resistance over a range from zero to 10,000 ohms. (RJO Part No. 9801-10000)
24	2	Complete Sets, Test and Adjustment equipment for all the Microprocessors furnished under this Contract*
25	1	Safe Braking Distance (SBD) Test Fixture as used in WTP 2.21 testing under this Contract. If this unit is computerized, all associated hardware and soft-ware (including source code) shall be included.
26	1	TWC Train Simulator*##
27	1	Complete set of card extenders for shop extender boards

\*NOTE: Unit shall be applicable to the manufacturer's equipment furnished under this Contract and shall be subject to approval by the designated Resident Engineer.

\*\*NOTE: One of these units shall be delivered directly to the designated Resident Engineer's Office no later than 30 days prior to the start of any ATC field testing.

#NOTE: See Part 2 of this Section.

##NOTE: See Part 2.06

###NOTE: See Part 2.07 A.

####NOTE: See Part 2.04

G. The Contractor shall evaluate all of his test procedures relative to test equipment requirements, and shall augment the BASIC ATC TEST DEVICE list (in Part 1.01-F.) to include one of every additional item of test equipment used. This shall include PCs, laptop computers, and special PC boards.

H. Furnish the following items of Specific ATC Test Equipment. Each item shall be portable unless otherwise indicated, and furnished complete with all necessary cables, adapters and ancillary devices needed to perform the function or tests for which it is designed. The items to be included are:

<u>ITEM</u>	<u>QUANTITY</u>	<u>SPECIFIC ATC TEST DEVICE</u>
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1	1	TWC Transmitter Test Unit for TWC transmitters furnished
2	1	TWC Receiver Adjustment Test Unit for TWC receivers furnished
3	1	Portable Test Fixture for the Vital DC Relays furnished
4	1	Portable Test Fixture for the Vital AC Relays furnished
5	1	Portable Test Fixture for the Non-Vital DC Relays furnished
6	1	Shop Test Fixture for Impedance Bonds furnished
7	1	Marker Coil Dynamic Test Unit**
8	1	Shop Test Fixture for the RTUs furnished
9	1	Shop Test Fixture for the ATP Modules furnished
10	2	Shop Test Fixture for the Non-Vital Station Processors furnished*#
11	2	Shop Test Fixture for the Non-Vital Interlocking Processors furnished*##
12	2	Shop Test Fixture for the Interlocking Vital Processors furnished*###
13	1	Shop Test Station for NVIP PCBs##

- \*NOTE: One for Maintenance and one for Training.
- \*\*NOTE: See Part 2.07 B.
- #NOTE: See Section 16924.2.11 B.3.
- ##NOTE: See Section 16926.2.08
- ###NOTE: See Section 16928.2.07 E.

I. Special Test Equipment Required

1. Each piece of special test equipment required by the Contractor to inspect, test, adjust, tune or otherwise modify the equipment to be provided under this Contract shall, at the conclusion of all field tests which make use of it, become the property of, and be delivered to, the Authority. Unless otherwise specified, this requirement shall be limited to a quantity of one piece of equipment of each type, regardless of the quantity the Contractor requires to expedite his testing program. This requirement shall not be construed to increase the quantity of test equipment listed in Part 1.01, paragraphs F, G, and H. See also Section 16981, Basic ATC Test and Inspection Requirements.

**PART 2 - PRODUCTS**

**2.01 TCR MAINTENANCE EQUIPMENT**

A. Workbench

1. The workbench shall be 42 inches high, 60 inches wide, and 30 inches deep. The framework for the bench shall be 14-gauge cold rolled steel. Side panels shall be 14-gauge cold rolled steel, and the under panels shall be 16-gauge steel. The bench top shall be formica bonded to three-quarter inch thick plywood. The bench shall have a heavy-duty drawer, supported by the bench frame and capable of storing a Room Book of Plans under the bench top. The drawer shall be steel as specified above and shall have the following minimum dimensions: 4 inches high, 40 inches wide, and 25 inches deep.

B. Stool

1. The stool shall have a 14 inch diameter seat with tubular steel adjusting leg extensions that lock securely at one inch intervals. The legs shall be adjustable from 18 inches to 27 inches.

C. Cabinet

1. The storage cabinet shall be made of steel. It shall be 36 inches high, 60 inches wide, and 16 inches deep, with one shelf. Shelf height shall be adjustable. The shelf shall be supported every 15 inches. The cabinet shall have 4 doors for access.
- D. Stepladder
1. The stepladder shall be a heavy-duty, type 1A, 6-foot, self-supporting, fiberglass, folding ladder.
- E. Locker
1. The locker shall be made of steel. The locker shall be 72 inches high, 15 inches wide, and 18 inches deep, and shall have one shelf mounted near the top. The locker shall have a full-height hinge, and a lockable door.

## **2.02 WAYSIDE MAINTENANCE EQUIPMENT**

- A. Gang Boxes shall be 60 x 30 x 48 inches in size, made of 16 gauge steel. Each box shall have two shelves and a continuously welded piano hinge for the lid. Gang Boxes shall be Delta #DEL-6841, or approved equal.
- B. Compression Bolted Bonding Equipment
1. The following new maintenance equipment shall be furnished to the Authority for performing compression bolted negative-return bonding:
    - a. One complete hydraulic installation tool, complete with appropriate nose assembly, for 5/8 inch diameter compression fasteners. (No. 586 tool with No. 99-709 Nose Assembly, as manufactured by Huck International, or approved equal.)
    - b. One 115 volt AC electrically-powered hydraulic unit, complete with 20 foot hydraulic hose kit, for operating hydraulic installation tools. This unit shall be Model 940 Powerig Hydraulic Unit, complete with hose kit, as manufactured by Huck International, or approved equal.
    - c. One dozen 5/8 inch diameter compression fasteners, No. C50LR-BR20-12, as manufactured by Huck International, or approved equal.
    - d. One dozen 5/8 inch diameter compression fasteners, No. C50LR-BR20-16, as manufactured by Huck International, or approved equal.
    - e. Two dozen terminal lugs, Burndy Type YA34-L, or approved equal.
- C. This equipment and material shall be in addition to that necessary for compression bonding required to be performed under this Contract.

## **2.03 ATC TEST EQUIPMENT**

- A. Furnish Basic Test and Maintenance devices in the quantities listed in Part 1.01 paragraphs F, and G, and Specific ATC Test devices as specified in Part 1.01 H.
- B. Each item of special purpose ATC test equipment shall be designed to fully test and align the device or function for which it is intended and shall have as a minimum, features to perform the tests specified for it in Section 16980, ATC Tests, Inspections and Quality Assurance.

## **2.04 DATA LOGGING DEVICES**

- A. Provide a notebook size, portable Data Logging Device for each station TCR installation. These devices shall be delivered to the designated Resident Engineer prior to commencement of wayside testing.
1. The Data Logging Device shall include a portable plug in/out serial communications cable for interfacing with the local STAP and NVIP systems.

2. The Data Logging Device shall include a Display Panel so that a signal maintainer can retrieve the recorded data and/or observe real time operation of the STAP or NVIP.
  3. The Data Logging Device shall not interfere with the normal operation of the STAP or NVIP.
- B. Provide two additional Data Logging Devices; one to be delivered to WMATA Design Engineering and one to be delivered to WMATA Operations Engineering prior to the commencement of wayside testing.

## **2.05 TWC RECEIVER/TRANSMITTER TEST SET**

- A. The TWC Receiver/Transmitter Test Set shall be a dedicated microprocessor-controlled device no larger than a notebook computer, and shall contain an FSK interface which is compatible with the Metrorail TWC equipment. As an alternative, this and other test equipment may be furnished in a combined unit, provided that operation does not exceed a normal Technician's understanding or cause the unit to exceed 15 pounds weight, and 15x18x6 inches in size.
- B. The microprocessor device shall be a ruggedized unit with 16 Mb memory and an IPCMCIA-144 modem. The test unit shall have an active matrix TFT color, 800x600 64,000 color LCD display.
- C. The test set shall be programmed in a Windows type environment to receive all commands from a screen menu. The test set shall display all test functions and indications in a Windows menu driven display.
- D. This device shall display the status of all bits in the TWC message: prefix and suffix bits; all bits relating to train status and control, and; all spare bits. The device shall be capable of testing all of the following:
1. TWC station receiver,
  2. Station transmitter,
  3. Fly-by receiver,
  4. Fly-by transmitter,
  5. TWC input and output of the ATP module,
  6. TWC signal quality and amplitude in the running rails.
- E. The test set shall contain a program which can analyze and display (in spectrum analyzer format) the incoming TWC signal on its display screens in comparison with the individual TWC status/control bits from the RTU scan sheets.
- F. The transmitter output shall be variable, from the screen menu, from 30 millivolts to four (4) volts, peak to peak.
- G. The unit shall be capable of operating from either a 120V ac source or from internal batteries. The internal batteries shall be capable of powering the unit for at least six (6) hours.
- H. The unit shall come complete with battery charger, all interface cabling, signal pick-up devices and interface circuitry.
- I. All associated hardware and software (including source code) shall be included.

## **2.06 TWC TRAIN SIMULATOR**

- A. The physical configuration of the TWC Train Simulator unit shall be identical to the physical

configuration of the TWC Receiver/Transmitter Test Set specified in Part 2.05 of this Section.

- B. The TWC Train Simulator shall provide the capability of testing the train TWC transmitter and receiver as a system to simulate a train communicating to the wayside TWC system. The unit shall have the capabilities to simulate all the bits (including spares) the train can transmit and receive, and display them on the screen in a Windows type environment.
- C. The unit shall be able to simulate the train communicating to:
  - 1. A fly-by transmitter
  - 2. A fly-by receiver.
- D. All associated hardware and software (including source code) shall be included.

## **2.07 MARKER COIL TEST UNITS**

- A. Marker Coil Test Unit
  - 1. The Marker Coil Test Unit shall be capable of automatically, or with minimum intervention, determining: the frequency, and, by means of a meter connected to its amplifier, the relative signal strength, which would be generated when passing over any marker coil on the Metrorail System. This unit shall be portable, light weight, and shall be bolted into a rugged carrying case which shall also serve to center the test unit at the same height as the carborne loops above the marker coil to be tested.
- B. Marker Coil Dynamic Test Unit
  - 1. The Marker Coil Dynamic Test Unit shall be capable of automatically, or with minimum intervention, determining the frequency and signal strength generated, and the location (+/- 10 feet) of any marker coil on the Metrorail System. This unit shall be portable, light weight and shall be bolted into a rugged carrying case. If this unit is computerized, all associated hardware and software (including source code) shall be included.

## **2.08 COMBINED TEST UNITS**

- A. As an alternative to individual computerized test units specified herein, the Contractor may provide computerized test units which combine the specified test capability of two or more of the individual units if the operation of these combined test units does not exceed a normal technician's understanding, or cause the unit to exceed 15 pounds weight and 15x18x6 inches in size.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. Install the TCR maintenance equipment in each new Train Control Room at the locations shown on the Contract Drawings, as specified herein, or as otherwise approved by the designated Resident Engineer.
- B. Mount the storage cabinet on the wall above the workbench. The bottom of the storage cabinet shall be no less than 15 inches above the top of the workbench.
- C. Mount a Gang Box at each interlocking in a manner and location approved by the designated Resident Engineer.
- D. Deliver the compression bolted bonding equipment and fasteners to the site(s) designated by the designated Resident Engineer.

### 3.02 MEASUREMENT AND PAYMENT

- A. ATC Maintenance Equipment
  - 1. Factors which will be considered when determining partial payments for ATC Maintenance Equipment will include:
    - a. Installation of the equipment in all of the new TCRs and at each new interlocking, as applicable.
    - b. Final acceptance of the ATC System by the Authority.
  - 2. ATC Maintenance Equipment shall be included in the cost of Material and Fabrication for the route segment included in this Contract.
  
- B. Basic ATC Test Equipment
  - 1. Factors which will be considered when determining partial payments for Basic ATC Test Equipment will include:
    - a. Safe delivery to the Authority of all Basic ATC Test Equipment in good working order.
    - b. Formal acceptance of the equipment by the Authority.
  - 2. The sum of payments for Basic ATC Test Equipment will equal the Lump Sum Price determined by the Cost-Loaded CPM, under:
    - a. BASIC ATC TEST AND MAINTENANCE EQUIPMENT
  
- C. Specific ATC Test Equipment
  - 1. The sum of payments for each item of Specific ATC Test Equipment will equal the applicable Unit Price determined by the Cost-Loaded CPM, under:
    - a. TWC TRANSMITTER TEST FIXTUR
    - b. TWC RECEIVER ADJUSTMENT TEST FIXTURE
    - c. PORTABLE TEST FIXTURE FOR VITAL DC RELAYS
    - d. PORTABLE TEST FIXTURE FOR VITAL AC RELAYS
    - e. PORTABLE TEST FIXTURE FOR NON-VITAL DC RELAYS
    - f. SHOP TEST FIXTURE FOR IMPEDANCE BONDS
    - g. MARKER COIL DYNAMIC TEST UNIT
    - h. SHOP TEST FIXTURE FOR RTUs
    - i. SHOP TEST FIXTURE FOR ATP MODULES
    - j. SHOP TEST FIXTURE FOR NON-VITAL STATION PROCESSORS
    - k. SHOP TEST FIXTURE FOR NON-VITAL INTERLOCKING PROCESSORS
    - l. SHOP TEST FIXTURE FOR INTERLOCKING VITAL PROCESSORS
    - m. SHOP TEST STATION FOR NVIP PCBs
  - 2. Payments for Specific ATC Test Equipment will be made as stipulated below. Upon safe delivery to the Authority, in good working order, of each item of Specific ATC Test Equipment selected by the Authority:
    - a. 100%ofapplicable CPM Unit Price

**END OF SECTION**

## SECTION 16932

### SPARE ATC EQUIPMENT AND SELECTABLE ITEMS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies:
  - 1. The furnishing of spare ATC equipment for this Contract.
  - 2. The furnishing of a price list of recommended ATC-related tools and equipment components from which the Authority may select quantities of individual items at the quoted prices up to a dollar amount equal to 3% of the CPM Price for ATC Material and Fabrication.
  - 3. The method to be used to determine prices to be charged to the Authority for items of Spare ATC Equipment, and for items of Selectable ATC Tools and Equipment Components.
- B. The Contractor shall furnish and deliver to the Authority the quantities of spare ATC equipment specified, and the quantities of selectable ATC tools and equipment components chosen by the Authority from the approved price list submitted by the Contractor.

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Division 1 Article IX Commencement, Prosecution and Completion of Work
  - 2. Section 16924 Non-Vital ATO & ATS Processor Systems
  - 3. Section 16925 Data Transmission System (DTS)
  - 4. Section 16926 Microprocessor Systems for Non-Vital Interlocking Functions
  - 5. Section 16928 Interlocking Vital Processor Systems
  - 6. Section 16953 ATP Track Modules
  - 7. Section 16964 Track Switch Operating Layouts
  - 8. Section 16965 Signal Layouts
  - 9. Section 16969 Snowmelter Layouts

##### 1.03 QUALITY ASSURANCE

- A. The ATC spare equipment and the ATC selectable tools and equipment components shall be of the same quality as specified within applicable Sections of these Specifications for their working counterparts.
- B. Factory Tests, as called for by the Contractor's approved quality assurance program, are applicable to the ATC spare equipment, selectable tools, and equipment components to be provided on this Contract.

##### 1.04 SUBMITTALS

- A. Submit, for the approval of the designated Resident Engineer, no later than 90 days prior to the ORD, a price list of recommended ATC tools and equipment components, showing the individual item prices and the quantities recommended. The designated Resident Engineer will make the final determination of items and quantities of ATC selectable tools and equipment components to be furnished.

## PART 2 - PRODUCTS AND MATERIALS

### 2.01 SPARE EQUIPMENT

- A. Furnish the following complete items and modules of spare equipment:
1. Two complete track switch operating layouts for each size and type of track switch included in this Contract, as indicated on the Contract Drawings. Each of these layouts shall include:
    - a. All items specified for a track switch operating layout in Section 16964, Track Switch Operating Layouts.
    - b. One complete set of special adjusting tools for switch-and-lock movements, and, if required by the manufacturer's switch machine layout, a switch circuit controller.
  2. Two complete signal layouts; one equipped for wall mounting, to include all wall-mounting brackets, and one equipped for ground mounting, to include mast, base, foundation and ladder or steps.
  3. One set of all special tools required for removing plugboard contacts, for removing plug-in relays, and for making any other special changes or adjustments to TCR equipment.
  4. One impedance bond of each of the eight frequency combination types (Part Numbers) normally used.
  5. One **WMATA Mini-Loop** inductive track loop and one 4-foot inductive track loop.
  6. Four ATP Track Modules as follows: two configured as Transmit/Receive Modules; one configured as an ATP Slave Transmitter Module, and; one configured as an ATP Receiver Module, all as described in Section 16953, ATP Track Modules.
  7. One complete and tested RTU System for training purposes. This unit shall have control, status, spare, and vacant capacities which are equivalent to the capacities of the largest, most complex working RTU delivered under this Contract. (The percentages of board slots which are equipped with control or status boards, active or spare, or that are left vacant, shall be the same as for the working unit, and the percentage of control and status points dedicated to train control or non-train control functions shall be the same as for the working unit.) The Contractor shall consult with the Authority and provide final details for this spare RTU System as specified by the Authority.
  8. One set of complete vital and non-vital processor modules, consisting of one of each type of processor used under this Contract to (collectively) perform all necessary Local and Remote functions of Station (STAP - Programmed Station Stopping and Train-to-Wayside Communications (TWC)), and Interlocking (NVIP and IVP) operations as described in Sections 16924, 16926, and 16928, respectively. The individual processors shall be of exactly the same type, and of the largest size, as their functional counterparts used in this Contract, complete with all PC boards. If different Train Control functions are performed by the same "type" of processor, i.e., by processors which are identical internally, except for the software, the Contractor shall provide only one of that type of processor.
  9. A recommended assortment of wire stripping and crimping tools and AAR nut wrenches. This assortment shall include a minimum of one of each tool required:
    - a. to crimp, insert, strip or extract any wire or cable used in this Contract, including 1000 KCMIL lugs and any other specialized connection.
    - b. for the removal and replacement of the jack-screws on plug coupler units.
  10. Two tubular electric snowmelter heating elements and two switch rod heater units for each type and size of switch layout equipped with snowmelters under this Contract.

### 2.02 SELECTABLE ATC TOOLS AND EQUIPMENT COMPONENTS

- A. The price list of recommended ATC tools and equipment components, from which the Authority may choose any quantity of any item or items, shall include, but not be limited to:
1. All major components of complete track switch operating layouts provided under this Contract, to include:
    - a. All items specified in Section 16964, Track Switch Operating Layouts.
    - b. A complete set of special adjusting tools for switch-and-lock movements, and, if required by the manufacturer's switch machine layout, a switch circuit controller.
  2. All components of signal layouts provided under this Contract.
  3. A complete set of all special tools required for removing plugboard contacts, for removing plug-in relays, and for making any other special changes or adjustments to TCR equipment.
  4. A recommended assortment of components such as relays, rectifiers, pushbuttons, transformers, ground detectors, fuses, circuit breakers, resistors, capacitors, reactors, control machine and PCB indicator LEDs, track and alarm indication panel LEDs, signal lamps, diodes and other solid state devices.
  5. A recommended assortment of telephone jacks, plugs and weatherproof covers for the TC Maintenance Telephone System.
  6. Individual impedance bonds of each of the eight frequency combination type (Part Number) normally used. Each of these eight impedance bonds shall be of the TWC type.
  7. A **WMATA Mini-Loop** inductive track loop and a 4-foot inductive track loop.
  8. Component parts, to the complete PC board level (including card cage and connectors), for each type of ATP Track Module provided under this Contract.
  9. Component parts, to the complete PC board level (including card cage and connectors), for each type of RTU PC Board provided under this Contract.
  10. Component Parts, to the complete PC board level (including card cages and connectors), for each unique type of PC Board for all processors provided under this Contract. (A CPU or memory card with unique EPROMs shall be considered to be a unique board.) These replacement boards shall be identical to, and interchangeable with, the boards of the working system.
  11. Rugged and portable carrying cases with hinged and latched covers and with a handle on top, to house and protect sets of replacement PC Boards and memory devices. Guides shall be fitted to the interior of these cases to hold each board and prevent contact between the components of any two boards. The bottom of the inside of each case shall be fitted with a one inch thick foam pad (closed cell neoprene) to protect the boards from impact during transit and storage. The resilience of this pad shall be selected to allow a reduction in pad thickness of about 25 percent due to the static weight of a board. The maximum weight of any case with a full complement of boards installed shall be twenty-five pounds. Provide a means of safely storing spare replacement memory devices within these cases, possibly in a compartment built into the case lid
  12. A recommended assortment of wire stripping and crimping tools and AAR nut wrenches.

## **PART 3 - EXECUTION**

### **3.01 DETERMINATION OF PRICES**

- A. Prices for items of Spare ATC Equipment (Part 2.01) and for items of Selectable ATC Tools and Equipment Components (Part 2.02) which are manufactured by the Contractor shall not exceed 85% of the Contractor's published catalog prices in effect at the time of ordering such equipment.
- B. Prices for items of Spare ATC Equipment (Part 2.01) and Selectable ATC Tools and

Equipment Components (Part 2.02) which are not manufactured by the Contractor shall not exceed 85% of the published catalog prices in effect at the time of ordering such equipment.

### **3.02 SELECTION**

- A. The designated Resident Engineer will select, from the approved price list of recommended ATC tools and equipment components, the quantities of individually selectable items of tools and equipment components to be furnished by the Contractor at the stated prices.

### **3.03 PREPARATION**

- A. All spare equipment and selectable tools and equipment components provided under this Section shall be packaged or treated to preclude deterioration of the product due to environmental conditions.
- B. All spare equipment, tools and equipment component items shall be properly packaged or crated by the Contractor to prevent damage to the items during shipment and storage.

### **3.04 DELIVERY**

- A. Upon notification by the Contractor of the delivery schedule, the designated Resident Engineer will furnish WMATA part numbers for all spare ATC equipment, tools and equipment components to be delivered. Each tool, equipment component and piece of spare equipment shall be identified by the Contractor with a WMATA identification number prior to delivery to the Authority.
- B. The Contractor shall deliver the spare ATC equipment items and the ATC tool and component items selected by the Authority to the address or addresses designated by the Authority no later than the Contract completion date specified in Division 1, Article IX, Commencement, Prosecution and Completion of Work.

### **3.05 MEASUREMENT FOR PAYMENT**

- A. Spare ATC equipment items will be measured for payment based upon the amount of specified spare equipment actually delivered and accepted.
- B. ATC selectable tool items and equipment component items will be measured for payment based upon the price list prices of the Authority-selected items actually delivered and accepted.

### **3.06 PAYMENT**

- A. The Contractor shall certify that the prices for the various items of ATC spare equipment and selectable ATC tools and equipment components which he manufactures do not exceed 85% of the Contractor's Catalog prices in effect at the time/date of bid opening and do not exceed 85% of the published prices for non-Contractor manufactured items as specified in Part 3.01, DETERMINATION OF PRICES.
- B. The Contractor agrees that if the cost of ATC Selectable Tools and Equipment Components ordered by the Authority is less than 3% (three percent) of the CPM price for ATC Material and Fabrication, a credit for the remaining amount will be taken by the Authority.
- C. The Sum of Payments for ATC Spare Equipment, will equal the CPM Lump Sum Price listed in the CPM prices under:
  - 1. ATC SPARE EQUIPMENT

- D. Payments for ATC Spare Equipment will be made as stipulated below:
  - 1. Upon delivery to and acceptance by the Authority of all items of ATC Spare Equipment required by the Authority
    - a. 100 Percent of the applicable CPM Price
  
- E. The Sum of Payments for the ATC Selectable Tool and Equipment Component Items will be determined by multiplying the number (quantity) of each Item selected times its applicable Price List Price, and totaling the results of these multiplications.
  
- F. Payments for ATC Selectable Tool and Equipment Component Items will be made as stipulated below:
  - 1. Upon delivery to the Authority and acceptance by the Authority of each Item of selectable ATC tools and components selected by the Authority
    - a. 100 Percent of the applicable Selectable Price List Item price

**END OF SECTION**

## **SECTION 16940**

### **ATC ELECTRICAL AND ELECTRONIC COMPONENTS AND MATERIAL** (Table of Contents)

#### **PART 1 GENERAL**

##### **1.01 SECTION INCLUDES**

- A. This SECTION lists the various 16940-series ATC Electrical and Electronic Component and Material Specification Sections:
1. Basic ATC Electrical and Electronic Component Requirements (Section 16941)
  2. Printed Circuit Cards (Section 16942)
  3. Vital Relays (Section 16943)
  4. Non-Vital relays and Timers (Section 16944)
  5. Plugboards and Cabinets for Relays and PC Cards (Section 16945)
  6. ATC Transformers (Section 16946)
  7. Ground Detectors (Section 16947)
  8. Plug Connectors (Section 16948)
  9. ATC Signal Wire and Cable (Section 16949)

**PART 2 - PRODUCTS**  
NOT USED

**PART 3 - EXECUTION**  
NOT USED

**END OF SECTION**

## SECTION 16941

### BASIC ATC ELECTRICAL AND ELECTRONIC COMPONENT REQUIREMENTS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies basic electrical requirements for ATC work, and the characteristics of certain basic electrical components which shall be furnished and installed by the Contractor.
- B. This Section specifies basic electronic requirements for ATC work, and the characteristics of certain basic electronic components which shall be furnished and installed by the Contractor.

##### 1.02 BASIC ELECTRICAL COMPONENT REQUIREMENTS

- A. All electrical components provided under this Contract shall be:
  - 1. New and free of manufacturing defects,
  - 2. Free of storage and handling damage,
  - 3. Clearly and permanently labeled with value and type identification
  - 4. Rated to operate at power, voltage, current and temperature levels at least 20 percent in excess of those to which the components will be subjected in service,
  - 5. Available from the manufacturer within 90 days of order, with a guaranteed supply for 20 years, and
  - 6. Capable of operating as required in the environmental conditions specified in Section 16914, Environmental Requirements.
- B. Any ATC module, device or appliance, furnished or provided under this Contract, which requires power to be supplied from a power supply system, regardless of system voltage, current, or frequency, shall be capable of operating satisfactorily and continuously at any voltage throughout the range of plus or minus 8 percent of the rated system voltage. The Contractor shall demonstrate conformance with this requirement in either the type acceptance test or the factory test.

##### 1.03 BASIC ELECTRONIC COMPONENT REQUIREMENTS

- A. All electronic components provided under this Contract shall be:
  - 1. New and free of manufacturing defects,
  - 2. Free of storage and handling damage,
  - 3. Clearly and permanently labeled with value and type identification,
  - 4. Rated to operate at power, voltage, current and temperature levels at least 20 percent in excess of those to which the components will be subjected to in service,
  - 5. Commercially available in the Washington, D.C. area unless otherwise approved by the designated Resident Engineer,
  - 6. Capable of operating as required in the environmental conditions specified in Section 16914, Environmental Requirements.

##### 1.04 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16914 Environmental Requirements
  - 2. Section 16921 ATC Power Distribution Systems
  - 3. Section 16931 ATC Maintenance and Test Facilities
  - 4. Section 16942 Printed Circuit Cards
  - 5. Section 16978 Miscellaneous Train Control Components and Materials

## **1.05 QUALITY ASSURANCE**

- A. Basic electrical components specified herein shall be factory tested by the Contractor. The Contractor shall see that factory tests are sufficiently rigorous to provide components which shall not prevent devices, circuits and systems in which the components are used from meeting the operating and reliability requirements specified herein.
- B. The basic electronic components specified herein shall be factory tested by the manufacturer. The Contractor shall select electronic components of sufficient quality to provide electronic modules which shall meet all of the operational requirements specified.
- C. Field testing of basic electrical and electronic components by the Contractor shall be accomplished as part of the field testing of the devices, circuits, electronic modules and systems in which these components are used.

## **1.06 ELECTRICAL COMPONENT SUBMITTALS**

- A. Submit scale drawings of each subtype of each basic electrical component specified herein.
- B. Submit technical data for each type of basic electrical component specified herein.
- C. Submit factory test reports for the basic electrical component specified herein.
- D. Samples of all solderless lugs and other terminals shall be submitted to the designated Resident Engineer for approval. Samples of the application of these solderless lugs and terminals to the wire the Contractor intends to use under this Contract shall be submitted for approval. The terminals and solderless lugs shall not be used until the Contractor has received approval for their use in writing from the designated Resident Engineer.

## **1.07 ELECTRONIC COMPONENT SUBMITTALS**

- A. Submit lists of the basic electronic components to be used in each type of electronic module provided under this Contract. These lists shall include:
  - 1. Name of module
  - 2. Name of component and quantity used
  - 3. Ratings and tolerances of component
  - 4. Manufacturer and model number of component
  - 5. Reliability (MTBF) data for component.
- B. Submit technical data for the compounds proposed to be used to impregnate transformers and inductors for use in ATC electronic modules. As an option, the Contractor shall submit technical data for the insulation and/or other materials he proposes for use in transformers and/or inductors instead of an impregnating compound.

## **PART 2 - PRODUCTS**

### **2.01 RESISTORS**

- A. All resistors, other than those required for electronic circuits;
  - 1. Shall be suitable for railway signaling circuits;
  - 2. Shall conform to all applicable recommendations of Part 14.2.15 (Recommended Design Criteria for Resistors) of the AREMA Signal Manual, and;
  - 3. Shall be subject to the approval of the designated Resident Engineer.
- B. Resistors used in electronic modules furnished under this Contract shall have a maximum tolerance of plus-or-minus 5 percent and shall be rated to dissipate a minimum of 1.5 times the maximum power they will be required to dissipate in operation.

## **2.02 CAPACITORS**

- A. Capacitors provided for power factor improvement of ATC power distribution systems shall be subject to the approval of the designated Resident Engineer.
- B. All other capacitors furnished under this Contract, except those of 10 mfd or less used in electronic modules, shall have a maximum tolerance of +75 percent, -50 percent and shall be rated for at least 1.5 times the maximum peak voltage to which they will be subjected in operation.
- C. Capacitors 10 mfd or less in value used in electronic modules furnished under this Contract shall have a maximum tolerance of plus-or-minus 10 percent except board-mounted power supply filter capacitors which may be plus-or-minus 20 percent. These capacitors shall be rated for at least 1.5 times the maximum peak voltage they will be subjected to in operation.

## **2.03 REACTORS AND INDUCTORS**

- A. All reactors, other than those required for electronic circuits;
  - 1. Shall conform to all applicable recommendations of Part 14.2.20 (Recommended Design Criteria for Air-Cooled Reactor) of the AREMA Signal Manual, and,
  - 2. Shall be subject to the approval of the designated Resident Engineer.
- B. All coils and chokes or other inductors used in electronic modules furnished under this Contract shall have windings impregnated with a compound approved by the designated Resident Engineer unless non-impregnated windings are approved by the designated Resident Engineer in writing.
- C. Inductors for use in electronic modules shall be rated to withstand a minimum of twice the maximum peak-to-peak voltage to which they will be subjected to in operation.

## **2.04 FUSES**

- A. Fuses shall be of the non-renewable, fibre-case, time-lag, fusion type unless otherwise authorized by the designated Resident Engineer.
- B. Fuses for installation on equipment racks and all fuses associated with power supplies shall be of the indicating type. This does not apply to AC track circuit fuses.
- C. Fuses shall be rated for a minimum of 125 percent of the maximum connected load and derated for an ambient operating temperature of 120 degrees F.

## **2.05 CIRCUIT BREAKERS**

- A. Provide circuit breakers which meet the following requirements:
  - 1. Each breaker shall have a short-circuit current interrupting rating in excess of the short-circuit current capability of the power supply to which it is connected.
  - 2. Each breaker shall have a nominal trip current rating of not less than 125 percent of the maximum steady current required by its load, derated for an ambient operating temperature of 120 degrees F., and in no case less than two times the current rating of the largest connected branch circuit current limiting device.
  - 3. When the breaker is utilized to supply power to loads with inrush current ratings higher than their steady current ratings, the selected breaker shall have a time-delay characteristic curve suitable for that load, according to the breaker manufacturer's recommendations.
  - 4. The voltage rating of the breaker shall not be less than the nominal voltage applied to the breaker.
  - 5. The breaker shall have endurance ratings equal to or greater than 5000 operations

- at rated voltage and current.
- 6. The voltage, current and current inrush ratings of the auxiliary trip-indicating contact of breakers so equipped (as specified on the Contract Drawings), shall be adequate for the trip-indicating device employed by the Contractor.
- 7. The breaker shall have mechanical characteristic ratings adequate for the service to which it is assigned. The Contractor shall select a breaker with characteristics designed to meet environmental conditions encountered in TCRs as stated in Section 16914, Environmental Conditions. The Contractor shall pay special attention to such factors as humidity, operating temperature, shock and vibration.
- 8. Circuit breakers shall be UL-listed.

**2.06 TERMINAL BLOCKS**

A. Basic Characteristics

- 1. Terminal blocks shall be modular, with solderless connections of the pressure clamp or wire wrap type. Connection resistance shall not exceed 0.0002 ohms. Terminals of the pressure clamp type shall be suitable for solid or stranded wire. Individual modular blocks shall have the following features:
  - 2. Built-in facility for affixing tags for identification.
  - 3. Terminals cross-connectable by shunt straps or sliding links as applicable.
  - 4. All metal parts, except wire wrap posts, recessed below the surface of the insulating material.

B. Insulation

- 1. Terminal blocks shall be rated for service at 600 volts minimum. Terminal block insulating material shall meet the requirements of ASTM Specification D-704, Type 6, where such specifications do not conflict with the following minimum requirements, which shall take precedence:
  - a. Material Pressure molded melamine or equal (non-carbonizing)
  - b. Water absorption Less than 0.75 percent after 24 hours immersion ASTM D-570
  - c. Impact strength 0.25 ft. lbs/in ASTM D-256
  - d. Tensile strength 4500 psi ASTM D-638
  - e. Compression strength 32 psi ASTM D-695
  - f. Dielectric strength 250 volts/mil at 100 degrees C ASTM D-48
  - g. Dielectric loss 0.10 at 1000 Hz ASTM D-48
  - h. Volume resistivity 10E11 ohms/cm ASTM D-48
  - i. Surface resistivity 0.3 x 10E12 ohms ASTM D-257
  - j. Heat distortion point 195 degrees F ASTM D-648
  - k. Creepage distance 0.5 inch  
(metal of one module to metal of adjacent module or to ground)

**2.07 TERMINALS FOR WIRES AND CABLES**

- A. All stranded signal wires of size 6 AWG or smaller to be terminated on terminal posts under this Contract shall be fitted with the approved crimp-on type terminal lugs furnished by the Contractor. These pre-insulated solderless lugs shall be of the following types as manufactured by Amp Inc. or approved equal.

<u>WIRE SIZE</u>	<u>INSULATION DIA.</u>	<u>CATALOG NO.</u>
18-22	.125	320554
14-16	.230	35349
10-12	.250	34855
8	.360	52041-1

- B. The Contractor shall make his own determination as to the adequacy of these terminals for the stud sizes and insulation diameters he intends to use under this Contract.
- C. Lugs for wires larger than No. 6 AWG shall be insulated with heat shrink tubing, subject to the approval of the designated Resident Engineer.

## **2.08 TRANSFORMERS**

- A. All transformers used in ATC electronic modules furnished under this Contract shall have windings impregnated with a compound approved by the designated Resident Engineer, unless non-impregnated windings are approved by the designated Resident Engineer in writing.
- B. Transformers used in ATC electronic modules shall not emit audible noise in excess of 40 dB referenced to 0.0002 dynes per sq. cm. at a distance of two feet while operating at rated voltage and load.

## **2.09 SEMICONDUCTOR DEVICES**

- A. All transistors, diodes, zener diodes or other semi-conductors furnished under this Contract shall carry a Joint Electron Device Engineering Council (JEDEC) number and shall be used within the published specifications for that number.
- B. All semiconductors furnished under this Contract shall be of the silicon type, unless otherwise approved by the designated Resident Engineer in writing.
- C. As an option to semiconductors carrying JEDEC numbers, the Contractor shall provide semiconductors approved by the designated Resident Engineer which are available from more than one manufacturer.
- D. Zener diodes used for voltage regulation or reference levels shall be of such rating that they will not be damaged if the entire load is removed abruptly, and shall have a zener voltage tolerance of plus-or-minus 5 percent or better.
- E. Zener diodes used for transient protection shall be of such rating that they will not be damaged in performing their function within all actual conditions encountered in the operating system.

## **2.10 INTEGRATED CIRCUITS**

- A. Integrated circuits shall not be damaged by the failure or partial failure of any one or any combination of the various supply voltages.
- B. Integrated circuits shall not be damaged by an overvoltage applied to the module of 1.4 times the normal supply voltage or by short circuits on the module inputs and/or outputs.
- C. Integrated circuits shall be immune to improper operation due to noise levels of up to 0.8 volts peak-to-peak on any module lead.

# **PART 3 - EXECUTION**

## **3.01 ELECTRICAL INSTALLATION**

- A. Install all basic electrical components of the correct type, size and rating required to provide the specified operation of the ATC system. This shall include replacement of basic electrical

components damaged or burned out in the course of installation and testing.

- B. Install fuses or circuit breakers of the correct type, size and rating to:
  - 1. Protect the electrical equipment and circuits from short-term and long-term overloads,
  - 2. Function properly as part of the ATC power distribution system protection, and,
  - 3. Function properly as part of the ATC failure alarm system (when so required by the Contract Drawings).
- C. Fuses shall be installed and removed using a suitable tool designed for such use. Provide a properly sized fuse puller within reach of every fuse in every rack containing fuses. The fuse pullers shall be attached to the racks at intervals not exceeding every third rack by means of non-conductive lanyards of the shortest length sufficient to reach all fuses in the three adjacent racks. These pullers shall be installed prior to commencement of any electrical test activities.
- D. Attach lugs to the ends of conductors in such a manner that the flexibility of the conductor will not be destroyed and the possibility of wire breakage at the terminal will be reduced to a minimum. Lugs shall be attached to the conductor with a tool made by the same manufacturer as the lug and/or terminal being used. The tool shall be equipped with a ratchet device which ensures proper application of the lug and which will not release until proper compression is attained. Tools which are excessively worn, damaged, abused, or show evidence of missing parts shall not be used. A minimum of one of each type of crimping tool shall be furnished as part of the requirements of Section 16931, Maintenance and Test Facilities.
- E. The Contractor shall use removable type contacts on plugboards for plug-in relays. The method of attaching the wires to the removable contacts shall be a solderless connection, except on plugboards for vital relays which may be solderless or soldered, and which shall be subject to the approval of the designated Resident Engineer.
- F. The method proposed for the application of solderless type terminals to wires of 1000 volt class shall be fully described and submitted to the designated Resident Engineer for approval.

### **3.02 ELECTRONIC INSTALLATION**

- A. Install all basic electronic components of the correct type, size and rating necessary to provide the specified operation of ATC electronic modules. This shall include replacement of basic electronic modules damaged or burned out in the course of installation and testing.

### **3.03 MEASUREMENT FOR PAYMENT**

- A. Basic electrical components will not be paid for separately. The cost of basic electrical components shall be included in the cost of the devices or circuits in which the components are used.
- B. Basic electronic components will not be paid for separately. The cost of basic electronic components shall be included in the cost of the electronic modules or circuits in which the components are used.

**END OF SECTION**

## SECTION 16942

### ATC - PRINTED CIRCUIT CARDS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the characteristics of printed circuit (PC) cards which shall be furnished and installed by the Contractor.
- B. The design and construction of PC cards of the same subsystem shall be of the same design. Cards of different subsystems shall be of the same design and construction wherever practicable.

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16926 Microprocessor Systems for Non-Vital Interlocking Functions
  - 2. Section 16941 Basic ATC Electrical and Electronic Component Requirements
  - 3. Section 16945 Plugboards and Cabinets for Relays and PC Cards

##### 1.03 QUALITY ASSURANCE

- A. All printed circuit cards shall be factory tested by the Contractor to determine their compliance with the Specifications for:
  - 1. Mechanical construction
  - 2. Electrical fabrication
  - 3. Circuit Logic
  - 4. Operation
- B. Each printed circuit card which meets all specified requirements shall be permanently marked with the Contractor's inspector's stamp
- C. The Contractor shall install only those PC cards which have passed the factory test and bear the inspector's stamp.

##### 1.04 SUBMITTALS

- A. The Contractor shall submit drawings showing the dimensions and layout of each basic type and size of printed circuit card he proposes to furnish.
- B. The Contractor shall submit factory test reports for all printed circuit cards furnished under this Contract for vital functions.

#### PART 2 - PRODUCTS

##### 2.01 BASIC DESIGN

- A. To the greatest extent possible and without causing an incompatibility with existing PC cards, the Contractor shall arrange the PC card circuitry in such a manner that terminals assigned to a given power supply, common, or ground shall be the same on each PC card in each subsystem.

- B. Where practical, the Contractor shall arrange the remaining PC card circuitry in such a manner that terminals assigned to a given function shall be the same on all PC cards in each subsystem.
- C. PC cards containing circuits performing logic functions which affect passenger safety or train routing shall be designed and circuited in such a way that removal or insertion of a PC card shall not create an unsafe condition.
- D. Printed circuit cards (boards) for use in non-vital interlocking processors shall be specially designed for "testability," i.e., they shall include test points and other testability facilities which shall enable fault isolation to the ambiguity levels specified in Section 16926.

## **2.02 CONSTRUCTION**

- A. Printed circuit cards shall be constructed of glass epoxy material meeting the requirements of NEMA Type FR-4.
- B. PC cards shall be of sufficient thickness to permit easy insertion and removal without buckling or breaking.
- C. PC cards shall be mechanically keyed to prevent incorrect interchange, or electrically interlocked to prevent operation in the event of incorrect interchange. They may also be interlocked through software programming.
- D. Conductor material shall be copper and shall be protected from exposure to air.
- E. Circuits shall be formed by etching. The etched circuits of vital PC cards shall conform exactly to the logic of the corresponding vital circuits contained in the Specifications. No external jumpers shall be used on vital PC cards provided under this Contract, either initially, or on replacement cards.
- F. PC cards shall be coated with an approved moisture-proofing compound.

## **2.03 COMPONENT MOUNTING**

- A. PC card-mounted-components which weigh more than one-half ounce or have a displacement of more than one-half cubic inch shall have a structural attachment to the card which is separate from the electrical attachment.

## **2.04 IDENTIFICATION**

- A. Each type of PC card shall be permanently and legibly marked with a unique number identifying that type of PC card.
- B. Each PC card shall be permanently and legibly marked with a unique serial number.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. Printed circuit cards shall be installed in 19-inch card file cabinets of the type specified in Section 16945, Plugboards and Cabinets for Relays and PC Cards, or in other special hardware approved by the designated Resident Engineer.

**3.02 MEASUREMENT FOR PAYMENT**

- A. Printed circuit cards will not be paid for separately. The cost of printed circuit cards shall be included in the cost of the various devices in which they are used.

**END OF SECTION**

## SECTION 16943

### ATC - VITAL RELAYS

#### PART 1 GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing and installation of all relays to be used in circuits which are vital to the safety of train control or operation. This shall include biased neutral relays, switch operating relays, switch overload relays, vital dc timer relays, vane type ac track relays and special purpose dc neutral relays.
- B. The Contractor shall furnish and install all such vital relays required to provide a complete working ATC system as specified herein.

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16916 Basic ATC Circuit Requirements.
  - 2. Section 16945 Plugboards and Cabinets for Relays and PC Cards
  - 3. Section 16955 Track and Alarm Indication Panels
  - 4. Section 16971 Racks and Cable Trays
  - 5. Section 16977 Tagging and Marking
  - 6. Section 16980 ATC Tests, Inspections and Quality Assurance

##### 1.03 QUALITY ASSURANCE

- A. Each vital relay shall be factory tested and the results legibly recorded on an applicable AAR "Office Record of Test" form, in conformance with the recommendations of the AREMA Signal Manual, Part 6.4.5 (Alternating Current Relays), and Part 6.4.1 (Direct Current Relays).
- B. The Contractor shall make a visual inspection of all vital relays and their plugboards at the time the relays are installed in the field to detect any obvious mechanical damage. The Contractor shall promptly replace any vital relays or plugboards which have sustained mechanical damage.
- C. Upon installation of the relays, the Contractor shall conduct field and breakdown tests in accordance with a test procedure approved by the designated Resident Engineer. Results of the field and breakdown tests shall be legibly recorded on approved Field and Breakdown Test Report forms.
- D. Operational tests shall be conducted as prescribed in the applicable Sections of Section 16980, ATC TESTS, INSPECTIONS AND QUALITY ASSURANCE.
- E. Type acceptance testing will be required for any solid state vital dc timer relay proposed for use under this Contract.

##### 1.04 SUBMITTALS

- A. The Contractor shall submit a detailed description of each type of vital relay he proposes to furnish on this Contract. He shall also indicate the circuits in which each type of relay is to be used. The Contractor shall obtain the designated Resident Engineer's written approval for each type of vital relay and its proposed application before proceeding with the

manufacture or procurement of the relays.

- B. The Contractor shall submit a Breakdown Test Procedure for field testing vital relays and a Breakdown Test Report form for recording the results thereof.
- C. Factory test reports for the associated wired plugboards shall accompany the relay test forms. These documents shall be required for "delivery approval" by the Engineer. See Part 3.03, Measurement for Partial Payments.
- D. Properly completed Field Test Report forms and Breakdown Test Reports shall be submitted to the Engineer within seven days of performance of the tests. These reports shall be required for "installation approval" by the designated Resident Engineer. See Part 3.03, Measurement for Partial Payments.
- E. The Contractor shall provide the Authority with 50 Relay Manuals. Each manual shall contain comprehensive descriptions and illustrations of each type of vital relay (and plugboard) provided under this Contract, to include such items as relay operation, adjustment, contact insertion and removal, testing and internal wiring diagrams.

#### **1.05 DELIVERY, STORAGE AND HANDLING**

- A. Vital relays shall be shipped separately from the racks in which they are to be mounted.

### **PART 2 - PRODUCTS**

#### **2.01 BASIC REQUIREMENTS**

- A. All vital relays supplied under this Contract shall be of the plug-in type furnished with transparent covers which are fire resistant and do not emit toxic gasses when exposed to fire.
- B. Provisions shall be included for mounting a typed or printed relay name tag on the front of this cover. The name tags shall be easily replaceable, but shall not come off due to vibration.
- C. Arc suppression for all vital dc relay coils shall be built into the relay or its plugboard, or shall be mounted to the back of the plugboard in a manner acceptable to the designated Resident Engineer. This arc suppression shall be of the capacitor-resistor type and shall prevent the load presented to a contact controlling that relay from exceeding the following values during steady state or switching conditions:

1.	Maximum volt-ampere load	15VA
2.	Maximum load current	1 ampere
3.	Maximum switched voltage	250 volts
- D. When three vital dc relays, suppressed as specified herein, are connected in parallel and operated from 28 volts, any vital relay front or back contact which breaks this load shall be capable of at least five million operations at this load without the contact resistance, measured with a 10 ma current, exceeding five ohms.
- E. All vital dc relays furnished shall conform to the applicable recommendations established by the AREMA Signal Manual, Part 6.2.1 (Tractive Armature DC Neutral Plug-in Relay) and Part 6.4.1 (DC Relays).
- F. All vital dc timer relays shall conform to the recommendations established by the applicable sections of Part 6.1.20 (Time Element Relay) of the AREMA Signal Manual.
- G. All ac track relays shall conform to the recommendations established by Part 6.4.5 (AC

Relays) and Part 6.1.35 (AC Induction Type Relay) of the AREMA Signal Manual.

- H. All vital relays shall be of the US&S PN-150 type or the GRS (Alstom Signaling Inc.) "B" type, or an approved equal.
- I. All vital relays and their plugboards shall be equipped with mechanical registration devices to prevent relays of the wrong style, contact arrangement, or operating characteristics from being mounted on any given plugboard. These registration devices shall be applied to the vital relays and their plugboards prior to mounting the relays on the plugboards for factory testing of rack wiring. See Section 16954.

## **2.02 BIASED NEUTRAL RELAYS**

- A. Biased neutral relays shall have a nominal operating voltage of 28 volts and shall be capable of operating continuously and successfully without resultant damage when voltages in a range from 18 to 35 volts inclusive are applied to their operating circuits.
- B. Biased neutral relays shall be so designed that their armature will not pick up when their permanent magnet is demagnetized. These relays shall also be designed so that a fault causing an interruption to the normal magnetic circuit of the relay shall not cause the relay armature to pick up while no current is being applied to the relay coils.
- C. Biased neutral relays shall be so designed that up to at least 50 times working energization applied for two seconds at both normal and reverse polarity will not affect their operating characteristics by more than two percent, and will not pick up their armature, i.e., "break" their back contacts and "make" their front contacts, on reverse polarity.
- D. Each biased neutral vital relay shall have a minimum of either:
  - 1. Four independent front contacts, two dependent front-back contacts, and two independent back contacts, or;
  - 2. Six dependent front-back contacts.
    - a. If option 2 is selected, the Contractor shall certify that any required circuit changes result in circuits which are at least as safe as those specified.
- E. All front contacts shall be silver-to-metalized carbon which conform to the recommendations of Part 6.2.1, paragraph 12, of the AREMA Signal Manual. Each biased neutral relay shall have a minimum of two silver-to-metalized carbon back contacts which conform to the same recommendations unless otherwise approved by the Engineer. In reviewing any proposed alternate back contact composition, the designated Resident Engineer will evaluate the composition, the overall relay characteristics, and the circuit applications of the contacts. It shall be the Contractor's responsibility to perform any tests required by the designated Resident Engineer and to provide all data requested by the designated Resident Engineer to prove that the alternate contact composition is at least as safe as the composition specified. Should an alternate back contact composition be approved and later be found to be unacceptable due to relay characteristics and/or circuit application, the Contractor shall provide relays as specified at no additional cost to the Authority.
- F. All biased neutral relays furnished under this Contract shall be identical.

## **2.03 SWITCH OPERATING RELAYS**

- A. Relays used to control the polarity of the operating current for switch-and-lock movements shall meet the following requirements in addition to the basic requirements specified above:
  - 1. The operating voltage range shall be from 22 to 35 volts inclusive, unless otherwise approved by the designated Resident Engineer.

2. A minimum of two front-back dependent contacts or two independent front contacts and two independent back contacts shall be provided.
  3. Each contact shall be equipped with a magnetic blow-out feature to effectively interrupt high currents and minimize contact wear. Each contact shall be capable of interrupting the normal switch-and-lock movement operating current 10,000 times without its resistance exceeding ten ohms measured at five amps.
- B. All switch operating relays furnished under this Contract shall be identical.

#### **2.04 SWITCH OVERLOAD RELAYS**

- A. Switch overload (stick) relays, used to detect an over-current condition during operation of a switch-and-lock movement, shall meet the following requirements in addition to the basic requirements specified above.
1. Relays shall be equipped with two separately wired, non-biased coils; one to be series connected in the switch operating circuit to detect over-current conditions, the other coil to be operated from nominal 28 Vdc and used as a holding coil in the overload stick circuit.
  2. Relays shall be furnished with a sufficient number of make-before-break contacts to perform the functions described in these Specifications. See Section 16916, Basic ATC Circuit Requirements.

#### **2.05 VITAL DC TIMER RELAYS**

- A. The timing elements of vital dc timer relays shall be electronically controlled. These relays shall be for nominal 28 volt dc operation, and shall operate successfully and without resulting damage with 26.5 volts to 31.5 volts applied to their operating circuits.
- B. Each vital dc timer relay shall be equipped with a timing adjustment device, external to its cover, which can be sealed. When sealed, it shall be impossible to adjust the timing interval. When the device is unsealed, the timing interval shall be adjustable from less than five seconds to more than 15 minutes. The adjustment shall be in increments of one second or less. Once adjusted, the timing interval shall repeat with an error of no more than  $\pm 5$  percent while the relay is operated at rated voltage  $\pm 5$  percent, and at  $\pm 50$  degrees F about the ambient temperature at which the interval was set. Alternately, once adjusted, the timing interval shall repeat with an error of no more than  $\pm 7$  percent when the ambient temperature is between -40 degrees C and +71 degrees C and while the relay is operated at nominal rated voltage  $\pm 5$  percent. For any voltage variation greater than  $\pm 5$  percent (but within the voltage limits of the bus) under the above temperature conditions, the timing interval shall repeat with an error which shall not exceed 15 percent.
- C. Each vital dc timer relay shall have a minimum of two dependent front-back contacts and two independent back contacts. All of the front contacts, and the independent back contacts shall be silver-to-metalized carbon contacts which conform to the recommendations of the AREMA Signal Manual, Part 6.2.1, paragraph 12.
- D. The vital timer relays shall begin their preset timing interval when energy is applied. All of the back contacts shall remain closed until the completion of the timing interval, at which time the back contacts shall open and the front contacts shall close. The front contacts shall then remain closed until energy is removed from the relay. When energy is removed from the relay, the front contacts shall open and the back contacts shall close. The relay shall be so designed and constructed that once energy has been removed from its input terminals, the full preset pick-up time interval shall elapse (when power is reapplied) before the relay can pick-up.
- E. All vital dc timer relays furnished under this Contract shall be identical and shall be

Microchron Timer Relays, Drawing No. 50800-100, GR.2, as manufactured by Alstom Signaling Inc. (formerly General Railway Signal Company) of Rochester, New York, or an approved equal.

- F. The Contractor shall furnish and install any timer repeater relays required by these Specifications, or necessary to meet the demands of the circuits, at no additional cost to the Authority.

## **2.06 AC TRACK RELAYS**

- A. Requirements For All AC Track Relays
  1. AC track relays shall be plug-in, two element, 60 Hz, vane type induction relays. They shall be capable of operating continuously and successfully without resultant damage with 100 to 135 volts, inclusive, applied to the local winding, and with 0.75 to 5.0 volts, inclusive, applied to the control winding.
  2. Each ac track relay shall have a minimum of two dependent front-back contacts. Each front contact shall be of the silver-to-metalized carbon type.
  3. These relays shall not be equipped with breathers.
  4. AC track relays shall conform to the recommendations established by Part 6.1.35 (AC Induction Relay) of the AREMA Signal Manual. These relays shall also conform to the recommendations established in Part 6.2.1 (Tractive Armature DC Plug-in Relay) of the AREMA Signal Manual insofar as base plate, plugboard and mounting are concerned.
  5. All ac track relays furnished under this Contract shall be identical.

## **2.07 SLOW RELEASE RELAYS**

- A. Vital slow release relays shall be of the direct current, neutral, tractive armature type and shall meet the following requirements in addition to the basic requirements specified above:
  1. Slow release relays shall have a nominal operating voltage of 28 volts dc and shall be capable of operating continuously and successfully without resultant damage when voltages in a range from 14 to 35 volts inclusive are applied to their operating circuits.
  2. Slow release relays shall have a minimum release time of 2.00 seconds at 28 volts dc input.
  3. Each slow release relay shall have a minimum of four independent front contacts, two independent back contacts, and two dependent front-back contacts.
  4. All contacts shall be silver-to-metalized carbon which conform to the recommendations of Part 6.2.1 (Tractive Armature DC Plug-in Relay), of the AREMA Signal Manual.
- B. All vital slow release relays furnished under this Contract shall be identical.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. All vital relays shall be rack mounted.
- B. Vital relays shall be arranged in racks as shown on approved rack arrangement plans. Relays shall be mounted at their preassigned locations on the racks only after the racks have been permanently mounted in the Train Control Room. The full complement of required mounting hardware to mount each relay.

### **3.02 SPECIAL REQUIREMENTS**

- A. Each biased neutral relay and each track relay, or their relay-repeater combinations, shall have at least one spare dependent front-back contact or one spare independent front and one spare independent back contact. This requirement shall be met throughout the installation and test period and at the conclusion of all field corrections.
- B. One Normal and one Reverse Switch Operating Relay shall be provided for each switch-and-lock movement.
- C. One Switch Overload Relay shall be provided for each switch-and-lock movement.
- D. Each track relay or track relay-repeater combination shall have one back contact wired out to a plug coupler for use by a track indication panel, as specified in Section 16956, Interlocking Control Panels. If the vital track relay is repeated by a non-vital logic relay, a contact on the non-vital repeater relay may be used for this purpose.
- E. No more than 90 percent of the available relay space in each relay rack shall be filled at the time of installation, and no more than 95 percent of the available relay space in each relay rack shall be filled upon completion of all field corrections and testing.
- F. Where vital relays are added to existing Train Control Room racks, the new relays shall be mounted in conformance with the existing relays, i.e., in such a manner that the fronts of all relays in the rack are in the same vertical plane.

### **3.03 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. Vital relays will be measured for partial payments on a unit basis. The "unit" shall include the relay, a completely wired and mounted plugboard of the proper type as specified in Section 16945, all the hardware required to register and mount the relay onto the plugboard, and the correct relay name tag.
- B. Factors which will be considered when measuring vital relays for partial payments will include:
  - 1. Delivery of the relays and their associated wired plugboards, and submission and approval of the required plugboard Factory Test Reports by the designated Resident Engineer.
  - 2. Installation of the relays, submission of the required Field Test Record forms and Breakdown Test Reports, and approval of the installation by the designated Resident Engineer.

**END OF SECTION**

## SECTION 16944

### ATC - NON-VITAL RELAYS AND TIMERS

#### PART 1 GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing and installation of relays and timers used in circuitry not considered vital to the safety of train control or operation. The Contractor shall furnish and install all such non-vital relays and timer equipment necessary to provide a complete working system under this Contract.

##### 1.02 DESCRIPTION

- A. Non-Vital Relays
  - 1. Non-vital relays are specified in three categories as follows:
    - a. Non-vital logic relays
    - b. Non-vital general purpose interfacing relays
    - c. Non-vital heavy duty interfacing relays
- B. Non-Vital Timers
  - 1. Non-vital timers shall be furnished for platform dwell time applications.

##### 1.03 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, work specified in the following Sections and documents:
  - 1. Section 16916 Basic ATC Circuit Requirements
  - 2. Section 16918 Special ATC Requirements for Specific Locations
  - 3. Section 16942 Printed Circuit Cards
  - 4. Section 16943 Vital Relays
  - 5. Section 16945 Plugboards and Cabinets for Relays and PC Cards
  - 6. Section 16971 Racks and Cable Trays
  - 7. Section 16980 ATC Tests, Inspections and Quality Assurance
  - 8. Factory Test Procedures approved by the designated Resident Engineer.

##### 1.04 QUALITY ASSURANCE

- A. The Contractor shall factory test non-vital relays and timers in accordance with the requirements of the applicable Factory Test Procedures approved by the designated Resident Engineer.
- B. The Contractor shall inspect the installation of non-vital relays and dwell timers in accordance with the requirements of the applicable Installation Inspection Procedure approved by the designated Resident Engineer

##### 1.05 SUBMITTALS

- A. The Contractor shall submit complete drawings and performance data for the non-vital dwell timers and for each type of non-vital relay he proposes to furnish under this Contract. The Contractor shall obtain the designated Resident Engineer's written approval for each type of required equipment before proceeding with the manufacture or procurement of that type of equipment.

- B. The Contractor shall submit a proposed Factory Test Procedure for each type of non-vital relay and timer approved for use under this Contract. These procedures shall be in conformance with the requirements specified in Section 16980, ATC Tests, Inspections and Quality Assurance.
- C. The Contractor shall submit an Installation Inspection Procedure for each type of non-vital relay and timer approved for use under this Contract. These procedures shall be in conformance with the requirements specified in Section 16980.
- D. The Contractor shall submit Factory Test Reports required by the Factory Test Procedure for non-vital relays and timers prior to the shipment of this material.

## **1.06 DELIVERY, STORAGE AND HANDLING**

- A. Non-vital logic relays, non-vital heavy duty interfacing relays, and non-vital timers, may be mounted and shipped in the racks or cabinets in which they are to be used. (See Sections 16945 and 16971.)
- B. Non-vital, general purpose interfacing relays shall be mounted and shipped on the printed circuit cards on which they are to be used. (See Section 16942.)

## **PART 2 - PRODUCTS**

### **2.01 BASIC NON-VITAL RELAY REQUIREMENTS**

- A. Covers and Name Tags
  - 1. Non-vital logic relays and non-vital heavy duty interfacing relays shall be of the plug-in type. Unless these relays are mounted in metal cabinets having non-combustible, transparent front plates, they shall be furnished with individual transparent covers which will not support combustion.
  - 2. Facilities shall be included for mounting a typed or printed relay name tag for each relay, either on the relay cover or on the relay cabinet front plate, as applicable. The name tag shall be easily replaceable, but shall not come off during normal service.
  - 3. The design of the individual relay covers and of the cabinet in which several relays are mounted shall permit viewing the relays without disassembly or other mechanical manipulation to determine whether each relay is picked up or dropped out.
- B. Arc Suppression
  - 1. Arc suppression for non-vital logic and heavy duty interfacing relay coils shall be built into the relays or into their plugboards. Arc suppression for non-vital, general purpose interfacing relay coils shall be built into the printed circuit cards on which the relays are mounted. (See Section 16916.)

### **2.02 NON-VITAL LOGIC RELAYS**

- A. Non-vital logic relays shall be plug-in, dc, neutral relays with a nominal operating voltage of 28 volts. These relays shall pick up with 18 volts, or more, applied to their operating circuit. These relays shall be capable of operating continuously with as much as 32 volts applied to their operating circuit.
- B. The typical pick up time for non-vital logic relays shall be less than 75 ms when energized with 18 volts. The typical drop out time for these relays shall be less than 100 ms when de-energized from 28 volts. These times shall be measured from the instant the switch applying the voltage closes until a front contact closes and from the instant the switch removing the voltage opens until a front contact opens.

- C. Each non-vital logic relay shall be equipped with a minimum of four front-back contacts. Each front-back contact shall be metal-to-metal and shall be capable of carrying one ampere continuously without the contact resistance, measured at this current level, exceeding 5 ohms. Each contact shall also be capable of breaking a 0.5 ampere dc resistive load at least 50 million times, at no less than 120 cycles per minute, without the contact resistance, as measured with a 10 ma current, exceeding 5 ohms. Non-vital logic relays shall be capable of electrical operation specified above after 100 million mechanical cycles without electrical load on the contacts.
- D. Arc suppression on the coils of each non-vital logic relay shall prevent the load presented to a contact controlling that relay from exceeding the following values during steady state or switching conditions:
 

1.	Maximum volt-ampere load	4.2VA
2.	Maximum load current	.15 ampere
3.	Maximum switched voltage	250 volts
- E. When three non-vital logic relays, suppressed as required by these Specifications, are connected in parallel and operated from 28 volts, a non-vital logic relay front or back contact which breaks this load shall be capable of at least 10 million operations at this load, at no less than 120 cycles per minute, without the contact resistance, as measured with a 10 ma current, exceeding 5 ohms.
- F. Non-vital logic relays shall conform to the recommendations established by the AREMA Signal Manual, Part 6.3.5 (Detachable DC Non-vital Relay), where the recommendations of the AREMA Signal Manual do not conflict with requirements specified herein.
- G. Non-vital logic relays shall be type "J," as manufactured by the Alstom Signaling, Inc., or type LP-100, as manufactured by the Union Switch & Signal Company, or an approved equal.
- H. All non-vital logic relays furnished under this Contract shall be identical.

**2.03 NON-VITAL GENERAL PURPOSE INTERFACING RELAYS**

- A. Non-vital general purpose interfacing relays shall be reed relays or crystal can relays, either type with hermetically sealed contacts and epoxy encapsulated coils. These relays shall be mounted on printed circuit cards described in Section 16942.
- B. Non-vital general purpose interfacing relays shall be dc relays with a nominal operating voltage of 28 volts. They shall pick up with 18 volts or more applied to their operating circuit, and must drop out when this voltage decreases below two volts at 20 degrees C.
- C. These relays shall be capable of operating continuously with as much as 32 volts applied to their operating circuit.
- D. The typical pick up time for non-vital general purpose interfacing relays shall be less than 25 ms when energized with 18 volts. The typical drop out time for these relays shall be less than 50 ms when de-energized from 28 volts. These times shall be measured from the instant the switch applying the voltage closes until a front contact closes and from the instant the switch removing the voltage opens until a front contact opens.
- E. All non-vital general purpose interfacing relays except those used for input and output interfacing of the RTU, shall be equipped with a minimum of two front contacts, one of which shall be used for an indication light circuit. Each contact shall be metal-to-metal and shall be capable of carrying and breaking a load with the following characteristics:

- |    |                          |              |
|----|--------------------------|--------------|
| 1. | Maximum volt-amp load    | 15VA         |
| 2. | Maximum load current     | 1 ampere     |
| 3. | Maximum switched voltage | 250 volts dc |
- F. Each contact shall be capable of breaking a resistive load with the above characteristics, or an inductive load suppressed so that at no time during steady state or switching conditions does the load exceed the above characteristics, at least 1.5 million times, at no less than 120 cycles per minute, without the contact resistance, measured at 10 ma, exceeding 3.0 ohms.
- G. Non-vital general purpose interfacing relays shall be capable of the electrical operation specified above after 10 million mechanical cycles without an electrical load on their contacts. Under all conditions, the minimum open contact resistance shall be 50 megohms at 400 volts dc and the maximum duration of contact bounce shall be 5.0 ms.
- H. Arc suppression on the coils of general purpose interfacing relays shall prevent the load presented to a contact controlling each relay from exceeding the following values during steady state or switching conditions:
- |    |                          |           |
|----|--------------------------|-----------|
| 1. | Maximum volt-ampere load | 15VA      |
| 2. | Maximum load current     | 1 ampere  |
| 3. | Maximum switched voltage | 250 volts |
- I. All non-vital general purpose interfacing relays used for non-RTU interfacing under this Contract shall be identical. Likewise, all non-vital general purpose interfacing relays used for RTU interfacing under this Contract shall be identical. All printed circuit card assemblies containing non-vital general purpose interfacing relays shall be identical.

#### 2.04 NON-VITAL HEAVY-DUTY INTERFACING RELAYS

- A. Non-vital heavy interfacing relays shall be plug-in, dc neutral relays with a nominal operating voltage of 28 volts. These relays shall pick up with 22 volts or more applied to their operating circuit, and must drop out when this voltage decreases below one volt. These relays shall be capable of operating continuously with as much as 32 volts applied to their operating circuit.
- B. The typical pick up time for non-vital heavy-duty interfacing relays shall be less than 35 ms when energized with 28 volts. The typical drop out time for these relays shall be less than 60 ms when de-energized from 28 volts. These times shall be measured from the instant the switch applying the voltage closes until a front contact closes and from the instant the switch removing the voltage opens until a front contact opens.
- C. Each non-vital heavy-duty interfacing relay shall be equipped with a minimum of two front-back contacts. Each contact shall be metal-to-metal and shall be capable of carrying and breaking a resistive or an inductive load which does not exceed the following characteristics one million times, at no less than 120 cycles per minute without the contact resistance, measured at 5 amps, exceeding one ohm:
- |    |   |              |
|----|---|--------------|
| 1. | Maximum continuous volt-amp load  | 200VA        |
| 2. | Maximum volt-amp load while relay contact is opening (transient due to inductive surge) | 350VA        |
| 3. | Maximum instantaneous load current  | 5 amps       |
| 4. | Maximum continuous load current   | 5 amps       |
| 5. | Maximum instantaneous switch voltage  | 100 volts dc |
- D. Each contact shall also be capable of carrying and breaking a resistive load or an inductive load which does not exceed the following characteristics five million times, at no less than

120 cycles per minute, without the contact resistance, measured at 0.5 amps, exceeding one ohm:

- |    |   |              |
|----|---|--------------|
| 1. | Maximum continuous volt-amp load  | 50VA         |
| 2. | Maximum volt-amp load while relay contact is opening (transient due to inductive surge) | 90VA         |
| 3. | Maximum instantaneous load current  | 1.25 amps    |
| 4. | Maximum continuous load current   | 1.25 amps    |
| 5. | Maximum instantaneous switch voltage  | 100 volts dc |

E. Arc suppression on the coils of each non-vital heavy interfacing relay shall prevent the load presented to a contact controlling that relay from exceeding the following values during steady state or switching conditions:

- |    |                          |           |
|----|--------------------------|-----------|
| 1. | Maximum volt-ampere load | 15VA      |
| 2. | Maximum load current     | 1 ampere  |
| 3. | Maximum switched voltage | 250 volts |

F. All non-vital heavy interfacing relays furnished under this Contract shall be identical.

## 2.05 DWELL TIMERS

A. Non-vital timers to control the dwell time of trains at station platforms shall be Series GP-60S, plug-in, automatic reset, delay/interval timers as manufactured by the Industrial Timer Division of the Esterline Corporation, or an approved equal.

B. Technical Specifications:

- |    |                   |   |
|----|-------------------|---|
| 1. | Operating Voltage | 120 Vac 60 Hz   |
| 2. | Timing Range      | 2 seconds to 60 seconds adjustable in one-second increments |
| 3. | Resetting Time    | Less than one second\                                       |
| 4. | Repeat Accuracy   | ±0.25 second  |
| 5. | Operating Life    | 5 x 10E6 operations minimum at rated load                   |

C. All dwell timers furnished under this Contract shall be identical.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

A. Logic Relays and Heavy-Duty Interfacing Relays

1. Non-vital logic relays and non-vital heavy interfacing relays shall be mounted in racks or metal cabinets as shown on approved plans. No more than 90 percent of the available relay space in each rack or cabinet shall be filled at the time of installation, and no more than 95 percent of the available relay space in each rack or cabinet shall be filled upon completion of all field corrections and testing.
2. Cabinets used to mount these relays shall have transparent front plates which do not support combustion. These cabinets shall be mounted in racks as specified in Section 16971.

B. General Purpose Interface Relays

1. Non-vital general purpose interfacing relays shall be mounted on printed circuit cards described in Section 16942.
2. Each printed circuit card on which non-vital general purpose interfacing relays are mounted shall have one indicator light mounted along the front edge of the card for

each relay in such a manner that the lights can be readily viewed for trouble shooting. The indicating light shall be operated by a contact on the relay so that it will be illuminated whenever the relay is picked up. Each indicating light shall be identified, both on the printed circuit card and on the transparent front plate of the card cabinet, with the name of the relay it indicates.

3. Groups of printed circuit cards on which non-vital general purpose interfacing relays are mounted shall be installed in metal cabinets that have transparent front plates or covers which do not support combustion. The design of the cabinets shall permit viewing the cards without disassembly or other mechanical manipulation to determine whether each relay indicator light is lighted.

C. Dwell Timers

1. The non-vital dwell timers shall be rack mounted.

### 3.02 SPECIAL REQUIREMENTS

- A. Each non-vital logic relay or logic relay-repeater combination shall have at least one spare dependent front-back contact. This requirement shall be met throughout the installation period and at the conclusion of field corrections and testing.
- B. When one or more non-vital logic relays are used as front contact repeaters for a vital track relay (or a vital track repeater relay), and none of the vital relay back contacts are wired to a plug coupler for use by a portable pen graph unit, one of the non-vital logic relay back contacts shall be wired for this purpose. See Section 16943, Vital Relays, paragraph 3.02, Special Requirements.

### 3.03 MEASUREMENT FOR PAYMENT

- A. Non-vital Logic Relays and Non-vital Heavy-Duty Interfacing Relays will be measured for payment on a unit basis. The unit shall include the relay, a completely wired and mounted plugboard of the proper type as specified in Section 16945, all the hardware required to mount the relay to the plugboard, and the correct relay name tag.
- B. Non-vital General Purpose Interfacing Relays will not be measured for payment separately, but will be considered to be part of the printed circuit cards on which they are mounted. See Section 16942.
- C. Dwell Timer Units will be measured for payment on a unit basis. The unit shall include the timer and all required wiring and mounting hardware.
- D. The following factors will be considered when measuring these items for partial payments:
  1. Delivery of the items by the Contractor and approval of their Factory Test Reports by the designated Resident Engineer.
  2. Installation of the items by the Contractor and approval of the installation by the designated Resident Engineer.

**END OF SECTION**

## SECTION 16945

### ATC - PLUGBOARDS AND CABINETS FOR RELAYS AND PC CARDS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing, installation, and wiring of various mounting devices for vital and non-vital relays and printed circuit cards.

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be lifted to, the following Sections:
  - 1. Section 16915 Basic ATC Equipment Requirements
  - 2. Section 16916 Basic ATC Circuit Requirements
  - 3. Section 16942 Printed Circuit Cards
  - 4. Section 16943 Vital Relays
  - 5. Section 16944 Non-Vital Relays and Timers
  - 6. Section 16949 Signal Wire and Cable
  - 7. Section 16948 Plug Connectors
  - 8. Section 16953 ATP Track Modules
  - 9. Section 16977 Tagging and Marking
  - 10. Section 16978 Miscellaneous Train Control Components and Materials

##### 1.03 QUALITY ASSURANCE

- A. The Contractor shall factory test all relay plugboards, all PC card connectors, and all cabinets for relays or printed circuit cards in the manner prescribed by factory test procedures previously approved by the designated Resident Engineer.
- B. The Contractor shall record the results of all such factory tests on the prescribed factory test report forms for submittal to the designated Resident Engineer.

##### 1.04 SUBMITTALS

- A. The Contractor shall submit the following for approval:
  - 1. Drawings and mechanical and electrical characteristics of each type of vital relay plugboard he proposes to furnish;
  - 2. Drawings and mechanical and electrical characteristics of each type of non-vital relay plugboard and cabinet he proposes to furnish;
  - 3. Drawings of each type of PC card connector and associated terminals he proposes to furnish;
  - 4. Drawings of the hardware and/or cabinets he proposes to use to mount PC cards;
  - 5. Drawings showing the proposed method of mounting each type of relay plugboard and relay or PC card cabinet to be used.
- B. The Contractor shall submit a factory test procedure for each type of relay plugboard, cabinet, or PC card connector he proposes to furnish.
- C. The Contractor shall submit properly filled out factory test reports for all plugboards and cabinets for relays and PC cards.

#### PART 2 - PRODUCTS

## **2.01 BASIC RELAY PLUGBOARD REQUIREMENTS**

- A. Plugboards for vital relays, non-vital logic relays, and non-vital heavy-duty interfacing relays shall have the following characteristics:
  - 1. The plugboard shall be designed for vertical mounting.
  - 2. The method of fastening the relay to the plugboard shall be designed to hold the relay securely in place and yet allow the relay to be easily removed.
  - 3. The plugboards shall be designed for the insertion of removable contacts attached to the external wiring.
  - 4. The plugboards shall be designed in such a manner that the removable contacts shall make direct contact with the relay coil leads and the relay contact springs.
  - 5. Arc suppression when required, shall be built into the relay plugboards or shall be mounted on the back of the plugboards in a manner acceptable to the designated Resident Engineer if it is not built into the relays themselves. (See Section 16916.)
  - 6. The back of each vital relay plugboard shall be equipped with a tag to indicate the nomenclature of the relay for which it is wired.
  - 7. Plugboards shall be identical for each type of plug-in relay.
  - 8. Plugboards for plug-in relays shall be designed for the insertion of removable contacts. The removable contacts shall be designed for connection to the wires by means of solder less connections. As an option for plugboards for vital relays only, the contacts shall be designed for soldered connections.
  
- B. Plugboards for vital relays shall have the following features in addition to those specified above:
  - 1. Plugboards for vital relays shall be equipped with a mechanical registration device to prevent relays of the wrong style, contact arrangement, or operating characteristic from being inserted.
  - 2. Vital relay plugboards shall be equipped with one voltage test post and one combination voltage-and-current test post unless otherwise specified. Vital relay plugboards for biased-neutral frequency-selection (QR) relays shall be equipped with one voltage test post and one combination voltage-and-current test post for the coil leads of each coil. Each current test post shall be so designed that ammeter leads can be attached and the test post opened to check the current without interrupting current flow to the relay coil involved.

## **2.02 PRINTED CIRCUIT CARD CONNECTORS**

- A. The types of printed circuit card connectors and their associated terminals shall be fully described in the Contractor's submittals to the designated Resident Engineer.
  
- B. PC card connector contacts shall have gold plating .000050 inch thick unless otherwise approved by the designated Resident Engineer.
  
- C. PC card connectors used as "mother board" connections shall be secured to the cabinet in such a manner that PC cards can be readily removed and inserted.

## **2.03 CABINETS**

- A. Cabinets used to house non-vital relays and printed circuit cards, shall be of rigid metal construction and shall be designed for mounting on standard 19-inch equipment racks.
  
- B. Cabinets shall be constructed of a non-corroding metal or shall be painted to the manufacturer's standard to match the finish of the equipment racks in which they are to be mounted.

- C. Each cabinet shall have a transparent front dust cover which will permit easy viewing of relay name tags and indication lights. This dust cover shall be made of a shatter-proof material which will not support combustion or emit poisonous or corrosive gases, even when exposed to flame or extreme heat. The covers shall be hinged or otherwise attached for easy removal from the cabinets. Fasteners for the front dust cover shall be of the rugged, metal, half-turn, twist-lock design. Light duty fasteners such as a plastic plunger and grommet design shall not be used. The rear cover shall either be hinged or secured with screws or fasteners of the half-turn, twist-lock design. The screws for fastening the rear cover shall have slotted heads with knurled finger grips and captive lockwashers for ease of assembly into a captive nut on the module. All fasteners shall be approved by the designated Resident Engineer.
- D. Relay and printed circuit board cabinets shall be equipped with plug connectors of the type specified in Section 16948, Plug Connectors. These plug connectors shall be mounted on the back panel of the cabinet. Internal wiring between these plug connectors and the relay plugboards or the PC card connectors shall be as specified for module wiring in Section 16949, Signal Wire and Cable. Sufficient slack shall be provided in this wiring to permit easy access to the relay plugboards and/or printed circuit card connectors mounted inside the cabinet when the cabinet back panels are open.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION OF RELAY PLUGBOARDS**

- A. Relay plugboards shall be factory installed and wired. A full complement of non-corroding fasteners shall be used to mount the plugboards on equipment racks or in relay cabinets.
- B. Wires shall be connected to the removable contacts in the manner specified by the manufacture of the contacts. Stripping and crimping tools recommended by the manufacturer of the contacts shall be used to make all wire-to-contact connections. A minimum of one of each type of crimping tool shall be furnished as specified in Section 16978.
- C. Each contact wire shall be of sufficient length to permit the contact to which it is connected to be moved to any contact position on the same relay plugboard. The wiring to each removable contact shall carry an approved tag indicating the relay contact number assigned to the wire.

#### **3.02 INSTALLATION OF RELAY AND PC CARD CABINETS**

- A. Cabinets for non-vital relays or printed circuit cards shall either be rack mounted prior to shipment or installed on the racks in the field. In either case a full complement of non-corroding mounting hardware shall be used to attach these modules to the rack in the manner previously approved by the designated Resident Engineer.
- B. Cabinets shall be marked with their identifying geometric coordinates as specified in Section 16977, Tagging and Marking.

#### **3.03 MEASUREMENT FOR PAYMENT**

- A. Relay plugboards and wiring will not be measured for payment separately, but will be included in the cost of the relays for which they are installed and wired. (See Sections 16943 and 16944.)

- B. Cabinets (if used) and/or hardware for mounting non-vital relay plugboards will not be measured for payment separately, but will be included in the cost of the relays which they support. (See Section 16944.)
- C. Cabinets and/or hardware for mounting printed circuit cards will not be measured for payment separately, but will be included in the cost of the devices in which the associated printed circuit cards are used.

**END OF SECTION**

**SECTION 16946  
ATC TRANSFORMERS**

**PART 1        GENERAL**

**1.01    SECTION INCLUDES**

- A.     This Section specifies the furnishing and installation of all transformers for ATC power distribution and isolation purposes, and for such other purposes as may be required to accomplish the functions specified herein.

**1.02    GENERAL REQUIREMENTS**

- A.     All ATC transformers provided under this Contract shall be of the air-cooled, dry type unless otherwise approved by the designated Resident Engineer.
- B.     The Contractor shall compute the sizes of all power and isolation transformers required to supply the loads imposed by other equipment he installs under this Contract. These computations shall be based upon a continuous duty cycle at maximum load, unless otherwise specified.
- C.     The Contractor shall furnish transformers having nameplate ratings at least 25 percent in excess of the maximum computed loads they are to supply.
- D.     Transformers shall be in accordance with the recommendations of Part 14.2.10 (Transformer, Dry Type) of the AREMA Signal Manual.

**1.03    RELATED SECTIONS**

- A.     Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1.     Section 16921             ATC Power Distribution Systems
  - 2.     Section 16952             DC Power Supplies
  - 3.     Section 16961             Audio Frequency Track and Loop Circuit Layouts
  - 4.     Section 16963             Power Frequency Track Circuit Layouts
  - 5.     Section 16965             Signal Layouts
  - 6.     Section 16980             ATC Tests, Inspections and Quality Assurance

**1.04    QUALITY ASSURANCE**

- A.     The Contractor shall factory test all ATC transformers furnished under this Contract.
- B.     The factory tests shall be made in accordance with the recommendations of Part 14.2.10 (Transformer Dry Type) of the AREMA Signal Manual and the provisions of Section 16980 of these Specifications.
- C.     Transformers shall be field tested as part of the overall testing of power distribution systems or of the other systems or devices in which the transformers are used.

**1.05    SUBMITTALS**

- A.     Submit the following to the designated Resident Engineer for approval prior to purchase or fabrication of the transformers:
  - 1.     Detailed copies of the computations used to determine the size of each transformer to be provided.
  - 2.     Scale drawings showing the physical characteristics of the proposed transformers and details of the method of mounting each type.

3. Internal wiring diagrams and performance data for each type and size of transformer proposed.
4. Technical data describing the basic materials proposed for transformer cores, coils, insulation, impregnating compound, and housings.

## **PART 2 PRODUCTS**

### **2.01 BASIC TRANSFORMER REQUIREMENTS**

- A. Cores
  1. Core laminations shall be grain oriented silicon steel.
  2. Maximum flux densities shall be substantially below saturation level.
  3. The core volume shall allow efficient transformer operation at 10 percent above the highest tap voltage.
  4. All laminations must be core plated or annealed, free of burrs and firmly butted.
  5. The core laminations shall be tightly clamped and compressed to provide quiet operation.
  6. Transformers shall not emit audible noise in excess of 50 dB (referenced to .0002 dynes per sq. cm.) at a distance of three feet while operating at rated voltage and load.
- B. Coils
  1. Coil conductors shall be continuous with terminations brazed or welded without auxiliary flux material.
  2. The entire core and coil assembly shall be predried by heat, impregnated with varnish or other approved compound, and cured at a minimum of 350 degrees F to reduce hot spots and seal out moisture.
  3. Coils shall be protected with an outer layer of glass tape or similar quality insulation.
- C. Insulation
  1. All ATC transformers furnished under this Contract, except those used in electronic modules, shall have insulation capable of withstanding 3000 volts DC between windings or from winding to core.
  2. The insulating material shall be subject to the approval of the designated Resident Engineer.
- D. Terminals
  1. All ATC transformers furnished under this Contract, except those used in electronic modules, shall be equipped with suitably insulated screw terminals or standard AAR binding posts for all primary and secondary lead wires.

### **2.02 TRACK TRANSFORMERS**

- A. The 60-Hz track circuit transformers required to supply power to track circuits at certain specified locations shall meet the following requirements in addition to those specified above:
  1. Track transformers shall have a nominal primary voltage of 120 volts, but shall also have primary winding taps and terminals for 110 and 115 volts.
  2. The secondary windings shall be provided with taps and terminals to supply voltages in one-volt increments up to a maximum of 15 volts.
  3. Track transformers shall be capable of carrying the track circuit load plus 25 percent, but in no case shall they be rated less than 300 VA.

### **2.03 SIGNAL HEAD TRANSFORMERS**

- A. Signal head transformers shall meet the requirements specified in Section 16965, Signal Layouts, in addition to the Basic Transformer Requirements specified above.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Power and isolation transformers shall be rack mounted unless otherwise specified or approved by the designated Resident Engineer.
- B. Use a full complement of non-corroding hardware to mount each transformer in the manner previously submitted by the Contractor and approved by the designated Resident Engineer. Mounting panels or brackets shall be rigidly designed so that they do not sag under the weight of the transformer.

### **3.02 MEASUREMENT FOR PAYMENT**

- A. Transformers will not be measured and paid for separately.
- B. The cost of track transformers shall be included in the cost of power frequency track circuit layouts (Section 16963).
- C. The cost of signal head transformers shall be included in the cost of signal layouts (Section 16965).
- D. The cost of transformers used in electronic devices shall be included in the costs of the associated electronic devices.
- E. The cost of transformers used in DC power supplies shall be included in the costs of the associated DC power supplies (Section 16952).
- F. The cost of power and isolation transformers used in power distribution systems shall be included in the cost of the associated power distribution systems (Section 16921).

**END OF SECTION**

## SECTION 16947

### ATC - GROUND DETECTORS

#### PART 1 GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing and installation of Ground Detectors for the uninterruptible, ungrounded, 120 Vac, and the ungrounded 28 Vdc energy buses in each Train Control Room.

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16922 Lightning/Surge Protection and Grounding Systems
  - 2. Section 16980 ATC Tests, Inspections and Quality Assurance

##### 1.03 QUALITY ASSURANCE

- A. Both the ac and dc ground detectors shall be subject to type-acceptance testing.
- B. The Contractor shall factory test all ground detectors for conformance with the requirements of these Specifications. Only those ground detectors meeting these requirements shall be shipped or installed.
- C. The Contractor shall field test all ground detectors as part of the respective TCR grounding systems. See Section 16922, Lightning/Surge Protection and Grounding Systems.

##### 1.04 SUBMITTALS

- A. The Contractor shall submit the following within 90 days of NTP for each type of ground detector he proposes to furnish:
  - 1. Mechanical drawings of all major components of the unit and the method of mounting the unit
  - 2. Electrical circuits
  - 3. Operating description
  - 4. Performance and sensitivity data
  - 5. Maintenance requirements
  - 6. Parts list
  - 7. Prototype unit for type-acceptance testing
  - 8. The Contractor shall submit a factory test report for each ground detector furnished under this Contract.

#### PART 2 - PRODUCTS

##### 2.01 BASIC DESIGN REQUIREMENTS

- A. The dc ground detector shall be sensitive enough to detect leakage currents from either terminal of the floating supply to ground through leakage paths having resistances throughout the range of zero to 10,000 ohms.
- B. The ac ground detector shall be at least sensitive enough to detect currents to ground (from either terminal of the floating supply) which would flow through an impedance of 2000 ohms.

- C. The ground detection schemes utilized shall allow the detectors to be immune to transient current flows that may be the result of charging distributed supply-to-ground capacitances. The detectors shall also be immune to induced power line ripple which may exist between the supply leads and ground.
- D. The ground detectors shall have a memory capability to provide an indication of a momentary or intermittent supply to ground leakage condition.
- E. The operation of the ground detectors shall not interfere with the operation of power, communication or ATC circuits or equipment.
- F. The ground detector circuits shall meet the fail-safe design criteria with respect to open circuits. Furthermore, the shorting or opening of any component part of the ground detector circuits shall be detectable.
- G. The "made" ground in the ground detecting part of the circuits shall be checked to validate its presence. This check shall be continuously made in a fail-safe manner.
- H. The ground detector repeater relays shall be vital relays and shall be energized when no ground is being or has been detected.
- I. The ground detector circuits shall operate stably over the specified temperature range and over a voltage range of from zero volts to 10 percent above the rated voltage of the power supply with which they are associated.

## **2.02 OPERATION AND INDICATIONS**

- A. It shall be necessary to manually reset either ground detector to its normal operating condition after a ground has been detected. The ground detector shall not remain in its normal indication position upon reset if the ground condition has not been eliminated.
- B. Each ground detector shall be equipped with two indicator lights:
  1. A white indicator to indicate that both buses are clear of grounds.
  2. A red indicator to indicate that a ground has occurred.
- C. Each ground detector shall be equipped with an electrically isolated contact to provide remote indication of a detected ground.
- D. Each ground detector shall be equipped with a three-position, center-off, momentary-contact test switch to check the operation of that detector by providing momentary leakage paths from ground to the buses being monitored. The impedance of these paths shall be 10,000 ohms for dc ground detectors and 2000 ohms for ac ground detectors.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. The Contractor shall install the ground detectors in the power racks in each TCR.
- B. Installation shall include all materials, labor and wiring required:
  1. to connect the ground detector ground references to the TCR ground system as shown on the Contract Drawings.
  2. to connect the ground detection indication contacts to the local RTU as shown on the Contract Drawings.
  3. to connect the ground detectors to the energy sources required to operate the

detectors and their local indication lights.

**3.02 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. The cost of Ground Detectors shall be included in the costs of Lightning/Surge Protection and Grounding Systems.
- B. Ground detectors will be measured for partial payments on a unit basis, based upon the number and type of such approved units actually furnished, installed, tested and accepted.

**END OF SECTION**

## SECTION 16948

### ATC - PLUG CONNECTORS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing and installation of multiple position plug connector assemblies required to connect multiconductor cables and/or individual wires to the internal wiring of racks, control panels or equipment modules.

##### 1.02 DESCRIPTION

- A. These assemblies shall hold and insulate individually mated, extractable pin-and-socket contacts which shall be mechanically crimped to individual wires or wire wrap pins.
- B. The connector assemblies shall be easily connected and disconnected by hand and shall be provided with mechanical locking and keying devices.
- C. Two basic types of connectors shall be furnished; a 28 contact, vital circuit type, and a 50 contact, non-vital circuit type.

##### 1.03 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16949 ATC Signal Wire and Cable
  - 2. Section 16978 Miscellaneous Train Control Components and Materials

##### 1.04 QUALITY ASSURANCE

- A. The following tests shall be made on six or more randomly selected plug connector assemblies at the start of the production run for this contract. The same tests shall be repeated on additional samples selected at intervals of no more than 500 plug connector assemblies as the production run continues.
  - 1. Each half of the plug connector assembly shall withstand for one minute, a dielectric strength test of 900 volts ac (RMS) applied between adjacent contacts and between the contacts and the other metallic parts of the connector assembly.
  - 2. A minimum of six randomly selected contacts shall have not less than ten pounds of retention after each contact has been inserted and extracted ten times using the applicable extraction tool. The force to dislodge the aged contacts from their cavities shall be measured and recorded after the eleventh insertion.
  - 3. The durability of the connector assemblies shall be measured by subjecting fully wired assemblies having a full complement of contacts to 500 cycles of mating and unmating, with the connectors being fully locked and unlocked during each cycle. After cycling as described above, the connector assemblies shall show no evidence of mechanical damage or missing parts.
  - 4. The mated connectors shall be vibrated in accordance with Method 204, Condition A of MIL-STD-202 with arrangements to monitor a test circuit with 100 ma flowing through the contacts. When tested as above, the connector assemblies shall show no evidence of cracking or breaking and there shall be no loss of continuity of any circuit greater than one microsecond.
  - 5. The mated connectors shall show no evidence of mechanical damage after being subjected to a shock test in accordance with Method 205, Condition C of MIL-STD-202, repeated three times, for a total of 18 drops.

6. The mated connectors shall show no evidence of mechanical damage after being subjected to temperature cycling in accordance with Method 107, Test Condition B of MIL-STE-202 with a minimum operating temperature of -55 degrees C and a maximum operating temperature of +150 degrees C.
  7. The unmated connectors shall show no evidence of corrosion and shall be capable of being mated and unmated after being subjected to a moisture environment in accordance with Method 106 of MIL-STD-202, except that 7b is not required.
- B. The Contractor shall provide a complete test report for each of the plug connector tests prescribed. These reports shall include the date, location, number and origin of specimens, type of test, test conditions, and results of the test.

## **1.05 SUBMITTALS**

- A. Complete drawings for each type of plug connector to be used shall be submitted to the designated Resident Engineer for approval prior to manufacture or procurement of the plug connectors. These drawings shall include complete parts lists and information required to order replacement parts. Drawings shall be required for the following components:
1. Molded plug connector blocks
  2. Protective shells for blocks
  3. All locking and keying devices
  4. Strain-relief clamping devices
  5. Extractable pin and socket contacts
- B. Three copies of all plug connector test reports shall be submitted to the designated Resident Engineer within seven days of the test performance.

## **PART 2 - PRODUCTS**

### **2.01 PLUG CONNECTOR ASSEMBLY**

- A. Each plug connector assembly shall consist of the following:
1. A two-part molded plastic connector block equipped to hold an appropriate number of solderless, pin-and-socket contacts.
  2. Devices for the mechanical locking and keying of the connector block halves.
  3. Protective shells for both connector block halves.
  4. A strain relief device for the external wiring portion of the connector assembly.
  5. Solderless, extractable pin-and-socket contacts.
  6. Where required, embedded wire wrap terminals for the internal wiring portion of the connector block.

### **2.02 CONNECTOR BLOCKS**

- A. The connector blocks shall consist of molded dielectric plastic shaped to accept the required number and types of contact pins, contact sockets and locking, keying and mounting devices. The dielectric material shall exhibit a minimum insulation resistance of 100 megohms as measured between adjacent pairs of contacts and between the accessory hardware and the closest contacts in each connector assembly half immediately after being exposed to 100 percent relative humidity at 120 degrees F for a period of at least 48 hours.
- B. The contact cavities shall be arranged in a rectangular grid configuration. The opening for each contact shall be uniquely identified by a coordinate molded into both the mating and wiring faces of each part of the connector block.
- C. The 28 contact, vital plug connector blocks shall provide a surface leakage distance of not

less than 1/4 inch between contacts and between the contacts and any other metallic part of the connector assembly.

### 2.03 LOCKING AND KEYING

- A. Each plug connector assembly shall include a device for mechanically locking the two mated parts together.
- B. Mechanical devices and facilities shall also be provided to allow the mating parts of connector assemblies to be keyed in such a manner that they cannot be coupled except when in the correct position relative to each other and cannot be coupled to the mating parts of other coupler assemblies keyed in a different pattern.

### 2.04 PROTECTION AND STRAIN RELIEF

- A. Each half of the plug connector block shall be protected by a metal shield which shall extend beyond the mating surface. These two shields shall overlap when the connector halves are coupled.
- B. The external wiring portion of each plug connector assembly shall be equipped with a device to grip the external wiring firmly in order to prevent strain on the plug connector contacts.

### 2.05 PIN AND SOCKET CONTACTS

- A. The pin and socket contacts shall be fabricated from commercial bronze or brass and plated with gold over nickel underplate. The retention springs of the pin and socket contacts shall be fabricated from stainless steel.
- B. The contacts shall be fabricated and classified in the required selection of sizes to accept wire sizes 16 through 22, AWG.
- C. Contact current rating and termination resistance shall meet the requirements of the following table with properly sized contacts applied to the wire sizes specified.

<u>WIRE SIZE (AWG)</u>	<u>16</u>	<u>18</u>	<u>20</u>	<u>22</u>
Minimum Current Rating (Amperes)	13.0	10.0	7.5	5.0
Maximum Termination Resistance (Milliohms) at rated current	1.7	2.0	2.7	4.0

- D. Contact termination resistance shall be measured in accordance with Method 307 of MIL-STD-202 at the rated current specified for each wire size.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. The 28 way, vital plug connector assembly shall be required where any vital circuits are to be interconnected and the 50 way, non-vital plug connector assembly shall be used where no vital circuits are to be interconnected.
- B. A plug connector may be dedicated to a single 50 or 30 conductor cable or it may be shared

by several cables or types of wire. When plug connectors are dedicated to single multiconductor cables, 20 percent of the wires and connector contacts shall be reserved for future working circuits.

- C. When a plug connector is assembled to a multiconductor cable, the strain relief device shall grip the cable outer sheath.
- D. When a vital plug connector is dedicated to a 30 conductor cable, all but two of the cable wires shall be terminated on connector contacts. The two extra wires shall be properly terminated and inserted into any contact cavity of the connector block. These wire ends shall be folded, taped, and stored under the strain-relief clamp for possible future service.
- E. When a non-vital plug connector is dedicated to a 50 conductor cable, each wire shall be terminated properly on a connector contact.
- F. In each case, a uniform scheme shall be followed in assigning specific cable wires to specific connector contacts.
- G. Where a full hand grasp is required to connect or disconnect a plug connector, a minimum of two inches of clear space shall be provided around the connector. A minimum of three-quarters of an inch of clear space shall be provided around connectors which can be connected or disconnected with thumb and fingertips only.
- H. Plug connectors shall be located and installed in such a manner that no part of the plug connector or its cable will extend beyond the wire routing as defined by the wire supports and in no circumstances shall the connector or its cable be permitted to protrude into an aisleway.
- I. Each plug connector assembly, as finally installed, shall be marked in such a manner that its mating halves shall be distinctly identified as being related to each other, but to no other plug connector assembly within the immediate area. These identification markings shall be applied in such a manner that they will not be obscured or worn off in normal use.
- J. Tools used to apply plug connector contacts to wire and tools used to extract contacts from the plug connector blocks shall be the size and type recommended by the manufacturer of the plug connector assemblies. A minimum of one of each type of these tools, to include one of each type of tool which may be necessary for the removal and/or replacement of the jack-screws shall be furnished under Section 16978.
- K. The Contractor shall furnish and install a mating blank plug coupler, complete with all accessory hardware, for each rack or module plug coupler installed as "future" or "spare."

### **3.02 MEASUREMENT FOR PAYMENT**

- A. Plug connectors will not be measured for payment separately. The costs thereof, at each TCR, shall be included in the costs for Plug Connected Cable Assemblies as specified in Section 16949, ATC Signal Wire and Cable.

**END OF SECTION**

## SECTION 16949

### ATC SIGNAL WIRE AND CABLE

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section includes specifications for the internal and external wire and cable to be used for the wayside ATC systems.

##### 1.02. INTERNAL SIGNAL WIRE AND CABLE

- A. This Section and the latest version of industry standard Wire and Cable Specification 940801, Interior Wire and Cable, specify the: furnishing; minimum design, manufacturing, performance and testing requirements, and; installation, of wire and cable for use in Train Control Rooms and inside train control equipment modules and housings. All internal wiring of ATC equipment and all intra-rack and inter-rack wire and cable in the TCRs shall conform to the requirements of this Section. The wire, cable, and insulation specified herein shall meet all requirements of the industry standard Wire and Cable Specification 940801 (W.&C.S. 940801). In addition, all internal wire and cable furnished by the Contractor shall be termite proof.
- B. Internal plug connected cable assemblies shall be as specified in this Section and in Section 16948, Plug Connectors.

##### 1.03 EXTERNAL SIGNAL WIRE AND CABLE

- A. This Section specifies the furnishing and installation of the three basic groups of cable required for ATC system wiring external to the Train Control Rooms and signal equipment housings. The basic external cable groups are:
  - 1. Signal Cables
  - 2. Special Control and Indication Cables
  - 3. Negative Propulsion Return Cables
- B. The intent of these Specifications is that the Contractor shall provide properly designed, well made and thoroughly tested external cable for vital and non-vital signal circuit, and negative propulsion return applications, which will render long service life to the Authority. External cable furnished by the Contractor shall be of rugged construction and shall have insulating and jacketing materials capable of a 40 year average service life. These cables shall be suitable for use in the environment to be encountered in the WMATA Rail Rapid Transit System and shall be certified for continuous operation at 90 degrees C in wet or dry locations, whether in trays, troughs, duct bank or conduits, above or below ground, or installed directly in the ground. All external cable furnished by the Contractor shall be termite proof.
- C. External signal cables supplied shall meet or exceed the requirements of the applicable standards of ICEA, NEMA, UL, ASTM, and the recommendations of Part 10.3.19 of the AREMA Signal Manual, with modifications and/or additions as detailed herein. Individual conductor insulation shall be Ethylene Propylene Rubber (EPR) as described in ICEA S-68-516.
- D. Multiconductor external signal cables permitted under this Contract shall have 2, 5, 7, 9, 12, 14, 19, 27, or 37 conductors. Multiconductor Special Control and Indication cables permitted under this Contract shall have 2, 6, 18, 25 or 50 twisted pairs.

- E. Multiconductor external signal cables containing more than two conductors shall contain 20-percent spare conductors or two spare conductors, whichever is greater. Local distribution cable shall contain ten percent spare conductors or one spare conductor, whichever is greater, except that two conductor local distribution cables (such as track circuit leads) will not require spare conductors.
- F. The requirements of these Specifications shall apply when there is a difference between the requirements of these Specifications and other specifications referenced herein.
- G. All insulation and jacketing compounds offered on this Contract by the cable manufacturer shall be formulated, applied, and, where applicable, vulcanized by the cable manufacturer in his own facilities, except as specified in Part 1.02.H. of this Section.
- H. If the cable manufacturer does not normally compound and otherwise prepare insulating materials in its own plant, it is acceptable for the cable manufacturer to have its proprietary formulations compounded and prepared at another, non-owned facility which complies with the manufacturing and end-product quality requirements specified herein.
- I. The Contractor may request the option, on an individual case basis, of providing, at no additional cost to the Authority, conduit, sleeves, pipe, core-boring or other special cable installation facilities approved by the designated Resident Engineer, which will either reduce the amount of cable required by providing more direct cable runs, or will provide access where no direct access was provided by others. (The Contractor shall inform the designated Resident Engineer at least two weeks in advance, and shall obtain approval at least one week in advance, of any core-boring work.)

#### 1.04 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16915 Basic ATC Equipment Requirements
  - 2. Section 16921 ATC Power Distribution Systems
  - 3. Section 16922 Lightning/Surge Protection and Grounding Systems
  - 4. Section 16923 TC Maintenance Telephone System
  - 5. Section 16925 Data Transmission System
  - 6. Section 16948 Plug Connectors
  - 7. Section 16955 Track and Alarm Indication Panels
  - 8. Section 16956 Interlocking Control Panels
  - 9. Section 16961 Audio Frequency Track and Loop Circuit Layouts
  - 10. Section 16962 Impedance Bond Layouts
  - 11. Section 16963 Power Frequency Track Circuit Layouts
  - 12. Section 16964 Track Switch Operating Layouts
  - 13. Section 16965 Signal Layouts
  - 14. Section 16967 Marker Coil Layouts
  - 15. Section 16968 Track Bonding Layouts
  - 16. Section 16969 Snowmelter Layouts
  - 17. Section 16971 Racks and Cable Trays
  - 18. Section 16973 Conduit
  - 19. Section 16977 Tagging and Marking
  - 20. Section 16978 Miscellaneous Train Control Components and Material
  - 21. Section 16980 ATC Tests, Inspections and Quality Assurance
  - 22. Section 16996 ATC Technical Appendix
  - 23. Section 16997 RTU SCAN SHEETS

**1.05 DOCUMENTS AND REFERENCES FOR INTERNAL SIGNAL WIRE**

- A. Applicable documents and references for internal signal wire shall be as specified in Section 3.0 of the industry standard Wire and Cable Specification 940801 (W.&C.S. 940801).

**1.06 INTERNAL SIGNAL WIRE DEFINITIONS**

- A. Internal Wire Definitions used in this Section shall be as specified in Section 4.0 of the industry standard Wire and Cable Specification 940801.

**1.07 QUALIFICATION AND CERTIFICATION SAMPLES FOR INTERNAL SIGNAL WIRE AND CABLE**

- A. In addition to meeting the Qualification and Certification requirements specified in Section 5.0 of the industry standard Wire and Cable Specification 940801, the cable manufacturer shall submit samples of each type of wire and cable to the Contractor.
- B. One-half of each qualification sample shall be retained for the Contractor's evaluation and the remaining one-half shall be forwarded to the designated Resident Engineer for final approval.

**1.08 SUBMITTALS FOR INTERNAL SIGNAL WIRE AND CABLE**

- A. Submit the following for the designated Resident Engineer's approval:
  - 1. Complete technical data describing the internal wire and cable which the Contractor proposes to finish in compliance with the requirements of this Section and W.&C.S. 940801.
  - 2. Qualification samples per Part 1.05 of this Section.
  - 3. Certified test reports of all breakdown tests conducted on finished internal cable as specified herein and W.&C.S. 940801.
  - 4. Certified test reports of all flame tests conducted on finished internal cable as specified herein and W.&C.S. 940801.

**1.09 QUALITY ASSURANCE FOR EXTERNAL SIGNAL WIRE AND CABLE**

- A. All cable manufacturers supplying external cable for this Contract must be approved by the designated Resident Engineer. The Contractor shall provide all of the data necessary for the demonstrations and tests required by the designated Resident Engineer. Approval will be based on the following criteria:
  - 1. Past Performance and Experience
    - a. The cable manufacturer must have had at least ten years of successful experience in supplying external cable to the railway/rapid transit industry for use as vital circuit signal control cable. A certified list of such installations spanning the past ten years shall be provided by each cable manufacturer desiring to be considered
  - 2. Quality Assurance Program
    - a. The manufacture of external cables in accordance with the requirements of these Specifications shall be accomplished in compliance with a Quality Assurance Program which meets the intent of the ASQC Standard C1-1985 corrected 1987, General Requirements for a Quality Program. Such compliance shall promote the production of properly designed, well made, and thoroughly tested cable which will render long service life to the user. Efficient methods of production, test, and product evaluation shall be used, but prime concern shall be focused on the necessary formal quality requirements to ensure that cable failure cannot



water tank tested after a minimum immersion time of six hours. For these tests, which shall be conducted per ICEA S-68-516, Section 6.27, test voltages shall be applied for a period of five minutes. While still immersed, the insulated conductors shall be subjected to the applicable test voltages as follows:

- 1) Minimum AC Test Voltage = 120 volts per mil of insulation thickness
- 2) Minimum DC Test Voltage = 375 volts per mil of insulation thickness

i. Voltage tests required for each reel of finished wire or cable after application to the shipping reel shall be either the AC Voltage test or the DC Voltage test. For these tests, which shall be conducted per ICEA S-68-516, Section 6.27, test voltages shall be applied for a period of five minutes. The appropriate minimum test voltages shall be as follows:

- 1) Minimum AC Test Voltage = 120 volts per mil of insulation thickness
- 2) Minimum DC Test Voltage = 375 volts per mil of insulation thickness

- C. The Authority reserves the right to witness any or all of the above tests and shall be notified two weeks in advance of each of the above tests.
- D. The Contractor shall prepare and certify a report for each of the above tests, to include all pertinent facts concerning the conditions and results of that test, plus the backup information required.

#### 1.10 SUBMITTALS FOR EXTERNAL WIRE

- A. The Contractor shall submit two certified copies of the following to the designated Resident Engineer for approval:
  1. A certified list of each cable manufacturer's railway/rapid transit signal installations for the past ten years and proof of same.
  2. Each cable manufacturer's (and, where applicable, each insulation and/or jacket material manufacturer's) Quality Assurance Program and proof of tenure.
  3. Full technical data for each type of cable which each cable manufacturer intends to supply.
  4. Qualification test reports for all qualification tests required by these Specifications.
  5. Monitoring procedures for the manufacture of cable and cable insulating material.
  6. Test procedures for cable and cable insulating material.
  7. Test reports for all qualification tests required by the designated Resident Engineer.
  8. Cable test and inspection reports for tests and inspections required and described by these Specifications.
  9. Test reports of cable tests conducted in the field in accordance with approved testing procedures.
- B. Information to be supplied by certified cable test reports for external cable shall include, but not be limited to, the following:
  1. Report number
  2. Date and location of test
  3. Description of test and test conditions
  4. Complete cable or wire description
  5. Lot, batch, and/or reel identification number
  6. Quantitative test results
  7. Summary of the test results
  8. Information on the components of the cable tested to include batch numbers and

- physical and electrical properties.
9. Traceability data.
- C. Submit the following completed, signed and notarized standard documents along with each Certified Test Report:
1. An Inspection Sheet for Wire and Cable
  2. A Physical Test Report.
- D. Submit detailed drawings showing the method and materials he intends to use to support cables in manholes, pull chambers, and on tunnel walls, as applicable.
- E. Submit to the designated Resident Engineer a program for maintaining and assuring the mechanical and electrical integrity of cable during cable pulls into pipe or conduit, as recommended by the cable manufacturer.
- F. Submit the manufacturer's recommended pulling tension for each type of cable to be used, for both cable grip and core hitch methods. The formula(s) for determining multi-cable pull calculations shall also be included. This information shall be submitted prior to any cable pull.
- G. Two copies of a "Pull Sheet" for each planned cable pull shall be submitted by the Contractor to the designated Resident Engineer at least one week prior to each actual cable pull. This "Pull Sheet" shall include the following information:
1. Date of proposed pull
  2. Cable nomenclature(s)
  3. Cable type(s)
  4. Cable routing
  5. Recommended pulling method
  6. Maximum recommended tension (as determined by the type of cable and pulling method, or, for multi-cable pulls, by calculation using the applicable formula(s).
  7. Room for recording the date of the actual pull, the maximum pull tension experienced during the pull, and any other pertinent information concerning the pull.
- H. Approved Pull Sheets will be returned to the Contractor prior to the proposed pull. The Contractor shall record the date of the actual pull, the actual method used, the maximum tension experienced during the pull, and other pertinent information, and resubmit the Pull Sheet(s) to the designated Resident Engineer.

#### **1.11 DELIVERY, STORAGE AND HANDLING FOR EXTERNAL CABLE**

- A. Shipping, storage and handling of external wire and cable shall be in accordance with the recommendations contained in Part 10.4.1 of the AREMA Signal Manual, the applicable cable manufacturer's recommendations, and as further specified herein.
- B. Cables shall be reeled in such a manner that both ends are accessible for testing on the reel. The Contractor shall ship each unit securely packaged and labeled for safe handling and shipment.
- C. Mark each single-conductor cable and each multiple-conductor cable to show UL label, size, voltage, manufacturer and number of conductors in accordance with NEC requirements.
- D. Store the cables in a dry and secure facility.
- E. During storage and handling prior to final conductor termination, cable ends shall be

sealed to prevent the entrance of moisture.

## **PART 2 - PRODUCTS**

### **2.01 INTERNAL WIRE CONDUCTORS**

- A. Stranded Internal Wire Conductors shall meet the requirements specified in Section 6.1 of the industry standard Wire and Cable Specification 940801.
- B. Solid Internal Wire Conductors shall meet the requirements specified in Section 6.2 of the industry standard Wire and Cable Specification 940801.

### **2.02 INTERNAL WIRE INSULATION**

- A. Material
  - 1. The insulation material for stranded and solid conductor internal wires shall be as specified in Section 7.1 of the industry standard Wire and Cable Specification 940801.
- B. Internal Wire Constructions
  - 1. Applicable internal wire constructions shall be as specified in Section 7.2 of the industry standard Wire and Cable Specification 940801.
- C. Insulation Thickness - Stranded and Solid Internal Wire
  - 1. Insulation thickness for stranded and solid wire shall be as specified in Section 7.3 of the industry standard Wire and Cable Specification 940801.
- D. Identification
  - 1. Internal Wire identification shall be as specified in Section 7.4 of the industry standard Wire and Cable Specification 940801.
- E. Internal Wire Performance Requirements
  - 1. Internal Wire performance requirements shall be as specified in Section 7.5 of the industry standard Wire and Cable Specification 940801.
- F. Color Coding of Internal Wires
  - 1. Color coding of internal wires shall be as specified in Section 7.6 of the industry standard Wire and Cable Specification 940801.

### **2.03 MULTICONDUCTOR INTERNAL CABLES**

- A. Multiconductor internal cable shall meet all requirements specified in Sections 8.0 through 8.9 (inclusive) of the industry standard Wire and Cable Specification 940801.

### **1.01 2.04 PACKAGING OF INTERNAL WIRE AND CABLE**

- A. Stranded internal wire and cable shall be packaged as specified in Sections 9.1 through 9.5, inclusive, of the industry standard Wire and Cable Specification 940801.

### **2.05 INDIVIDUAL EXTERNAL WIRE CONDUCTORS**

- A. General Requirements
  - 1. All conductors of external wire and cable, including the individual conductors of multi-conductor signal cables, shall be rated for continuous operation at 90

- degrees C in wet or dry locations, whether in trays, troughs or conduits above or below ground, exposed runs, or direct buried. The rated life shall be 40 years.
2. The insulation of external signal cables shall be either Type I or Type II ethylene propylene rubber. Individual conductors shall be insulated with either Type I EPR insulation per Part 2.05.C.1., or Type II EPR Insulation per Part 2.05.D. of this Section. All single conductor external signal cable shall have a jacket which meets the requirements of Part 2.05.D. of this Section.
  3. The insulation of negative propulsion return cables shall be Type II ethylene propylene rubber. Negative propulsion return cable shall have a jacket which meets the requirements of Part 2.05.E.2. of this Section.
  4. The insulation or insulation system of external wire and cable shall fit tightly to the conductor and shall be free-stripping. Insulation or insulation system thickness shall be in accordance with the following :

0 to 600V Service

Conductor Size(AWG)	Average Wall Thickness (mils)* (as determined by ICEA S-68-516 Section 6.4)
16 to 8	78
7 to 2	94
1 to 0000	109

601 to 2500V Service

Conductor Size (AWG)	Average Wall Thickness (mils)* (as determined by ICEA S-68-516 Section 6.4)
14 to 000 AWG	156
225 to 1000 KCMIL	190

\*The minimum wall thickness shall be not less than 90 percent of the average wall thickness.

- B. Conductor Requirements
1. Signal Conductors:
    - a. Material - soft annealed copper ASTM B-33
    - b. Construction - stranded ASTM B-8
    - c. Coating - continuous tin alloy(vital signal cable only) ASTM B-33
    - d. Resistance - ICEA S-68-516(NEMAWC 8) Section 2.5
    - e. Stranding:
      - 1) smaller than 14 AWG ASTM B-8  
Class B
      - 2) 14 AWG to 00 AWG ASTM B-8  
Class C
  2. Negative Propulsion Return Conductors:
    - a. Material - soft annealed copper ASTM B-33
    - b. Construction - stranded ASTM B-8

c.	Resistance -	ICEA S-68-516 (NEMA WC 8)Section 2.5
d.	Stranding:	
	1) Extra-flexible, 1000 KCMIL cable,	Class G stranded (427 Strands)
	2) Standard 1000 KCMIL cable,	Class D stranded. (127 Strands)
	3) 500 KCMIL	Ropelay

C. Type I Insulation & Insulation System Requirements

1.	Primary insulation:	
a.	Material - rubber-like:	
	1) vulcanized during construction	ICEA S-68-516(NEMA WC 8)
b.	Chlorine content, maximum % by weight	Zero
c.	Physical properties, original:	
	1) Tensile strength, minimum psi	1000
	2) Elongation at rupture, minimum %	25
	3) Tensile stress, minimum psi at 200% elongation	600
d.	Physical properties after:	
	aging 168 hours, air oven, at 121 degrees C:	
	1) Tensile strength, minimum % of original	8
	2) Elongation at rupture, minimum % of original	75
	3) Mechanical water absorption:	
	a) Maximum (mg/sq.in.) after 7 days immersion at 70 degrees C	8
2.	Jacket:	
a.	Material - rubber-like,	
	1) vulcanized during construction	ICEA S-68-516(NEMA WC 8)
b.	Chlorine content maximum % by weight	15
c.	Physical properties, original:	
	1) Tensile strength, minimum psi	1800
	2) Elongation at rupture, minimum %	300
	3) Tensile Stress, Minimum psi at 200% elongation	800
d.	Physical properties after	
	aging for 168 hours, air oven,at 121 degrees C:	
	1) Tensile strength ,minimum % of original	85
	2) Elongation at rupture ,minimum % of original	45
e.	Oil immersion, 18 hours,121 degrees C, ASTM No. 2 oil:	
	1) Tensile strength, minimum % of original	70
	2) Elongation at rupture minimum % of original	70
f.	Mechanical water absorption;	
	1) Maximum (mg/sq.in.)after 7 days immersion in 70 degrees C, water;	20
g.	Oxygen index min. (ASTM D2863)	30
h.	Smoke Density Rating, as per ASTM E662-83 using a 100 mil slab thickness:	
	1) Flaming Mode,	
	a) 4 minute	325 (max.)
	b) 20 minute peak	400 (max.)

- 2) Non-Flaming Mode
  - a) 4 minute 325 (max.)
  - b) 20 minute peak 480 (max.)
- 3. Primary Insulation and Jacket Combined:
  - a. Flame Resistance, as per ICEA S-19-81 Section 6.19.6 Pass
  - b. Cold Bend after -35 degrees C, for 3 hours:
    - 1) Mandrel diameter = 10 x O.D. No cracks
  - c. Insulation resistance constant (K)
    - 1) minimum at 15.6 degrees C 10,000
  - d. Surface resistivity,
    - 1) minimum 200,000 mega-ohms
- 4. Electrical stability in water as per ICEA S-68-516(NEMA WC 8) Section 6.21 Dielectric constant, SIC:
  - 1) Maximum after
    - a) 24 hours immersion 3.5 SIC
  - 2) Maximum increase between:
    - a) 1 and 14 days 2.0%
    - b) 7 and 14 days 1.5%
  - 3) Maximum Dielectric constant, SIC
    - a) between 1 and 90 days(with no failure) 3.6 SIC
- 5. Ozone resistance ICEA S-19-81, Part 6.8
  - a. After three hours exposure to an ozone concentration of not less than 0.025% nor more than 0.030% by volume No cracks

D. Type II Insulation Requirements

- 1. Material - rubber-like,
  - a. vulcanized during construction ICEA S-68-516(NEMA WC 8)
- 2. Chlorine content,
  - a. maximum % by weight Zero
- 3. Physical properties, original:
  - a. Tensile strength, minimum psi 1500
  - b. Elongation at rupture, minimum % of original 250
  - c. Tensile Stress, minimum psi at 200% elongation 800
- 4. Physical properties after aging 168 hours 80 degrees C, oxygen pressure, 300 psi:
  - a. Tensile strength, minimum % of original 85
  - b. Elongation at rupture, minimum % of original 75
- 5. After 20 hours, at 128 degrees C, Air pressure 80 psi:
  - a. Tensile strength, minimum % of original 75
  - b. Elongation at rupture, minimum % of original 50
- 6. Oil immersion ASTM No. 2 oil, 18 hours, 121 degrees
  - a. Tensile strength, minimum % of original 50
  - b. Elongation at rupture, minimum % of original 50
- 7. Mechanical water absorption
  - a. Maximum (mg/sq.in.) after 7 days immersion in 70 degrees C, water 15
- 8. Flame Resistance, as per ICEA S-19-81 Section 6.19.6 Pass
- 9. Smoke Density Rating, as per ASTM E-662-83, using a 100 mil slab thickness:
  - a. Flaming Mode,
    - 1) 4 minute 325 (max.)
    - 2) 20 minute peak 400 (max.)

- b. Non-Flaming Mode,
  - 1) 4 minute 325 (max.)
  - 2) 20 minute peak 480 (max.)
- 10. Cold Bend, -35 degrees C, for 3 hours:
  - a. Mandrell diameter = 10 x O.D. No cracks
- 11. Insulation resistance constant (K)
  - a. Minimum at 15.6 degrees C 25,000
- 12. Surface resistivity, minimum 200,000 mega-ohms
- 13. Electrical stability in water, as per ICEA S-68-516 (NEMA WC 8)  
Section 6.21: Dielectric constant, SIC:
  - a. Maximum
    - 1) after 24 hours immersion 3.5 SIC
    - 2) Maximum increase between:
      - a) 1 and 14 days 2.0%
      - b) 7 and 14 days 1.5%
    - 3) Maximum Dielectric constant, SIC
    - 4) between 1 and 90 days (with no failure) 3.6 SIC
- 14. Ozone resistance ICEA S-19-81, Part 6.8
  - a. After three hours exposure to an ozone concentration of not less than 0.025% nor more than 0.030% by volume No cracks

E. Requirements for Negative Propulsion Return Cables

- 1. Insulation:
  - a. Ethylene-propylene rubber, ICEA Type II, 90°C, suitable for dry and wet locations.
- 2. Jacket:
  - a. Overall nonmetallic jacket of chloro-sulfonated polyethylene, or cross-linked polyolefin.
  - b. Cross-linked polyolefin jacket shall comply with the following physical requirements. Properties tested in accordance with Part 6 of ICEA S-68-516 (NEMA WC8) where ethylene-propylene-rubber (EPR) insulation is used. Jacket material shall be free of PVC and PVC-based compounds.
    - 1) Physical Properties, original: (ASTM D-412)
    - 2) Tensile strength, minimum
      - a) pounds per square inch: 1800
    - 3) Elongation at rupture, minimum percent: 150
    - 4) Physical Properties after aging (ASTM D-573)  
168 hours, air oven test at 100 degrees C, +/-1 degree C:
      - a) Tensile strength, minimum
        - (1) percentage of unaged value: 100
      - b) Elongation at rupture, minimum
        - (1) percentage of unaged value: 80
  - c. Oil immersion: (ASTM D-471)
    - 1) 18 hours at 121 degrees C, +/-1 degree C, Table 1, No. 2 oil:
      - a) Tensile strength, minimum
        - (1) Percentage of unaged value: 80
      - b) Elongation at rupture, minimum
        - (1) Percentage of unaged value 80
  - d. Jacket materials other than cross-linked polyolefin shall comply with ICEA S-68-516 (NEMA WC8). Jacket material shall be free of PVC and PVC-based compounds.
  - e. Additional Requirements:
  - 1) Insulation Power Factor: Twopercent maximum.
  - f. Bond jacket to insulation to prevent moisture pockets.

- g. Minimum peel strength of the jacket from insulation: Four pounds per inch width.
- h. UL labeling: Type RHW-2.
- i. Flame Retardancy:
  - 1) Negative propulsion return cable shall demonstrate flame retardancy in accordance with vertical tray flame test, UL44.
- j. Applied Voltage Testing:
  - 1) Negative Propulsion Return Cables shall pass applied ac voltage dielectric strength test, i.e., six-hour water-immersion test, in accordance with paragraphs 3.5.2, and 6.27.1 of ICEA S-68-516.

**2.06 MULTICONDUCTOR SIGNAL CABLE**

**A. General**

- 1. Where used in this Section, the term "multiconductor signal cable" shall be interpreted as meaning any multiconductor cable applied in circuits, either vital or non-vital, the function of which has a direct effect upon the operation of trains or the ability of the system or subsystems to implement control upon the trains.
- 2. All multiconductor external signal cable shall be assembled from conductors which meet the requirements of Part 2.05, Individual External Wire Conductors.

**B. External Cable Assembly**

- 1. External Cable Assembly shall be per ICEA S-68-516 (NEMA WC 8), Part 5, unless otherwise specified herein.
- 2. Multiconductor external cable shall be made by assembling individual or twisted pairs of insulated conductors into a tight cylindrical form. Individual or twisted pairs in a cable having more than two wires shall be assembled helically and with adjacent layers wound in opposite directions.
- 3. Twisted pairs shall consist of two individually insulated conductors cabled with a length of lay as short as good construction will permit, but not longer than ten inches. Where more than one twisted pair is included, the length of lay of adjacent pairs shall differ by at least one-half inch.
- 4. Twisted pairs shall not be provided in combination with individual wires in the same cable.
- 5. Interstices shall be filled with moisture-resistant fillers.
- 6. A marker tape printed with sequential footages at one foot intervals shall be placed with the core. In addition to the footages this marker tape shall display, at intervals of no more than 30 inches, the name of the cable manufacturer and the year in which the cable was manufactured. The complete core assembly shall be wrapped with flame-retardant core tape or tapes with a 12.5-percent minimum lap. As an option, the core assembly shall be encased in an extruded, flame-retardant, moisture resistant, elastomeric cushion layer of the following thickness:

Core Diameter (inches)	Thickness (mils)
0 - 1.5	47
1.501 & larger	62

- 7. When an extruded rubber cushion layer is used, a pull cord shall be included beneath the cushion layer to provide for efficient stripping of this layer. This cord shall be compatible with all other components of the cable.
- 8. The taped cable core shall be covered with suitable bedding tape(s) when flat metal armor tape is used or with an inner jacket when corrugated metal armor tape is used.
- 9. Multiconductor external cables of 8 or more conductors shall have a 0.005-inch thick bronze (or an 0.008-inch thick zinc) corrugated or flat tape armor which shall be helically applied and overlapped approximately 12 percent. An overall separator tape shall be applied over the armor tape to protect the armor from attack by the overall jacket material.

10. The core, with or without armor, shall be covered with an outer jacket having a nominal thickness in accordance with ICEA S-68-516, Table 4-5. The inner jacket, when corrugated tape armor is used, shall be of sufficient thickness and so formulated to completely fill the voids on the underside of the corrugated metal tape. Cable jacketing material shall conform to the cable jacket specification contained herein.

C. Cable Identification and Conductor Markings

1. In addition to the internal sequential marker tape, the cables shall have the following information imprinted on the surface of the outer jacket at intervals of not more than three feet:
  - a. Manufacturer's name
  - b. Number of conductors
  - c. Size of conductors
  - d. Voltage rating
2. Individual conductors of multiconductor signal cables shall be imprinted at intervals of not more than six inches with the conductor identification. The identification shall be in the form of a number printed in both numeral form and English.
3. The cable and conductor markings shall be of a color which contrasts with the material on which it is imprinted and shall be of sufficient size to be easily recognized. The markings shall be permanent.

D. Cable Jacket Specification

- |    |   |                          |
|----|---|--------------------------|
| 1. | Material - rubber-like,<br>vulcanized during construction:                    | ICEA S-68-516(NEMA WC 8) |
| 2. | Chlorine content,   |                          |
|    | a. Maximum % by weight  | 15                       |
| 3. | Physical properties, original:  |                          |
|    | a. Tensile strength, minimum psi  | 1800                     |
|    | b. Elongation at rupture, minimum %   | 300                      |
|    | c. Tensile stress, minimum psi at 200% elongation                             | 800                      |
|    | d. Physical properties after aging<br>168 hours, 121 degrees C, air oven;     |                          |
|    | 1) Tensile strength, minimum % of original                                    | 8                        |
|    | 2) Elongation at rupture, minimum % of original                               | 45                       |
| 4. | Oil immersion, ASTM No. 2 oil: 18 hours, 121 degrees C,                       |                          |
|    | a. Tensile strength, minimum % of original                                    | 70                       |
|    | b. Elongation at rupture, minimum % of original                               | 70                       |
| 5. | Mechanical water absorption,  |                          |
|    | a. 7 days, 70 degrees C water:  |                          |
|    | 1) Maximum mg per square inch   | 20                       |
| 6. | Oxygen Index, minimum (ASTM D2863)  | 30                       |
| 7. | Smoke density rating, as per<br>ASTM E662-83, using a 100 mil slab thickness: |                          |
|    | a. Flaming Mode,  |                          |
|    | 1) 4 minute   | 325 (max.)               |
|    | 2) 20 minute peak   | 400 (max.)               |
|    | b. Non-Flaming Mode,  |                          |
|    | 1) 4 minute   | 325 (max.)               |
|    | 2) 20 minute peak   | 480 (max.)               |
| 8. | Cold bend, -35 degrees C, for 3 hours   |                          |
|    | a. Mandrel diameter = 10 x O.D.   | No cracks                |
| 9. | Surface resistivity, minimum  | 200,000 mega-ohms        |

E. Finished Cables

1. Finished cables having 7 or fewer conductors shall be capable of passing the IEEE Vertical Tray Flame Propagation Test, IEEE Standard 383-1974, or the UL-44 Vertical Tray Flame Test. The test sample shall have 7 or fewer conductors.
2. Finished cables having 8 or more conductors shall be capable of passing the following horizontal flame test. The test sample shall have 8 or more conductors.
  - a. Support a four-foot length of the multi-conductor cable specimen horizontally over a ribbon gas burner. The cable shall be supported parallel to the burner length in a manner which will maintain a spacing of 3/4 inch to two inches between the burner and the cable throughout the test.
  - b. The cable specimen shall be connected to a 3-wire, 120-240 volt circuit such that conductor-to-conductor and conductor-to-metal-armor-tape shorts will be indicated.
  - c. The flame temperature shall be monitored by a thermocouple and the flame temperature output regulated at 1400-1500 degrees F. The thermocouple shall be located in the flame close to, but not touching, the surface of the cable.
  - d. Readings of the thermocouple output shall be recorded each minute during the test.
  - e. The cable will be acceptable if no shorts are detected within six minutes after the flame is ignited.

**2.07 SPECIAL CONTROL AND INDICATION CABLE**

- A. Multiconductor cable applied in non-vital signal circuits, i.e., signal circuits the functions of which do not control or affect the ability to control operation of trains, shall conform to the following requirements:
 

1.	Minimum conductor size	19 AWG
2.	Chlorine content of insulation, maximum percent by weight	22
3.	Inner jacket	PE or PVC
4.	Metal tape armor, helically applied, bronze or zinc:	
a.	Minimum thickness	
1)	Bronze:	5 mils
2)	Zinc:	8 mils
5.	Minimum overlap	12%
6.	Outer jacket	PVC or XLPVC
7.	Chlorine content of jacketing materials,	
a.	maximum percent by weight	22
- B. Finished cables shall be capable of passing the IEEE Vertical Tray Flame Propagation Test set forth in IEEE Standard 383-1974, or the Vertical Tray Flame Test in UL 44. In all other respects, cable shall conform to ICEA Pub. No. S-61-402 (NEMA WC 5), Part 7.4, Type B.

**2.08 DISTRIBUTED COMPUTER INTERCONNECTION CABLE**

- A. Cable to be used to interconnect distributed computers of the computerized Automatic Train Control System shall be shielded twisted pair or shielded multiple twisted pair and shall meet the same conductor and insulation requirements as specified in Part 2.07 for Special Control and Indication Cable.

**PART 3 - EXECUTION**

**3.01 CONDUCTOR SIZING**

- A. All conductors shall be sized per the National Electrical Code, but shall not be smaller than the minimum conductor sizes specified herein.

- B. Conductors shall be sized in such a manner that voltage drop at the farthest load does not exceed 3 percent during peak load conditions.

### **3.02 INSTALLATION OF INTERNAL WIRE AND CABLE**

- A. Wires and cables shall be installed in a neat, workmanlike manner. Cables in trays or in troughs shall be laid therein and pulled into same. Cables shall be installed with a minimum amount of cross-over in the trays and troughs and shall not be pulled tightly around bends. All exposed wires and cables entering or leaving equipment racks or housings shall be protected from abrasion.
- B. Nylon straps shall be provided and installed for bundling and cabling of conductors where two or more single conductors of the same circuit are exposed in cable trays or cable troughs. Straps shall be installed approximately every five feet along the cable run. Wires of multiconductor cables exposed by the stripping of the cable jacket for terminations shall be trained in a neat, workmanlike manner and tied approximately every three inches with nylon straps.
- C. There shall be no point-to-point redundancy of wires for increased current capacity.
- D. Single conductor No. 14 wire shall be used for interconnecting switch machines and junction boxes, signal junction boxes and lamp compartments, and interconnecting other miscellaneous internal equipment.
- E. The smallest size wire the Contractor shall use for power cross termination and power wiring shall be No. 14 AWG. If No. 14 does not satisfy the load current requirements, the wire shall be increased in size according to the load requirements, at no additional cost to the Authority.

### **3.03 MODULE WIRING**

- A. Unless otherwise approved by the Engineer in writing, all module wiring shall be accomplished with solderless connections using solid wire for wire wrap connections, and stranded wire for crimped connections, as specified herein. Minimum wire size shall be No. 22 AWG for stranded wire and No. 24 AWG for solid wire.

### **3.04 RACK WIRING**

- A. Unless otherwise approved by the Engineer in writing, all rack wiring shall be accomplished with solderless connections. Wire used for rack wiring shall be stranded wire, minimum size No. 20 AWG, or multiconductor cables as specified herein. Where wires of a multiconductor cable are used for intra-rack wiring, any unused conductors shall be folded back and taped.
- B. Rack wiring shall be neatly tied into compact bundles. The main bundles and branches shall be secured to the racks in a manner which shall preclude physical damage due to pressure or abrasion and prevent the wire weight from being supported by the wire terminations, connections, or plug connectors. The arrangement of the wire bundles and cables shall be such that they do not interfere with visual inspection, troubleshooting, or repair of the rack mounted equipment.

### **3.05 RACK-TO-RACK WIRING**

- A. Rack-to-rack wiring shall be accomplished with solderless connections using multiconductor cables as specified herein, or single conductors tied into bundles to form unjacketed multiconductor cables. Unjacketed multiconductor cables shall consist of individual

conductors of size 14 AWG or larger wire and shall have a maximum tie spacing of six inches.

- B. All rack-to-rack wiring shall be routed via the overhead cable trays, with one foot of slack between the cable tray and each rack to which the cable is connected.
- C. Cables shall not be pulled into the cable trays, but shall be laid loosely and neatly in the trays with a minimum of crosses.
- D. Cable connections to all racks except the entrance racks shall be via plug connections. Cable connections to the entrance racks may be made in the same manner as field wiring.

### 3.06 HIGH VOLTAGE WIRING

- A. Internal wire used in circuits directly connected to the rails and internal wire used in circuits which operate at voltages in excess of 600 volts shall meet the requirements of this Section for 601 to 2500 volt service.

### 3.07 EXTERNAL CABLE APPLICATION

- A. The Contractor shall be responsible for the sizing of all conductors greater than the minimum size specified, due to the application of his design or due to voltage losses caused by long cable runs. Where special cable configurations and/or conductor sizes larger than the minimum sizes specified herein are necessary to meet the specified operating conditions of the system, the Contractor shall provide same at no additional cost to the Authority. Increases in required conductor size shall be in accordance with the National Electrical Code.
- B. If the Contractor's Train Control System requires the use of shielded cable, the Contractor shall provide the required shielded cables, and all additional related terminating required to provide single-point grounding of the shield at no additional cost to the Authority. The shielded cable supplied shall meet all requirements of these cable specifications and the shield shall be grounded as specified in Section 16922, Lightning/Surge Protection and Grounding Systems. Armor tape shall not be considered as a substitute for a shield. Each electrically contiguous segment of armor tape shall be grounded at only one point.
- C. The Contractor shall furnish and install the amounts of specified types of external cable necessary to provide a complete ATC System. The various types of cable and their applications shall include, but not be limited to, the following:
  - 1. GROUP I - SIGNAL CABLES
    - a. Audio Frequency Track Circuits
      - 1) An individual twisted pair cable, minimum size 16 AWG, shall be furnished and installed between the terminating point in the TCR and the associated trackside junction box for each impedance bond, track circuit bridging receiver unit, speed command transmission loop, or other inductive track loop device. When these devices are located more than 4000 feet from the TCR, the minimum wire size shall be No. 14 AWG. This twisted pair **shall not** be part of a multiple twisted-pair cable between the TCR and a wayside distribution box. **Individual twisted pairs for audio frequency track detection signals of the same track circuit (i.e. transmitter and receiver bond lines) shall be separated by at least two inches for any parallel length exceeding 700 feet. A grounded metal separator may be substituted for the two inch separation in cable troughs.**
      - 2) Track cable leads for impedance bonds and speed command devices shall always terminate in an adjacent wayside junction box and then continue as specified to the track circuit or speed

- transmission device.
- 3) In direct fixation construction, where the cable is installed in conduit between the junction box and impedance bond or speed command device, a continuation of twisted pair No. 14 or No. 16 AWG shall be used.
  - 4) In ballast construction, the cable between junction box and impedance bond and/or speed command device shall consist of No. 14 or No. 16 twisted pair cable (as applicable), installed inside rubber hose of the type specified in Section 16961, Audio Frequency Track and Loop Circuit Layouts, or in conduit along the edge of the crosstie.
  - 5) The individual cables between a terminating receiver wayside junction box and the running rails shall be 1000-volt class cable, minimum size No. 6 AWG.
  - 6) The Contractor shall also furnish and install one spare twisted pair cable, identical to that specified for AF track circuit devices, along each main track between successive Train Control Rooms. The spare cable for each track between consecutive TCRs shall be terminated in both TCRs and shall be intermediately terminated in wayside junction boxes associated with AF track and speed command devices for that track. **Wherever feasible, the spare cable shall be provided a service loop at each intermediate junction box without actually entering the junction box. At locations where the service loop is not feasible the spare cable shall be terminated in the junction box and the slider straps left in the open position.**
- b. Speed Command Loops
- 1) A single conductor, size 10 AWG cable shall be installed adjacent to the running rails in a loop configuration, as shown on the Contract Drawings, to provide for the transmission of speed commands through interlockings, as required. The loops so formed shall be transposed, as required, to minimize coupling to the rails.
  - 2) The No. 10 AWG cable used for speed command loops in interlockings shall have 600 volt insulation and be encased in hose. See Section 16961, Audio Frequency Track and Loop Circuit Layouts.
  - 3) Where the No. 10 AWG loop wires serve as leads between the track loop itself, and;
    - a) an adjacent wayside junction box; or
    - b) an impedance-matching transformer they shall be twisted to minimize induction radiation and interference.
  - 4) Speed Command Loop control wires from the Train Control Room to a wayside junction box shall be twisted pair, minimum size 14 AWG. See also Part 3.07.C.(GROUP I),9., Interlocking Control Distribution, of this Section.
- c. TC Maintenance Telephone
- 1) Size No.16 AWG twisted pair cable, identical to that used for AF track circuits, shall be furnished and installed to connect all telephone jacks of the TC Maintenance Telephone System along the wayside. A separate cable of this type shall be installed along each main track to connect the telephone jacks mounted in train control equipment along that track. See Section 16923, TC Maintenance Telephone System, and the Contract Drawings.
- d. Power Frequency Track Circuits
- 1) One-thousand-volt-class single conductor cable shall be furnished and installed for 60-Hz track circuits. The only exception is that, in areas of high concentration of 60-Hz track leads, these circuits may

- be accumulated into a dedicated 1000-volt-class multiconductor cable between the TCR and the wayside distribution junction box.
- 2) Cable for the feed end of each 60-Hz track circuit shall be minimum size No. 10 AWG. Cable for the relay end of such track circuits shall be minimum size No. 14 AWG from the TCR to the wayside junction box.
  - 3) Feed end track circuit leads extending more than 400 feet and relay end track circuit leads extending more than 1000 feet shall be increased in conductor size to compensate for the additional cable length resistance losses.
  - 4) The cables between the wayside junction box and the running rail connections shall be single conductor, size 10 AWG, 1000 volt class, for both direct fixation and ballast construction.
  - 5) Cable used for 60-Hz track circuit signal rail jumpers in crossovers shall be single conductor size 6 AWG, 1000-volt class, as shown on the Contract Drawings. The long signal-rail jumper used to connect the two "halves" of the signal rail in a diamond or universal crossover 60-Hz track circuit shall be installed in schedule 80 F.R.E. conduit.
- e. Line Circuit Cable
- 1) The Contractor shall furnish and install one or more 27 conductor, minimum size 14 AWG cables, as required, for line circuits between consecutive TCRs for the route segment included in this Contract, and between the first TCR for the route segment included in this Contract and the TCRs at the tie-in locations with the existing ATC System.
- f. Station Stop Markers
- 1) A five conductor, size 14 AWG cable shall be furnished and installed between the TCR and each variable frequency marker coil junction box. A three-conductor, size 16 AWG twisted cable shall be furnished and installed between each variable frequency marker coil tuner unit and its associated junction box. See Section 16967, Marker Coil Layouts.
- g. Controlled Signals
- 1) A seven conductor, size 14 AWG cable shall be furnished and installed between each controlled signal and its associated Train Control Room or wayside distribution box. See Section 16965, Signal Layouts.
- h. Switch-and-Lock Movements
- 1) The cables to be furnished and installed between each switch junction box and the TCR (or an interlocking distribution junction box) shall be a single seven conductor (minimum size 14 AWG) for control and indication and a single five conductor (minimum size 10 AWG) for operation, or one composite cable (made up of two or more minimum size 10 AWG conductors) for operation, plus ten or more (minimum size 14 AWG) conductors for control, indication and spares. The minimum size of the two conductors for operation shall be increased to size 8 AWG if the distance from the switch junction box (or interlocking distribution junction box) to the TCR is more than 400 ft., and shall be increased to size 6 AWG if this distance exceeds 1000 ft. See Section 16964, Track Switch Operating Layouts.
- i. Interlocking Control Distribution
- 1) As an alternative, the Contractor shall furnish and install one or more multiconductor signal cables, each consisting of six twisted pairs, size 14 AWG, assembled as described in Part 2.02.B, between a distribution junction box for each interlocking, and its associated

- TCR. These cables shall be used for the various speed command inductive track loops required by the interlocking.
- 2) As an alternative, the Contractor shall furnish and install one or more of the following multiconductor signal cables between each interlocking distribution junction box and its associated TCR to consolidate control, operation, and indication wiring:
    - a) 12c No. 14
    - b) 19c No. 14
    - c) 5c No. 10
    - d) 7c No. 1
- j. Marker Signals
    - 1) A five conductor, size 14 AWG cable shall be furnished and installed between each marker signal and its associated Train Control Room or wayside distribution box. See Section 16965, Signal Layouts.
  - k. Route Selection Pushbuttons
    - 1) A seven or twelve conductor, size 14 AWG cable, as required, shall be furnished and installed between each route selection pushbutton and its associated wayside junction box or distribution box, or the TCR. See Section 16966, Wayside Pushbutton Layouts.
  - l. Snowmelter Control and Indication
    - 1) A nine conductor, size 14 AWG cable shall be furnished and installed between the TCR and each snowmelter control case for control and indication purposes, and for energization of the SM case heaters. See Section 16969, Snowmelter Layouts.
  - m. Snowmelter Energy Supply
    - 1) The Contractor shall furnish and install a single conductor, No. 1 AWG (minimum size), 1000-volt-class underground cable between the propulsion power contact rail and the snowmelter control case via the contact rail Fuse Box.
  - n. Snowmelter Heating Elements
    - 1) The Contractor shall furnish and install:
      - a) A single conductor, size 6 AWG, 1000-volt-class underground cable between the snowmelter control housing and each running-rail snowmelter heating element controlled from that housing, and;
      - b) A single conductor, size 10 AWG, 1000-volt-class underground cable between the snowmelter control housing and each switch rod heater unit controlled from that housing.
    - 2) Maximum length for each of these cables shall be 75 feet unless otherwise authorized in writing by the Engineer. See Section 16969, Snowmelter Layouts, and the Contract Drawings.
  - o. Next Train Sign Control Cable
    - 1) The Contractor shall furnish and install a five conductor, minimum size 14 AWG cable from the TCR to the applicable AC Service Room in each Terminal Station. The routing for each of these cables shall be as previously approved by the designated Resident Engineer.
2. GROUP II - SPECIAL CONTROL AND INDICATION CABLE
    - a. Multiconductor Special Control and Indication Cable, minimum size 19 AWG, for use by the Data Transmission System, shall be furnished and installed from TCRs to DTS junction boxes (cabinets) furnished by other disciplines at certain locations(As Applicable) to meet the minimum twisted pair requirements shown below.
      - 1) Traction Power Substation (SS) 100 Twisted-Pair
      - 2) AC Service Room (Near) (or Single) 75 Twisted-Pair

- |     |   |                  |
|-----|---|------------------|
| 3)  | AC Service Room (Far)   | 50 Twisted-Pair  |
| 4)  | Tie Breaker Station (TBS)   | 31 Twisted-Pair* |
| 5)  | Jet Fan Control Room (JFC)  | 31 Twisted-Pair* |
| 6)  | Fan Shaft (FS)  | 25 Twisted-Pair  |
| 7)  | Vent Shaft (VS)   | 6 Twisted-Pair   |
| 8)  | Sewage Ejector (SEJ)  | 6 Twisted-Pair   |
| 9)  | Drainage Pumping Station (DPS)  | 6 Twisted-Pair   |
| 10) | Sump Pump (Special Locations only)                                      | 6 Twisted-Pair   |
| 11) | *The cables used shall be limited to 2, 6, 18, 25 and 50 Twisted Pairs. |                  |
- b. The Contractor shall install a 25 twisted-pair, Special Control and Indication cable between the TCR entrance rack and the associated TC/COMM Interface Cabinet (by others) at each TCR newly equipped with an RTU under this Contract. See Section 16925, Data Transmission System (DTS).
  - c. The ATC Subcontractor shall furnish and install a two-pair, solid-conductor, telephone-type cable between the RTU in each new TCR and the associated Main Distribution Frame (MDF) (furnished by others in the Communications Equipment Room), leaving sufficient wire at the MDF end for proper termination by the Communications subcontractor. Each pair in this cable shall be individually shielded, size 22 AWG wire. Larger wire will not be acceptable. See Section 16925.
  - d. Unless otherwise specified, the Contractor shall size the conductors of all special control and indication cables in such a manner that the working voltage drop for any circuit in the cable does not exceed ten percent with a working load of one-half ampere on the circuit.
3. **GROUP III - NEGATIVE PROPULSION RETURN CABLE**
- a. All Negative Propulsion Return Cable shall be rated for 2000 Volts. The insulation shall be Ethylene-propylene rubber, ICEA Type II, 90°C, suitable for dry and wet locations.
  - b. The cable shall have an overall nonmetallic jacket of chlorosulfonated polyethylene or cross-linked polyolefin. The jacket shall be bonded to the insulation to prevent moisture pockets. The minimum peel strength of the jacket from the insulation shall be four pounds per inch width for either type of jacketing used.
  - c. The insulation power factor shall not exceed two percent.
  - d. The cable shall carry UL labeling, Type RHW-2.
  - e. Cable furnished and installed for the connection between impedance bond center taps (or shunt-bar center taps) and substation return or tiebreaker station return bus bars or moles shall be single conductor, 1000 KCMIL Class D (127 strand). See Section 16968, Track Bonding Layouts. Cable furnished and installed for negative return cross bonding and switch bonding, and for connection between the impedance bonds and the running rails, shall be single conductor, extra-flexible, 1000 KCMIL, Class G (427 strand).
  - f. Cable furnished and installed for negative-return, compression-bolted rail-web bonding shall be single conductor, 500 KCMIL, Ropelay with 2000-volt-class insulation. See Section 16968, Track Bonding Layouts.

### 3.08 CABLE INSTALLATION

- A. General
  1. The installation of wire and cable shall conform to Part 10.4.40 (Wiring) and Part 10.4.1 (Wires & Cables) of the AREMA Signal Manual except as modified herein.
  2. The Contractor shall notify the designated Resident Engineer at least 24 hours prior to installing cables.
  3. The Contractor shall provide sufficient slack in cable conductors at all terminating posts to enable three reterminations of the conductor due to broken eyelets without

reservicing or repositioning the cable. In types of installation where the cable cannot be constrained, sufficient cable slack shall be provided to prevent damage to the cable due to vibration.

4. Signal cable shall not be bent to a radius less than 20 times the diameter of the cable during installation or as finally installed, except as permitted in writing by the designated Resident Engineer.
5. Cable splices will not be allowed as a normal installation practice for non-vital circuits, and will not be permitted for cables carrying vital circuits. Cables carrying vital circuits over long distances, such as the wayside TCR-to-TCR cables, shall be terminated in wayside junction boxes in lieu of being spliced. Intermediate junction boxes shall not be installed prior to approval of their construction, configuration and location by the Engineer. Upon written request, and only under extreme circumstances and because of installation hardship, will the use of cable splicing in certain non-vital cable runs be considered, all subject to the designated Resident Engineer's prior approval.
6. Cable splices, where permitted in non-vital circuit cables, shall be of the cable manufacturer's recommendation or the 3M (Minnesota Mining and Manufacturing Co.) type, all subject to the designated Resident Engineer's approval. Further, all splices other than the 3M type shall have a layer of fireproof tape applied over the splice and for six inches beyond each end of the splice. All cable splices shall be waterproof and shall have the same or greater service life as the cable to which they are applied.
7. All cable entrance openings in equipment enclosures, manholes and junction boxes shall be sealed with either a compression type fitting or pliable sealing compound after the cable is in place. Sealing compound shall be used to seal the area around cable where the cable emerges from the end of a conduit, pipe or duct bank. The Contractor shall install conduit sealing bushings in the ends of all unused Train Control conduits to prevent fluids or gases in the conduits from entering the enclosure. These bushings shall be Type CSBI as manufactured by O-Z/Gedney, or approved equal.
8. A suitable lubricating medium (Cable Pulling Lubricant), as specified in Section 16978.2.09, shall be used when pulling cables into conduit, pipe, or duct bank.
9. Where cable transfers from trays or troughs to conduit the ends of the conduit shall, for guidance, be fitted
10. with plastic end bells to prevent damage to the cable.
11. Wherever multiple conductor cables are terminated the outer sheath of the cable shall be carefully removed to the point of cable entrance. At the end of the cable sheath or covering, two layers of plastic electrical tape shall be applied. This tape shall be Reference No. 88, as manufactured by the 3M Company, or an approved equal. As an alternative, the Contractor shall apply a heat shrink sleeve to the end of the cable sheath.
12. The Contractor shall be responsible for the dewatering and removal of all dirt and trash from trenches, pipe, manholes, pull chambers, cable trough, surface trench, conduit and duct bank prior to and during the installation of cable, at no additional cost to the Authority.

**B. Buried Installation**

1. Horizontal runs of buried cable greater than 15 feet shall be installed in PVC conduit per the requirements of this Section.
  - a. Cable shall be buried to a uniform depth of not less than 30 inches. A bed of sand at least four inches thick shall be provided in the bottom of the trench. The cable shall be laid neatly, but loosely on this sand bed, with a minimum of cable crossings. The cable shall then be covered with a minimum of four inches of sand before backfilling. Loam or clay, free of lumps, stones or other debris, may be substituted for sand only with the prior written approval of the Engineer. Backfill shall be compacted to not less than 95 percent of the maximum dry density of the respective materials as determined by AASHTO Test Designation T-99.

- b. Cable passing under tracks or under ballast, or within track right-of-way shall normally be installed in conduit provided by others. Track right-of-way is defined as an area encompassing the ties and rail and extending two feet beyond the ends of each tie. When no conduit has been provided in such an area, the Contractor shall furnish Schedule 80 PVC conduit for this purpose and shall bury this conduit not less than 30 inches below the ties. See Section 16973, Conduit.
- c. In all areas beyond the right-of-way area where cables cannot be buried to a uniform depth of 30 inches, the Contractor shall, at no additional cost to the Authority, either install surface trench or install the cable in concrete encased Schedule 80 PVC to the maximum uniform depth allowable by field conditions. At transition areas between buried and non-buried installation, the cable shall be protected by Schedule 80 PVC. Horizontal runs of PVC buried at or greater than a depth of 30 inches will not require concrete encasement.
- d. Where cable leaves the ground at other than buildings, or in foundations or pedestal mounted junction boxes, it shall be protected by heavy duty, two-ply, fiber reinforced rubber hose or Schedule 80 PVC conduit. The top end of each hose or conduit shall be filled with sealing compound where the cable emerges.
- e. The cables used as track leads between the rail connections and the wayside junction box shall be protected by vertical bootlegs of heavy duty, two-ply, fiber reinforced, one-inch I.D. neoprene hose where they pass through the ballast and the subgrade. Cable not extending beyond the far rail shall be placed in heavy duty, two-ply, fiber reinforced, one-half inch I.D. neoprene hose or Schedule 80 PVC conduit which shall be clamped to the side of the crosstie as shown on the Contract Drawings.
- f. Cable shall be installed in a steel or wrought iron pipe wherever the cable passes under pavement or roadway. This pipe shall extend two feet beyond the edges of the pavement.
- g. The Contractor shall be responsible for all shoring required to prevent undermining and cave-ins during cable burying operations and shall also be responsible for any damages or lost time resulting from inadequate shoring. Any trench over 3 feet deep shall be shored.
- h. Where a buried cable enters a conduit, pipe, pedestal, or concrete foundation, for an equipment case, junction box, or other piece of Train Control equipment in which the cable is to be terminated, or bootlegs for track circuit or snowmelter connections, a five foot slack coil of that cable shall be installed in a trench below the point of entrance.
- i. Cable required to carry current at 600 volts or more shall not be installed in the same trench as signal or other low voltage cable without prior written consent of the Engineer.
- j. If signal, communication or track circuit cables, due to installation hardship, must be installed in the same trench as, or are required to cross cable carrying current at 600 or more volts, these low voltage cables shall be installed so that the distance between them and the high voltage cables shall not be less than 30 inches for all the cables. Where the high and low voltage cable cross or diverge, the area between the two types of cable shall be filled with sand to a distance of two feet along each type of cable from the point of their nearest proximity.
- k. Locate, dig and backfill the cable trench with a minimum of disturbance to the right-of-way. The Contractor shall reestablish and/or repair any portion of the right-of-way and/or drainage system that may be disturbed by the cable burying operations. Excess spoils shall be evenly distributed along the right-of-way if digging operations are at the subgrade level and ballast has not yet been installed. If ballast has been installed, care shall be taken to cover the

ballast during digging operations in order to keep the ballast clear of spoils. In the latter case, excess spoils shall be removed from the property and disposed of at no additional cost to the Authority.

- I. Install mylar cable marking tape at a depth of six inches while backfilling each cable trench.

C. Non-Buried Installation

1. Direct Fixation in Tunnel Areas

- a. Train control cables shall be installed along the tunnel walls in an organized fashion within the area allotted to them. Cable crosses shall be kept to a minimum. The topmost cable(s) shall be assigned for through runs with local cable(s) below them to facilitate cable branching into the wayside equipment in an orderly manner. Where the Contractor has more cable than will fit in the allocated area, the Contractor shall furnish and install additional approved cable mounting devices at no additional cost to the Authority. Cable runs along tunnel walls shall not interfere with access to grab bars located on the tunnel walls at access points to the safety walk.
- b. Channel inserts will have been provided by others for the Contractor's use, mounted on approximately four foot centers in the tunnel walls. The Contractor shall furnish and install fastenings or mounting devices to secure the cables to the channel inserts. These fasteners shall be properly sized to the cable, or shall be adjustable to the proper size to support the cable without undue compression. Prior to cable installation the Contractor shall clear and remove any foreign material from the channel inserts where necessary. Where channel inserts are missing, the Contractor shall provide a substitute device which performs the same function and is acceptable to the Engineer. Any additional work and materials involved with the installation of the substitute device shall be provided at no additional cost to the Authority.
- c. Sufficient slack shall be provided in the cable between fasteners to allow for expansion and contraction of the cable without damage to the cable or the fasteners.

2. Installation in Trays, Troughs or Surface Trench

- a. Cable installed in trays, troughs or surface trench shall be laid therein and not pulled into place. Cables installed in trays, troughs and surface trench shall have a minimum amount of crossover and shall not be pulled tightly around bends.

3. Installation in Conduit or Pipe

- a. Remove any foreign material from conduits by using an appropriate mandrel. The Contractor shall then clear or swab dry each conduit or pipe before installing cable therein. It shall be the Contractor's responsibility to prove existing conduits prior to use. The Contractor shall maintain the conduits and/or pipe in a clean and dry condition during the installation process up to and including the time each conduit or pipe is sealed as specified, at no additional cost to the Authority.
- b. The Contractor shall have an approved Pull Sheet in his possession for each cable pull executed, and shall record thereon the date of the pull, the method used, the maximum pull tension experienced for each applicable pull, and other pertinent data. The Contractor shall resubmit a copy of each completed Pull Sheet to the designated Resident Engineer within one week of the pull. See Part 1.08 G of this Section.
- c. Conduct cable pulls in accordance with the cable manufacturer's recommendations. In the absence of any such specific recommendations, the Contractor shall use an approved wire cable grip extending not less than 18 inches back from the end of the cable when pulling cable. The clutch on the pulling device shall be set to slip at 50 percent of the weight per 1000 feet

of the cable to be pulled or at the manufacturer's maximum force rating, whichever is less. The equipment used for pulling cable shall be equipped with a dynamometer which shall indicate the pulling force in pounds. An approved cable pulling lubricant, as specified in Section 16978, shall be applied to the cable when installing cable in conduit or pipe.

- d. Cables shall not cross one another when they are pulled into a conduit or pipe and care shall be taken not to have the conductors pulled tight or kinked in conduit fittings or boxes. All cables to be installed in a given conduit or pipe shall be pulled and installed simultaneously.
  - e. Furnish and install potheads and filling compound where cables enter or leave conduit or pipe. The potheads and filling compounds shall be as specified in Section 16978, Miscellaneous Train Control Components and Materials, and shall be applied in conformance with the manufacturer's instructions.
  - f. Local cable runs from wayside equipment in direct fixation to the trackside junction boxes shall be installed in embedded conduit which has been provided by others. Where embedded conduit is not provided by others for this purpose, the Contractor shall chip and grout the required conduit in place below the structure surface. In doing this work, the Contractor shall not cut any concrete reinforcing bars without the prior written approval of the designated Resident Engineer.
4. Installation in Manholes and Pull Chambers
- a. Furnish and install clamps or other cable restraining hardware in manholes or other areas where support is needed for cables entering or leaving conduit or pipe or passing through the manhole. Apply an identification tag to each TC cable in every manhole.
  - b. Sufficient slack shall be provided in each cable so that the bending radius of each cable shall not be less than 20 times the diameter of the cable. Where the specified minimum bending radii of cables do not allow strapping or clamping to channel inserts, the Contractor shall furnish and install approved manhole racks with insulators to support the cables.
  - c. All mounting and fastening materials used for this application by the Contractor shall be stainless steel, as specified in Section 16915, Basic Equipment Requirements. Use of anodized channel is unacceptable in manholes and pull chambers.
  - d. Cables shall be installed in a manner which will prevent their injury by persons and equipment entering and exiting the manholes via ladders or other climbing devices.
  - e. Install and support cable in manholes and pull chambers in accordance with the approved version of drawings he has submitted for this work.
5. Special Installation Requirements
- a. Provide sufficient slack in all cable installation runs to prevent damage to the cable or its terminations due to expansion or contraction.
  - b. Provide appropriate special protection for cables in areas where the cables are unavoidably exposed to hazardous conditions such as vibration or sharp corners on equipment. The Contractor shall be responsible for replacing, at no additional cost to the Authority, any cable he has installed which is subsequently damaged as a result of his failure to provide such special protection.

**END OF SECTION**

**SECTION 16950**

**ATC - EQUIPMENT MODULES**  
(Table of Contents)

**PART 1 - GENERAL**

**1.01 SECTION INCLUDES**

A. This SECTION lists the various 16950-series Train Control Equipment Module Specification Sections:

- |    |                                   |                 |
|----|-----------------------------------|-----------------|
| 1. | Transfer and Bypass Equipment     | (Section 16951) |
| 2. | DC Power Supplies                 | (Section 16952) |
| 3. | ATP Track Modules                 | (Section 16953) |
| 4. | Switch and Lock Movements         | (Section 16954) |
| 5. | Track and Alarm Indication Panels | (Section 16955) |
| 6. | Interlocking Control Panels       | (Section 16956) |

**PART 2 - PRODUCTS**

NOT USED

**PART 3 - EXECUTION**

NOT USED

**END OF SECTION**

**SECTION 16951**  
**ATC - TRANSFER AND BYPASS EQUIPMENT**

**PART 1 - GENERAL**

**1.01 SECTION INCLUDES**

- A. This Section specifies the furnishing and installation of Automatic Transfer and Bypass-Isolation equipment as part of each new TCR Power Distribution system provided under this Contract. For each TCR, this equipment shall include:
1. A high speed, single phase Automatic Transfer Switch to supply an uninterruptible 120 volt, 60 Hz bus.
  2. A one-way, bypass-to-normal Bypass-Isolation Switch to provide a safe and convenient means of bypassing and isolating the Automatic Transfer Switch for test and maintenance purposes without interrupting ATC functions.
  3. All devices and wiring required to cause the Transfer and Bypass equipment to function as specified herein.

**1.02 RELATED SECTIONS**

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
1. Section 16916 Basic ATC Circuit Requirements
  2. Section 16921 ATC Power Distribution Systems
  3. Section 16922 Lightning/Surge Protection and Grounding Systems
  4. Section 16941 Basic ATC Electrical and Electronic Component Requirements
  5. Section 16980 ATC Tests, Inspections and Quality Assurance

**1.03 SWITCHING**

- A. The Automatic Transfer Switch shall immediately throw from the Normal to the Reserve service whenever the Normal 120 volt, 60 Hz bus falls below 85 percent of its nominal voltage and the Reserve voltage is 85 percent of nominal or higher.
- B. Once the switch has thrown to the Reserve 120 volt, 60 Hz service, it shall remain in that position until the Normal service voltage returns to at least 95 percent of its nominal value and remains in that range for a time period adjustable from 15 seconds to five minutes, whereupon the switch shall retransfer the load to the Normal service. This "return-delay time" feature shall be nullified and the switch shall immediately retransfer to the NORMAL position if the Reserve service falls below 85 percent of its nominal value and the Normal service voltage is at least 85 percent of its nominal value.

**1.04 BYPASS AND ISOLATION**

- A. The Bypass-Isolation Switch shall perform two functions:
1. Connect the load directly to the Normal service without interrupting service to the load.
  2. Electrically isolate the Automatic Transfer Switch from the load and both services.
- B. Interlocks shall be provided to prevent:
1. Moving the bypass switch handle from the AUTOMATIC to the BYPASS-TO-NORMAL position unless the Automatic Transfer Switch is in its NORMAL position and the Normal service is at least 85 percent of its nominal value.
  2. Isolation of the Transfer Switch prior to bypassing the load to the Normal service.
  3. Removal of the load bypass connection prior to reconnection of the Automatic Transfer Switch to the load and both services.
  4. Moving the bypass switch handle from the BYPASS-TO-NORMAL to the

AUTOMATIC position unless the Automatic Transfer Switch is in its NORMAL position.

#### **1.05 QUALITY ASSURANCE**

- A. The factory tests for Transfer and Bypass Equipment shall meet the requirements of Underwriters Laboratories Standard UL 1008 and the requirements specified herein. The overload and endurance tests specified in UL 1008, Sections 21 and 23, respectively, shall be conducted prior to the temperature rise tests specified in UL 1008, Section 22. The factory tests shall also include a test to determine the transfer time of each Transfer Switch in each direction.
- B. Field installation inspections and operational tests of automatic transfer switches and bypass-isolation switches shall be conducted as specified in the approved inspection and test procedures submitted by the Contractor.

#### **1.06 SUBMITTALS**

- A. Prior to purchase or fabrication of Transfer or Bypass Equipment, the Contractor shall submit:
  - 1. A copy of the calculations used to determine the size of the Automatic Transfer Switch and Bypass-Isolation Switch he proposes to use in each TCR. The calculations shall reflect:
    - a. Proper coordination of the transfer and bypass equipment with the size of the load to be supplied and the characteristics of protective devices to be provided.
    - b. The relative electrical capabilities of the Automatic Transfer and Bypass-Isolation Switches proposed.
  - 2. Complete drawings, operational explanations, performance data and sizes for the Transfer and Bypass equipment he proposes to furnish and install. The drawings shall include control, interlocking, and indication circuits and hardware, transfer times, mounting details, wiring diagrams and a complete parts list.
- B. Prior to installation of Transfer and Bypass Equipment, the Contractor shall submit:
  - 1. A Train Control Room arrangement plan for each TCR which identifies the Transfer and Bypass Equipment and indicates where it is to be mounted in the room. This does not have to be a separate submittal if such a plan has previously been submitted for other purposes.
  - 2. Copies of the factory test reports for the Transfer and Bypass Equipment. These shall include plotted traces of the output voltage showing the actual transfer time of each transfer switch in each direction, i.e., from Normal to Reserve, and from Reserve to Normal when activated by the removal of the applicable initial voltage source.
  - 3. Proposed procedures for installation inspection and field testing of the Transfer and Bypass Equipment.
- C. Upon installation and field testing of the Transfer and Bypass Equipment, the Contractor shall submit a complete field test report.

### **PART 2 - PRODUCTS**

#### **2.01 AUTOMATIC TRANSFER SWITCH**

- A. The Automatic Transfer Switch shall be of the electrically operated, mechanically held type, rated for continuous duty in an unventilated sheet metal enclosure. All accessory control and indication devices shall be removable from the front of the Transfer Switch without removal of the switch panels from the enclosure and without disconnection of drive linkages or power

conductors. The Transfer Switches provided shall meet the requirements of Underwriters Laboratories Standard UL 1008 for Automatic Transfer Switches and other requirements specified herein.

- B. The switching mechanism shall have only two positions, NORMAL and RESERVE, inherently interlocked mechanically and with main contacts mechanically attached to a common shaft. The switching mechanism shall cause the main contacts to transfer the load from one service to another with an output power interruption period of sufficient brevity not to cause any track relays or traffic sticks to drop, and not to cause any other failure in the ATC System.
- C. The main contacts shall be of the brush, segmented, or silver alloy, wiping action type and shall be protected by arcing contacts in sizes above 40 amperes. The "constant current" rating for the main contacts and associated arc-quenching apparatus shall be at least 20 percent higher than the maximum working load computed for the transfer switch by the Contractor and approved by the designated Resident Engineer. The contact configuration shall utilize magnetic forces to keep main contacts closed when subject to high fault currents.
- D. The transfer switch shall have the thermal capacity to carry its withstand rating without contact welding or electrical or mechanical damage.
- E. Sensing and control relays shall be continuous duty industrial control type with minimum contact rating of 10 amperes. The voltage sensitive relays shall be of the close differential type, factory adjusted for 95 percent pickup and 85 percent drop-out. The return-delay time relay shall be adjustable from 15 seconds to five minutes in at least eight steps.
- F. Each Automatic Transfer Switch shall be equipped with the following test and adjustment features:
  - 1. A spring-return test pushbutton or equivalent which shall, when operated, cause the switch to transfer from the NORMAL to the RESERVE position. The transfer switch shall then remain in the RESERVE position until the test button has been released and the preset return-delay time period has run out. The test pushbutton shall be clearly identified by a metal or phenolic label or approved equal.
  - 2. Facilities for testing and adjusting the undervoltage sensitivity for both the Normal and Reserve services.
  - 3. Facilities for testing and adjusting the return-delay time mechanism.
- G. The Automatic Transfer Switch shall be equipped with the following indication features:
  - 1. At least five independent auxiliary contacts shall be provided for transfer switch position indicating use. Three of these contacts shall close when the transfer switch is in the NORMAL position and the other two shall close when the switch is in the RESERVE position. All of these auxiliary contacts shall have 10 ampere minimum continuous contact rating and shall be activated by the switching mechanism. One of these contacts shall be used to energize a remote relay indication of the transfer switch position as shown on the Contract Drawings.
  - 2. The Transfer Switch shall include four LED indicating light units:
    - a. One amber LED unit to indicate the availability of Normal service energy of the proper voltage (Normal voltage sensing relay energized)
    - b. A second amber LED unit to indicate the availability of Reserve service energy of the proper voltage (Reserve voltage sensing relay energized)
    - c. A green LED unit to indicate when the transfer switch is in the NORMAL position
    - d. A red LED unit to indicate when the transfer switch is in the RESERVE position
- H. The indications provided by these LED indicators shall be visible from the outside of the Transfer Panel. The LED units shall be, as applicable:

1. SP940112-R (RED)
  2. SP940224 (GREEN)
  3. SP940112-A (AMBER)
  4. as manufactured by Data Display Products of El Segundo, California, or approved equal.
- I. The Automatic Transfer Switch, complete with all its control, test and indication equipment, shall be housed in a non-ventilated NEMA-12 type enclosure constructed of 11 gauge sheet metal. Provision shall be made for locking the doors of this enclosure. When the metal used is not inherently non-corrosive, the enclosure shall be finished in grey ANSI-61, or approved equal. The switch position and power indicating lights shall be mounted on the front of this enclosure. This assembly of power transfer equipment shall be known as the Transfer Panel.
- J. Each control, test or indicating device mounted on the front of the Transfer Panel shall be clearly identified by a metal or phenolic label firmly attached to the panel.

## **2.02 BYPASS-ISOLATION SWITCH**

- A. Each Bypass-Isolation Switch shall be compatible with its associated Automatic Transfer Switch and shall be designed to the same standards as the Automatic Transfer Switch. The Bypass-Isolation Switch shall have "withstand current" abilities equal to or greater than the associated Automatic Transfer Switch.
- B. The Bypass-Isolation Switch shall be arranged so that one person can perform the bypass and isolation functions through the operation of a maximum of two handles at a common deadfront panel:
1. A handle labeled BYPASS CONTACTS which shall connect the load to the Automatic Transfer Switch when in the AUTOMATIC position, and which shall transfer the load from the transfer switch to the Normal service by means of make-before-break contacts when rotated to the NORMAL position.
  2. A handle labeled ISOLATION CONTACTS which shall disconnect the Automatic Transfer Switch from both the Normal and Reserve service leads when moved from the CLOSED to the OPEN position. Provision shall be made for padlocking this handle in the OPEN position.
- C. The Bypass-Isolation Switch shall be equipped with the following indication features:
1. A red indicating LED light (of the same type as used on the Transfer Switch) on the faceplate of the Bypass-Isolation Switch which shall be illuminated when the BYPASS CONTACTS handle is in the BYPASS-TO-NORMAL position.
  2. Sufficient auxiliary contacts to provide remote ac power and bypass indications as shown on the Contract Drawings. One of these contacts shall close only when the BYPASS CONTACTS handle is in the AUTOMATIC position and another contact shall close only when the BYPASS CONTACTS handle is in the BYPASS-TO-NORMAL position. These contacts shall have a 10 ampere minimum continuous contact rating and shall be activated by the bypass mechanism.
- D. The Bypass-Isolation Switch shall either be housed in a NEMA-12 type sheet metal enclosure of its own, or shall be housed in an isolated compartment of the Transfer Panel enclosure. In either case, the Bypass-Isolation Switch shall have a metal faceplate of its own. The operating handles and the BYPASS indication light shall be mounted on this faceplate. Housing and faceplate metal which is not inherently non-corrosive shall be finished in grey ANSI-61 or approved equal.
- E. The two operating handles, the two positions for each handle, and the BYPASS indication LED light unit shall all be clearly identified by metal or phenolic labels firmly attached to the faceplate of the Bypass-Isolation Switch.

- F. A fail-safe solenoid lock or similar device shall be included in the Bypass-Isolation Switch to prevent movement of the BYPASS CONTACTS handle except when the Transfer Switch is in the NORMAL position and Normal service energy of the proper voltage is available.

### **2.03 TERMINALS AND WIRING**

- A. The Bypass-Isolation Switch, and the Automatic Transfer Switch together with its accessory control and indication devices, shall be completely factory wired internally. If the Bypass-Isolation Switch is mounted in the Transfer Panel, the interlocking control circuits shall also be factory wired. Auxiliary contacts for external indication of interlocking control purposes shall be wired to external solderless terminals of the pressure clamp type. All external power, load, control, and indication terminals shall be clearly identified by permanent tags or markings.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. The Contractor shall wall mount the Transfer Switch and the Bypass-Isolation Switch as shown on the approved drawings. Electrical connections to the power distribution system of the Train Control Room shall be made as shown on the Contract Drawings.
- B. The Transfer and Bypass Equipment shall be wired utilizing single conductor, stranded wire and jumpers, neatly bundled and shaped. The size and type of wire and the wiring diagram shall be as shown on the approved drawings.

### **3.02 FIELD INSPECTION AND TESTING**

- A. The Contractor shall conduct a complete field inspection of the Transfer and Bypass equipment installation and correct any discrepancies noted.
- B. The Contractor shall field test the automatic transfer and bypass-isolation equipment as part of the respective TCR Power Distribution Systems. See Section 16921.

### **3.03 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. Transfer and Bypass Equipment will be measured for partial payments on a unit basis. For purposes of payment, this equipment group "unit" shall include:
  - 1. An Automatic Transfer Switch with all its associated control, indication and test devices and enclosure;
  - 2. A complete Bypass-Isolation Switch, and;
  - 3. The equipment required to provide interlocking between the Automatic Transfer Switch and the Bypass-Isolation Switch, all as specified above.
- B. Factors which will be considered before partial payments are made will include, but not be limited to:
  - 1. Delivery of each complete Transfer and Bypass Equipment Group and approval of factory test reports for each major component by the designated Resident Engineer;
  - 2. Complete installation of each Transfer and Bypass Equipment Group, to include all required wiring, and;
  - 3. Approval by the designated Resident Engineer of the installation and operation of the Transfer and Bypass Equipment Group.

**END OF SECTION**

## SECTION 16952

### ATC - DC POWER SUPPLIES

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing and installation of direct current power supplies of various voltages and capacities to supply power to all wayside direct current ATC equipment furnished or installed under this Contract.

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
- |    |               |  |
|----|---------------|--|
| 1. | Section 16914 | Environmental Requirements                                 |
| 2. | Section 16915 | Basic ATC Equipment Requirements                           |
| 3. | Section 16916 | Basic ATC Circuit Requirements                             |
| 4. | Section 16921 | ATC Power Distribution Systems                             |
| 5. | Section 16922 | Lightning/Surge Protection and Grounding Systems           |
| 6. | Section 16941 | Basic ATC Electrical and Electronic Component Requirements |
| 7. | Section 16949 | Signal Wire and Cable                                      |
| 8. | Section 16955 | Track and Alarm Indication Panels                          |
| 9. | Section 16980 | ATC Tests, Inspections and Quality Assurance               |

##### 1.03 QUALITY ASSURANCE

- A. All DC power supplies furnished under this Contract shall be factory tested by the Contractor in the manner prescribed in a factory test procedure prepared by the Contractor and approved by the designated Resident Engineer. Only those power supplies passing this factory test and receiving approval of the test from the designated Resident Engineer, shall be shipped to the project site.
- B. Field testing of all DC power supplies furnished under this Contract shall be performed by the Contractor in the manner specified in Section 16980, ATC Tests, Inspections and Quality Assurance.

##### 1.04 SUBMITTALS

- A. The Contractor shall submit the following for approval by the designated Resident Engineer prior to procurement or fabrication of the DC power supplies, and within 90 days of NTP:
1. Complete mechanical and electrical drawings for each type and size of DC power supply to be furnished. These drawings shall include details of the internal protection and alarm indication components and any required filtering and regulation components.
  2. Complete physical characteristics and performance data for each type and size of DC power supply to be furnished. This information shall include the amount of heat, noise and electromagnetic emissions generated by the power supplies over an output power range of 10 to 130 percent of rated output in steps of 10 percent.
  3. Proposed location and method of mounting the various DC power supplies on the rack.
  4. A detailed Factory Test Procedure and Factory Test Report Form for each type of DC power supply to be furnished.

- B. The Contractor shall submit for approval, a completed Factory Test Report, in the approved format, for each DC power supply.

## **PART 2 - PRODUCTS**

### **2.01 BASIC DC POWER SUPPLY REQUIREMENTS**

- A. All DC power supplies furnished under this Contract shall be immune to external RF energy from portable 2-way radios and personal communications devices such as cellular telephones, and shall meet the following basic requirements:
1. Transformers
    - a. Transformers used in DC power supplies shall not emit audible noise in excess of 50 dB (referenced to 0.0002 dynes per square cm.) at a distance of three feet when operated anywhere within the range of input and output voltages and currents specified.
  2. Filters
    - a. The power supplies requiring filter capacitors shall be so designed that their filter capacitors can be replaced without removing the power supply from the rack on which it is mounted.
  3. Electrical Insulation
    - a. The power supplies shall have sufficient insulation to be cable of withstanding, for one minute, 600 volts, 60 Hz applied between the input leads (connected together) and the output leads (connected together).
  4. Cooling
    - a. The power supplies shall be designed for natural convection cooling. No supplementary fans or other cooling devices will be allowed.
    - b. The Contractor shall bear in mind that a power supply may be mounted on a rack with other power supplies and shall accordingly be certain that convection area and other components are sized and have dissipation ratings, for such installations.
  5. Duty Cycle
    - a. The power supplies shall be designed for a continuous duty cycle with the exception of the WHB which shall be designed for an average five percent duty cycle.
  6. Failure Alarm
    - a. Each DC power supply shall be equipped with a failure alarm device which shall detect any internal failure which would impair the ability of the power supply to deliver its full rated load. This device shall be normally energized by a small percentage of the rated load current of the power supply and shall cause two separately wired internal contacts to open when a failure is detected. One of these contacts shall be independently wired to binding posts for an external alarm indication circuit. The second contact shall be used to light an indication lamp or LED indicator mounted on the power supply. (See Section 16955, Track and Alarm Indication Panels, and the Contract Drawings.) This circuit shall function even if the output voltage is maintained by a tandem power supply. The power supply shall be so designed that the internal failure indication lamp or LED can be replaced without removing the power supply or any adjacent equipment from the rack.
  7. Input Voltage
    - a. The power supplies shall not be damaged by a sustained input voltage varying from 0 to 150 percent of the rated input voltage. Nominal supplied input voltages may range from 110V to 125V per leg at the incoming

- feeder disconnect.
8. Current Rating
    - a. The power supplies shall be sized in such a manner that no individual power supply operates at less than 20 percent of its rated current output during normal operation of the power bus fed therefrom.
  9. Output Current
    - a. The power supplies shall self-limit their output current to no more than 200 percent of their rated load unless otherwise specified herein. Reverse output current protection shall be provided to prevent shorting or sagging of tandem supplies in the event of filter capacitor failure.
  10. Identification
    - a. Each power supply shall be clearly and permanently labeled with the following:
      - 1) Manufacturer's name
      - 2) Part or model number
      - 3) Serial number
      - 4) Input rating
      - 5) Output rating (Continuous or intermittent)
  11. Components and Wiring
    - a. Electrical and electronic components used in DC power supplies shall be as specified in Section 16941. Internal wire shall meet the requirements of Section 16949. Power supplies which are designed to be repaired in the rack shall have all components in modular assemblies which do not require soldering to replace.

## 2.02 POWER SUPPLIES FOR MAJOR DC BUSES

- A. All power supplies used to feed the four major DC buses (B28G, LB, B5G and WHB) shall meet the following requirements in addition to the basic requirements specified in Part 2.01 of this Section:
  1. Housing
    - a. Each power supply shall be housed in a metal panel-chassis combination with no exposed electrical connections or wires. A perforated protective cover shall be used to provide for convective heat transfer. Metal used in this housing and cover which is subject to corrosion shall be protected by zinc plating or an approved equivalent finish applied after forming.
  2. Front Panel
    - a. The front panel shall be designed for use in mounting the power supply in a standard 19-inch rack with EIA hole spacing. All panel mounted indicating, adjusting or protective devices, or openings for such devices, shall be legibly and permanently labeled.
  3. Electrical Insulation
    - a. The power supplies shall be electrically insulated so that they will be capable of withstanding, for one minute, 600 volts, 60 Hz applied between:
      - 1) The input leads (connected together) and the chassis.
      - 2) The output leads (connected together) and the chassis.
  4. Panel Mounted Indicators
    - a. Each power supply shall have an output voltmeter, an output ammeter and a normally illuminated power failure light (lamp or LED) mounted on its front panel. As an option, the Contractor shall provide this metering on a separate panel in the same rack as the power supplies. Meter accuracy shall be  $\pm 2$  percent with nominal readings at center scale.
  5. Terminals
    - a. The power supplies shall be equipped with standard AAR type binding

posts (No. 14-24 studs) within the chassis, for the connection of all external input and output power leads. Terminals for external connections to the internal failure alarm contacts shall be of the 8-32 barrier strip type or standard AAR type binding posts. Each terminal shall be permanently labeled. No terminal shall protrude outside the chassis.

- b. Where 120-volt input terminals are in close proximity to failure indication terminals, a grounded metal barrier shall be provided to prevent accidental application of 120V to the other terminals.
- 6. Protection
  - a. Internal circuit breakers or fuses shall be easily reset or replaced from outside the power supply.
- 7. Adjustment
  - a. Output voltage adjustment over the specified range shall be easily made and locked from outside the power supply.

## 2.03 LOCAL POWER SUPPLY

- A. Application
  - 1. These power supplies shall be provided to feed the grounded 28 VDC bus (B28G-N28G or B12G-N12G) for operating ATC logic circuits entirely contained within the Train Control Rooms and non-vital circuits which extend outside the TCRs.
- B. Additional Requirements
  - 1. These power supplies shall meet the following requirements in addition to the requirements specified in Parts 2.01 and 2.02 of this Section.
  - 2. Output Current
    - a. Rated Output Current
      - 1) These power supplies shall be furnished in no more than three maximum continuous current ratings selected as required by the application.
    - b. Overload Current Rating
      - 1) Each power supply shall have a short-time overload rating stamped on the nameplate. The overload rating shall be at least 125 percent of rated load sustained for one minute out of any ten consecutive minutes.
    - c. Overload Current Limiting under Short-Circuit Conditions
      - 1) Output current shall be limited to 250 percent of maximum continuous rating. If this short circuit current is sustained for 30  $\pm$ 10 seconds, an internal hand-resettable protective device shall operate to disconnect input power, without harm to power supply components. If this short circuit current is sustained for less than the 30 seconds, recovery of normal output voltage shall be automatic upon removal of the short circuit condition.
    - d. Reverse Current Prevention
      - 1) Reverse output current shall be prevented by circuitry contained within the power supply. This circuitry shall isolate all of the active components within the power supply (including filter capacitors) from the output terminals of the supply. If a circuit other than a blocking diode is used for control of reverse current, a small amount of reverse current will be allowed; however, this shall not exceed 2 percent of the rated current.
  - 3. Output Voltage (During Warm-Up Period)
    - a. Time and Voltage
      - 1) The power supply output shall stabilize within a period of 20

- minutes after rated input voltage is applied to the supply. During this period, the output voltage shall not be greater than 120 percent of rated DC voltage, regardless of load.
- 2) Output Voltage Ripple and Noise
    - a) During the warm-up period, ripple shall not exceed 3 percent of the rated voltage (as measured peak-to-peak), and noise shall be limited to 7 percent of the rated voltage (as measured peak-to-peak) at any frequency.
4. Output Voltage (After Warm-Up Period)
- a. Rated Output Voltage
    - 1) The output voltage shall be adjustable to plus or minus 0.1 percent of the system voltage, at rated input voltage, with an ambient temperature of 25 degrees C, when operating at 50 percent of rated output current.
  - b. Regulation of Output Voltage
    - 1) Versus Input Voltage
      - a) The output voltage at 50 percent load current, shall not vary more than  $\pm 2$  percent for input voltage variations of  $\pm 15$  percent of rated voltage at constant ambient temperature.
    - 2) Versus Ambient Temperature
      - a) The output voltage at 50 percent load current and constant rated input voltage shall not vary more than  $\pm 2$  percent over a temperature range of -30 degrees C to +70 degrees C at constant rated line voltage.
    - 3) Versus Load Current
      - a) The output voltage, from no load to full rated load current, at constant rated input voltage and constant ambient temperature, shall not vary from the output voltage at 50 percent load current by more than plus or minus one half of one percent.
    - 4) Versus Time (Long Term)
      - a) After the warm-up period and once adjusted to a rated voltage with given constant input and load conditions, the output voltage shall not vary more than  $\pm 0.5$  percent in a 72 hour period.
    - 5) Versus Line Voltage, Load Current and Ambient Temperature
      - a) With the worst combination of load current and line voltage, and with temperature variation ranging from -30 degrees C to +70 degrees C, the output voltage shall never vary more than  $\pm 12$  percent of rated voltage.
  - c. Output Voltage Transients
    - 1) Variation in output voltage due to load changes of up to 50 percent of maximum load and for a 10 millisecond interruption of input power shall be limited to  $\pm 1.0$  percent of rated output voltage, peak. Recovery to the point where the waveform stays within the ripple tolerance shall occur within 80 milliseconds of the initiation of the load change.
  - d. Ripple and Noise on Output Voltage Once the power supply output voltage has stabilized:
    - 1) Output ripple, related to the power frequency, shall not exceed one half of one percent of rated voltage.
    - 2) Noise, unrelated to the power frequency, shall be limited to one half of one percent of rated voltage peak-to-peak at any frequency.

- e. Overvoltage Protection
  - 1) If the circuitry of the power supply is such that failure of one or more components within the supply could cause an output voltage greater than that allowed in the requirements of this article, an overvoltage circuit shall be added which senses this overvoltage condition and shuts the power supply down. Such circuitry may be of the "crowbar" type which causes an overcurrent protection condition resulting in the operation of the unit's overcurrent feature in consequent (manually resettable) shutdown. This circuit shall be designed to limit peak overvoltage conditions to a maximum of 125 percent of the rated continuous voltage.
- 5. Input Voltage
  - a. These power supplies shall be designed and rated to operate on 120 volts RMS (Nominal), derived from one phase of a 208Y/120V, 60 Hz, 3-phase, 4-wire grounded neutral service bus, with the input voltage varying by as much as  $\pm 15$  percent and the frequency varying by as much as 0.5 Hz. At the Contractor's option, these supplies may be designed to operate at 208 volts RMS derived from one or all three phases of the 3-phase, 4-wire grounded neutral service. See Section 16921, ATC Power Distribution Systems, and the Contract Drawings.
- 6. Parallel Operation
  - a. Circuitry shall be provided within the power supply for control of the output voltage in a manner which shall cause the power supply to share the total bus load equally with all other parallel connected (tandem) power supplies feeding a given bus. This circuitry may require an additional terminal on the power supply which can be interconnected with its counterpart on the paralleled power supplies to properly control the load sharing as specified in Part 3 of Section 16921, ATC Power Distribution Systems.
- 7. Reliability
  - a. The 100-ampere power supply units shall have a minimum individual MTBF of 100,000 hours. Supply units of 50 amperes rating and less shall have a minimum individual MTBF of 150,000 hours. MTBF shall be calculated at 50 percent load. The maximum MTTR for any individual local power supply unit shall be one hour.

#### **2.04 LINE POWER SUPPLY (LB-LC)**

- A. Application
  - 1. These power supplies shall be provided to feed the non-grounded DC bus (LB-LC) for operating the 28 Vdc ATC vital logic circuits which extend outside the Train Control Rooms.
- B. Requirements
  - 1. These power supplies shall meet all the requirements specified in Parts 2.01 and 2.02 of this Section. These supplies shall also meet all the requirements specified in Part 2.03, except for paragraphs A, and B.2.a.
- C. Output Current
  - 1. The output current of the LB-LC supplies shall be suitable and adequate for the load supplied.

#### **2.05 LOGIC BUS POWER SUPPLIES**

- A. Application

1. These power supplies shall be provided to feed the grounded logic bus (B5G-N5G) for operating low voltage ATC logic circuits entirely contained within the Train Control Rooms.
- B. Requirements
1. These power supplies shall meet all the requirements specified in Parts 2.01 and 2.02 of this Section. In addition, these power supplies shall meet all the requirements specified in Part 2.03, except for paragraphs A, B.2a, and B.4.a.
- C. Rated Output Current
1. These power supplies shall have an output rating suitable and adequate for the load supplied.
- D. Rated Output Voltage
1. These power supplies shall have a rated voltage (after the warm-up period) adjustable to within 0.1 percent of the nominal logic bus voltage, at rated input voltage, and ambient temperature of 25 degrees C, and a load of 50 percent of the rated continuous output current.

## **2.06 WHB POWER SUPPLIES (WHB-WHC)**

- A. Application
1. These power supplies shall be provided to feed the non-grounded WHB DC bus (WHB-WHC) for switch-and-lock movement and snowmelter control circuits at TCRs controlling interlockings.
- B. Requirements
1. These power supplies shall meet the requirements specified in Part 2.01 of this Section, (with the exception of paragraphs A.2, A.8, and A.9) and Part 2.02 of this Section.
- C. Rated Output Current
1. These power supplies shall be rated at a current value sufficient to simultaneously operate five of the switch-and-lock movements supplied by the Contractor.
- D. Rated Output Voltage
1. These power supplies shall deliver to the switch-and-lock movements, at any load, or temperature between 0 degrees C and +70 degrees C, their rated voltage (110 Vdc on the specified machines) plus or minus 5 percent, at rated input voltage, and an ambient temperature of 25 degrees C. The output voltage may vary somewhat from its rating during warm-up, but it shall not exceed 120 percent of rated voltage and the warm-up period shall not be greater than 20 minutes.
- E. Ripple and Noise
1. The ripple and noise of these power supplies shall not interfere with any electrical or electronic system furnished by the Contractor or with the Communications Systems.
- F. Output Voltage Transients
1. Output voltage transients may appear on these power supplies for internal or external reasons; however, the circuitry of the power supply shall contain devices to protect the rectifiers utilized in the supply.
- G. Input Voltage
1. These power supplies shall be designed and rated to operate on 208 volts RMS,

3 phase, derived from a 208Y/120V, 60 Hz, 3 phase, 4 wire grounded neutral, source. The input voltage may vary as much as  $\pm 15$  percent, and the frequency may vary  $\pm 0.5$  Hz.

- H. Terminals (Quantity)
  - 1. A minimum of three bussed terminals shall be provided for each power supply polarity. Four terminals shall be provided for the output of the two contacts of the failure circuit.

## **2.07 VITAL TRAFFIC CIRCUIT POWER SUPPLIES**

- I. The individual power supplies provided by the Contractor for Traffic Circuits shall have enough capacitance to be unaffected by operation of the TCR Automatic Transfer Switch.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. DC Power supplies shall be rack mounted unless otherwise specified or approved by the designated Resident Engineer.
- B. The Contractor shall use a full complement of non-corroding hardware to mount each DC Power Supply in the manner previously submitted by the Contractor and approved by the designated Resident Engineer. Mounting panels or brackets shall be rigidly designed so that they do not sag under the weight of the power supply.

### **3.02 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. DC Power Supplies will be measured for partial payments based upon the number and type of required groups of such approved supplies furnished, installed and accepted.
- B. Each "group" shall include all hardware required to mount all the DC power supplies included therein.
- C. Factors which will be considered when determining partial payments for the DC power supply groups will include:
  - 1. Delivery of all DC power supplies required for a given group and approval of their Factory Test Reports.
  - 2. Installation of the entire DC power supply group by the Contractor and approval of the installation by the designated Resident Engineer.

**END OF SECTION**

## SECTION 16953

### ATC - ATP TRACK MODULES

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing and installation of equipment modules required to perform the following basic ATP functions:
1. Generate train detection frequency signals.
  2. Generate coded speed command and door command signals.
  3. Receive train detection frequency signals.
  4. Drive vital track relays when the proper train detection frequency signals are being received.
  5. Allow adjustment of the track detection sensitivity from the receiver end of the module. (The ATP module shall allow for a 20-foot preshunt adjustment of the longest track circuit within 75 percent of the limit of the overall adjustment capability of the module).

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
1. Section 16904 Current Automatic Train Control System
  2. Section 16949 Signal Wire and Cable
  3. Section 16961 Audio Frequency Track and Loop Circuit Layouts
  4. Section 16962 Impedance Bond Layouts
  5. Section 16963 Power Frequency Track Circuit Layouts
  6. Section 16971 Racks and Cable Trays
  7. Section 16980 ATC Tests, Inspections and Quality Assurance

##### 1.03 QUALITY ASSURANCE

- A. All ATP modules shall be factory tested in accordance with the factory test procedure approved by the designated Resident Engineer.
- B. All ATP modules installed under this Contract shall be field tested after installation, both prior to connection of field wayside equipment and after connection of field wayside equipment, as specified in Section 16980, ATC Tests and Inspections.

##### 1.04 SUBMITTALS

- A. The Contractor shall submit the following to the designated Resident Engineer for approval prior to purchase or fabrication of ATP track modules, and within 90 days of NTP:
1. Drawings of the proposed modules including complete parts lists, ordering information, mounting details, internal and external wiring details, and mechanical and electrical component descriptions.
  2. Internal circuit plans for the modules.
  3. A complete factory test procedure for the modules.
- B. The Contractor shall submit all required factory test reports to the designated Resident Engineer for approval prior to shipment of the modules to the work site.

#### PART 2 - PRODUCTS

## 2.01 TRANSMITTER

- A. Train detection and speed command frequency transmitters and associated input equipment shall consist of:
  - 1. Oscillators
  - 2. Code rate generator
  - 3. Power amplifier
  - 4. Coupling units
  - 5. Isolating transformer
- B. This equipment shall operate from 28 Vdc.
- C. Train detection and ATP speed command signals shall be generated by separate oscillators. The output frequency of either oscillator shall not drift by more than 0.5 percent of nominal.
- D. The code rate generator outputs shall not vary from their assigned rates by more than 0.5 percent.
- E. The power amplifier shall produce sufficient signal to operate at least two 2000-foot track circuits. A plug coupler with programmable level settings determined by jumpers shall be provided to enable a selection of varying signal strengths. A minimum power level setting of five (5) percent shall be provided for use on minimum length track circuits. If the five percent setting is not sufficiently low for proper operation of certain track circuits, the Contractor shall provide one or more supplementary devices to lower the power level to the extent necessary for proper operation of the track circuit(s) involved. A common electronic code rate generator shall be provided to modulate both the train detection and speed command signals in a given track circuit.
- F. Transmitting coupling units shall be capable of transmitting all ATP speed commands and one train detection signal, and shall be capable of receiving one train detection signal.
- G. The coupling unit output shall be connected through an isolating transformer, if required, to the impedance bond located at wayside by twisted-pair, copper-wire cable of a suitable conductor size. Shielded cable shall not be used unless approved by the designated Resident Engineer. Refer to Section 16949 for cable data.
- H. The signal strength of the ATP transmitter shall be capable of driving the cab level of the longest bond-to-bond **track circuit or WMATA Mini-Loop or** four foot loop track **transmitters** to a maximum of 210 milliamps **rail current** (signal strength measured with the WMATA Cab Level Adjustment Test Fixture). The required cab level output for each track circuit shall be attainable at no more than 85 percent of the maximum output level of the transmitter.

## 2.02 RECEIVER

- A. The equipment receiving the train detection signal from the track coupling device shall produce a dc voltage of the required polarity to drive a biased neutral vital relay only when the received signal is within the specified range of the nominal frequency and input signal coding is detected. The frequency ranges at 3db down shall be as follows:
  - 1. F1: 2100 Hz  $\pm$  20 Hz
  - 2. F2: 2320 Hz  $\pm$  20 Hz
  - 3. F3: 2580 Hz  $\pm$  20 Hz
  - 4. F4: 2820 Hz  $\pm$  20 Hz
  - 5. F5: 3100 Hz  $\pm$  20 H
  - 6. F6: 3370 Hz  $\pm$  20 Hz
  - 7. F7: 3660 Hz  $\pm$  20 Hz

8. F8: 3900 Hz ± 20 Hz

- B. The frequency tolerances in the preceding paragraph necessitate a filter with a narrow bandwidth. The Contractor shall design the filter to minimize ringing (fill-in) between track frequency pulses. The Contractor shall also design the receiver detection circuitry to minimize the detrimental effect of the residual amount of the ringing that remains. The signal-to-noise ratio shall be greater than ten to one.
- C. The connection from the impedance bond or bridging receiver to the coupling unit of the receiving equipment shall be through an isolation transformer, if necessitated by equipment design.

### **2.03 CONFIGURATION**

- A. The standard ATP track module shall contain both train detection transmitting and receiving equipment and speed and door command transmitting equipment. These modules shall also include speed restriction plugs which shall use internal jumpers to cause reduced speed commands to be generated when the plug positions in the module are reversed. Test points and a toggle switch to cause the track relay to drop shall be mounted on the front of the ATP track modules in such a manner that they are not accessible without unsealing and removing the transparent front cover of the modules.
- B. The Contractor may provide "receive only" ATP modules to drive track relays upon receipt of train detection signals.
- C. The Contractor may provide ATP "slave" transmit-only modules for use in conjunction with standard ATP transmitter/receiver modules to transmit train detection and train command signals within interlockings.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. The Contractor shall install all ATP modules for use on this Contract in the TCR on equipment racks specified in Section 16971.
- B. The ATP modules shall be interconnected with associated AF track circuit equipment described elsewhere in these Specifications and as shown on the Contract Drawings.

### **3.02 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. ATP Track Modules, Slave Modules and Receiver Modules will not be measured separately for partial payments, but will be measured as part of the racks on which they are mounted.

**END OF SECTION**

## SECTION 16954

### ATC - SWITCH-AND-LOCK MOVEMENTS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing and installation of switch-and-lock movements at the locations indicated on the Contract Drawings.

##### 1.02 DESCRIPTION

- A. Each switch-and-lock movement shall be designed to perform the throwing, locking and point detection functions of the Track Switch Operating Layout, using separate rods for each function. See Section 16964.
- B. These switch-and-lock movements shall be electrically controlled and operated and shall consist of the following components:
  - 1. Motor
  - 2. Cranking Arrangement
  - 3. Clutch
  - 4. Mechanical Locking Mechanism
  - 5. Circuit Controller
  - 6. Point Detector
  - 7. Housing and Cover

##### 1.03 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16949 Signal Wire and Cable
  - 2. Section 16964 Track Switch Operating Layouts
  - 3. Section 16969 Snowmelter Layouts
  - 4. Section 16974 Locks & Keys
  - 5. Section 16980 ATC Tests, Inspections and Quality Assurance
  - 6. Section 16996 ATC Technical Appendix

##### 1.04 QUALITY ASSURANCE

- A. Test each switch-and-lock movement before shipping it to the job site. This factory testing shall be conducted in accordance with the Contractor's Factory Test Procedure for switch-and-lock movements as approved by the designated Resident Engineer.
- B. The Contractor shall inspect each switch-and-lock movement after it has been installed and correct any deficiencies noted. This inspection shall be conducted in conformance with the requirements of the Contractor's Installation Inspection Procedure as approved by the designated Resident Engineer.
- C. The final operational tests of the switch-and-lock movements shall be conducted as described in Section 16982, Preliminary and Interlocking Tests (Level A).

##### 1.05 SUBMITTALS

- A. The Contractor shall, within 90 days of receipt of Notice-to-Proceed, submit performance data and mechanical and electrical drawings for the switch-and-lock movements he proposes to

furnish under this Contract. The drawings shall include complete installation details and shall show how the hand crank is to be locked to the switch-and-lock movement. The Contractor shall obtain the designated Resident Engineer's written approval for the proposed switch-and-lock movements before proceeding with the manufacture or procurement of this equipment.

- B. The Contractor shall submit a Factory Test Procedure for the approved switch-and-lock movements. This procedure shall be in conformance with the requirements of Section 16980, Tests and Inspections.
- C. The Contractor shall submit an Installation Inspection Procedure for switch-and-lock movements. This procedure shall be in conformance with the requirements of Section 16980, ATC Tests and Inspections.
- D. The Contractor shall submit Factory Test Reports of switch-and-lock movements to the designated Resident Engineer prior to shipment of the movements.
- E. The Contractor shall submit for the Engineer's approval, five copies of manuals describing the installation, operation and maintenance of the approved switch-and-lock movements to be furnished under this Contract.
- F. The Contractor shall furnish a minimum of two copies of the approved installation, operation and maintenance manuals for each switch-and-lock movement provided under this Contract, but no fewer than 20 copies total.

#### **1.06 DELIVERY, STORAGE AND HANDLING**

- A. Prior to shipment, all unpainted metal parts of the switch-and-lock movements shall be given a thorough coating of a protective substance approved by the designated Resident Engineer in order to prevent corrosion. All unused threaded outlets shall be suitably plugged or capped.
- B. During storage and after installation, switch-and-lock movements shall be properly lubricated and maintained by the Contractor on a regular timed program until accepted by the Authority. The designated Resident Engineer will have the right to monitor the Contractor's compliance with this maintenance requirement from time to time as he deems necessary.
- C. The **two** hand cranks and a set of adjusting wrenches & **tools** for each switch-and-lock movement shall be delivered to the Authority at the time of Level A partial system acceptance of the interlocking involved.

### **PART 2 PRODUCTS**

#### **2.01 BASIC DESIGN CRITERIA**

- A. The switch-and-lock movements shall be designed for electric operation and shall not be equipped with a hand-throw mechanism. They shall however, be equipped to permit emergency manual operation by means of a hand crank. **Hand crank operation of the Switch-and-Lock Movement shall be so designed that it is operational with the friction clutch and/or the motor removed from the machine.**
- B. Insertion of the hand crank into the switch-and-lock movement **shall be prevented until, or** shall cause the opening of electrical contacts before the crank mechanically engages with the switch-throwing mechanism. The opening of these contacts shall disconnect the switch-and-lock movement motor and the switch repeater relays. **However, the opening of these cut-out contacts shall not open a repeater relay shunt circuit otherwise applied by the circuit**

controller of the Switch-and-Lock Movement. Once opened, these cut-out contacts shall latch in the open position until manually reset. Removal of the hand crank and closing of the hand crank cover shall not cause restoration of this latch.

- C. Switch-and-lock movement motors shall be suitable for repeated successful operation at their rated dc voltage, plus or minus eight percent without undue damage to their contacts which shall have a useful life in excess of 150,000 switch operations over two years.
- D. The cranking arrangement shall mechanically convert the rotational torque supplied by the motor or the hand crank into a longitudinal force to move the switch points.
- E. The clutch shall protect the motor from the mechanical shocks which may be encountered at end of stroke or during abnormal track switch operation such as obstructed points or rods. The friction clutch shall be adjustable to slip reliably and consistently within the range of 12 to 14 amperes of motor current. Once adjusted, the clutch shall not slip at motor currents below this range..
- F. The mechanical locking mechanism shall prevent point movement by vibration or otherwise after the points have reached the Normal or Reverse position and the switch-and-lock movement has been de-energized.
- G. The circuit controller shall indicate that the points are moved to and locked in the Normal or Reverse position and shall also control the connections to the motor.
- H. The circuit controller point detector shall provide an indication when mechanical locking is in effect that the points are in the Normal or Reverse position. The circuit controller point detector shall incorporate a latch-out feature that may be enabled or disabled by the user. When enabled, this latch-out feature shall prevent restoration of the point detector indications until a maintainer manually resets the latch-out whenever the points have been detected moving ¼ inch from the stock rail without first mechanically unlocking the Switch-and-Lock Movement (e.g. a trailed or forced switch point.) This feature shall be disabled at the time of commissioning and shall be easily enabled by WMATA without additional parts.
- I. The case shall serve as a mounting bed for the various other components of the switch-and-lock movement. The cover(s) shall protect these components from the environment. Each hinged cover on the machine shall have brass or stainless steel hinge pins. The case and cover(s) shall conform to Part 12.1.1 of the AREMA Communications & Signals Manual.
- J. Each switch-and-lock movement shall conform to the recommendations contained in Part 12.2.1 of the AREMA Signal Manual, where the recommendations of the AREMA Signal Manual do not conflict with other requirements established herein.
- K. All switch-and-lock movements supplied shall be identical unless otherwise specified. Switch-and-Lock Movements shall be of the type, Model M-3, as manufactured by Union Switch & Signal, Inc. of Pittsburgh, Pennsylvania, or approved equal.
- L. Each Switch-and-Lock Movement shall be permanently identified by a serial number that encodes the date of manufacture to the nearest month or week. The serial number shall be prominently displayed on the case of the Switch-and-Lock Movement near the motor.
- M. Removable covers or other parts of the Switch-and-Lock Movement, which appear to be nearly symmetrical but require a specific orientation for proper operation of the machine shall have mechanical keying or asymmetrical fastener pattern to prevent incorrect orientation

when being assembled.

- N. Slip-on electrical connections shall not be used in the Switch-and-Lock Movement.
- O. The motor circuit shall be terminated to an accessible single test-nut binding post or similar device designed for repeated ease of opening and closing of the circuit for periodic maintenance. An ammeter connected across the opened circuit shall be used to measure motor current for either direction of operation during WMATA's periodic testing.
- P. The hand crank operation of the machine shall be designed to avoid tight clearances of less than 3 inches between fixed equipment or structures and any part of the hand crank handle without modification to equipment or structures not furnished with the Switch-and-Lock Movement.
- Q. Electrical contact spring fingers of the circuit controller shall be operated by cam action. To prevent metal fatigue, each electrical contact spring finger, when moved from its at-rest position shall be displaced no more than 2 degrees of angular deflection per linear inch of spring finger length. All electrical contacts of the circuit controller shall wipe on make and break. Contacts that break motor current shall wipe a minimum of 1/32 inch on make and break.

## 2.02 OPERATING CHARACTERISTICS

- A. Each switch-and-lock movement shall be capable of repeated successful operation without damage at voltages from 90 to 150 volts dc at the machine. Reliability will be based upon operation at 90 to 130 volts dc at the machine.
- B. Switch-and-lock movement operating time shall be measured from the closure of a front contact on the switch operating relay (WR) to the closure of a front contact on the switch repeater relay (WPR) when the switch-and-lock movement is driving a load, the characteristics of which are shown in Part 12.2.5 of the AREMA **Communications & Signals** Manual.
- C. When the switch-and-lock movement operating voltage, as measured at the switch-and-lock movement, is between 90 volts and 130 volts, switch operating time shall be less than the time indicated by the SWITCH OPERATING TIME vs. VOLTAGE curve shown in the Technical Appendix of these Specifications.
- D. The operating voltage used to determine the limit on switch operating time shall be measured at the switch-and-lock movement while the switch is in transit, with the operating supply voltage being **110** volts dc nominal in the Train Control Room.
- E. Under manual operation, once the hand crank has been inserted, it shall take no longer than 20 seconds to hand crank a switch from the Normal locked position to the Reverse locked position, or vice versa.
- F. The hand crank shall be of sufficient size and appropriate configuration for ease of use, as approved by the designated Resident Engineer.
- G. **Motor control contacts of the circuit controller shall open the motor circuit, by opening two contacts (double-break) of the motor energy circuit at the completion of switch operation. However, they shall not remove motor current before completion of switch locking action unless sufficient kinetic energy is stored to complete the locking action.**

- H. When the Switch-and-Lock Movement is unlocked (e.g. lock dog is less than ½ inch engaged within the lock rod) the repeater relay circuit shall be shunted by the circuit controller and the motor control contacts of the circuit controller shall be closed to permit motor operation in either direction.

### 2.03 IDENTIFICATION

- A. All wire and cable terminals of the switch-and-lock movements shall be tagged or numbered to designate the terminals and contacts in conformance with the Contractor's wiring diagrams.
- B. A number corresponding to the number of its controlling pushbutton shall be securely fastened to the cover of each switch-and-lock movement. This number shall be not less than three inches high, made of cast metal, and painted white. Where two movements are to be repeated by one WP relay, the number of each switch-and-lock movement shall be supplemented by the letter "A" or "B," made as specified above, and centered directly under the number.

### 2.04 PAINTING

- A. Switch-and-lock movements shall be painted in accordance with the recommendations contained in Part 1.5.10 of the AREMA Communications & Signals Manual. The finish color shall be black, except as noted above.

### 2.05 SECURITY

- A. Provisions shall be made for the use of a padlock of the type specified in Section 16974 on each hinged or removable cover or special opening on the machine. This shall include, but not be limited to the following:
  1. A padlock to restrict entry to the inside of the switch-and-lock movement
  2. A padlock to restrict entry to the opening into which the hand crank is inserted to hand crank the movement
  3. A padlock to secure the hand crank to the movement in its storage position.

### 2.06 INTERNAL HEATERS

- A. Switch-and-lock movements shall be provided with internal heating devices to prevent condensation or frost accumulation on contacts and the motor armature. The Contractor shall provide a separate control switch on the power rack in the Train Control Room for all the internal switch-and-lock movement heating devices required at any given interlocking.

### 2.07 HAND CRANKS AND ADJUSTING WRENCHES & TOOLS

- A. Two hand cranks and one set of adjusting wrenches & tools shall be provided for each switch-and-lock movement furnished under this Contract.
  1. Hand cranks shall be equipped with swivel handles.
  2. Adjusting wrenches & tools shall include the minimum number of each tool required to perform all the adjusting and testing required during either initial installation and set-up or for maintenance of the switch-and-lock layout. Tools and gauges required to periodically verify conformance to 49CFR Part 236 FRA standards shall be included in this set.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. The Contractor shall install switch-and-lock movements in accordance with the requirements of his own installation drawings, as previously approved by the designated Resident Engineer, and as shown on the Contract Drawings, with particular attention to maintaining specified clearances in all directions. The distances from centerline of track to centerline of switch-and-lock movement shall be maintained at 4 feet 9 inches as shown on the Contract Drawings unless otherwise authorized in writing by the designated Resident Engineer. **All fixed and moving parts of the functional Switch-and-Lock Layout outside the gage lines of the track (excluding the removable hand-crank handle) shall be at least ½ inch below the top of the running rail without cutting switch ties to a depth of more than 3¾ inches.**
- B. In areas of direct fixation trackwork, the Contractor shall weld four switch machine anchor bolts to the gauge plate extensions (furnished by others) for each switch-and-lock movement. Each anchor bolt shall be a 3/4 inch diameter, 3-1/2 inch long threaded stud (such as a Nelson stud, type CPL, or approved equal) with a yield strength of 50,000 PSI. The Contractor shall determine the proper locations on the gauge plate extensions for these anchor bolts. The welding procedure for the anchor bolts shall be in accordance with ANSI/AWS D1.1-98, Structural Welding Code - Steel. Details of this procedure shall be submitted to the designated Resident Engineer for approval prior to commencement of work. Attachment shall be made by resistance welding. As an option, the Contractor shall drill and chamfer the plate extensions to allow anchor bolts to be attached by downhand fillet welds on the bottom of the gauge plate extensions. Prior to beginning the work, two anchor bolts shall be installed in a piece of 3/4 inch thick A-36 steel plate using an approved method, and tested in accordance with the applicable paragraph(s) of ANSI/AWS D1.1-98. In addition, the two installed studs shall be torque tested by the Contractor in accordance with the applicable paragraph(s) of ANSI/AWS D1.1-98.
- C. Where, due to the height of the switch machine or some other cause, the standard gauge plate extensions (provided by others) cannot be used, it shall be the Contractor's responsibility to provide modified gauge plate extensions, of a design and material previously approved by the designated Resident Engineer, at no additional cost to the Authority. It shall also be the Contractor's responsibility to perform any additional work, e.g., chipping and grouting, which may be necessary to permit such special gauge plate extensions to be installed in a manner satisfactory to the designated Resident Engineer, all at no additional cost to the Authority. Where chipping is necessary, due to insufficient depth for normal installation of the switch operating layout, the Contractor shall also provide proper drainage for the switch-and-lock movement at no additional cost to the Authority.
- D. Further installation criteria and final adjustment shall be as described in Section 16964, Track Switch Operating Layouts.

### 3.02 MEASUREMENT FOR PARTIAL PAYMENTS

- A. Switch-and-lock movements will be measured for partial payments based upon the number of movements delivered, installed, and accepted.
- B. For measurement purposes, each switch-and-lock movement shall include the hand operating crank, the set of switch adjusting wrenches, and all required mounting hardware. It shall not include the padlocks supplied with the switch-and-lock movement. See Section 16974.

**END OF SECTION**

## SECTION 16955

### ATC - TRACK AND ALARM INDICATION PANELS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing and installation of Track and Alarm Indication Panels which shall be supplied in varying quantities (the quantity depends primarily upon the number of track circuits to be indicated) in each Train Control Room. The visual indications shall be implemented with Light Emitting Diode (LED) indicator units.

##### 1.02 DESCRIPTION

- A. These Track and Alarm Indication Panels shall accomplish the following functions:
1. Provide a suitably identified red LED indicator of track occupancy for each track circuit within the limits of the control room.
  2. Provide a suitably identified red LED indicator of track occupancy for the track circuit immediately adjacent to the limits of the control room in each direction on each track.
  3. Provide a pair of suitably identified LED indicators to show the direction of traffic for each track within the control limits of the TCR. At TCRs with interlockings, additional traffic direction indicator pairs shall be provided, one pair for each traffic block emanating from the interlocking. A white indicator shall indicate normal traffic direction, and a red indicator shall indicate reverse traffic direction.
  4. Provide a suitably identified red LED Blown Fuse indicator for each indicating fuse bus in the TCR.
  5. Provide a suitably identified red LED indicator for abnormal conditions for each individual device in the following categories:
    - a. Ground Detectors
    - b. Automatic Transfer Panel
  6. Where applicable, provide suitably identified red LED Non-Vital Interlocking Processor Problem indicator(s).
  7. Where applicable, provide a suitably identified red LED Snowmeter Problem indicator, and individual red LED Snowmelter Failure indicators for each snowmelter-equipped track switch. Where applicable, provide two suitably identified white LED VP On-Line indicators, and two suitably identified red LED VP Failure indicators for each local IVP System.
  8. Provide an audible alarm device and an associated control switch mounted on the front panel as described in Part 2 of this Section.
  9. Provide an output for the connection of an event recorder (local positive grounded energy-switched) at a "test plug coupler" (female receptacle) located on the front panel for each of the indications specified in paragraphs 1 through 8 above as well as a signal return (local negative grounded energy).
- B. All inputs to the Track and Alarm Indication Panels shall be taken from dry contacts provided specifically for them on the devices and circuits specified above. Where necessary, suitable relays shall be provided for this purpose.

##### 1.03 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
1. Section 16921 ATC Power Distribution Systems
  2. Section 16922 Lightning/Surge Protection and Grounding Systems
  3. Section 16928 Interlocking Vital Processor Systems

4. Section 16931 ATC Maintenance and Test Facilities
5. Section 16948 Plug Connectors
6. Section 16949 Signal Wire and Cable
7. Section 16952 D.C. Power Supplies
8. Section 16982 Preliminary and Interlocking Tests

#### **1.04 QUALITY ASSURANCE**

- A. The Contractor shall factory test each Track and Alarm Indication Panel in accordance with a test procedure previously approved by the Engineer, to ensure mechanical, electrical and operational conformance with the requirements of these Specifications. The Contractor shall record the results of these tests on the prescribed Factory Test Report forms for submittal to the Engineer. Only those panels for which Factory Test Reports have been approved shall be shipped to the job site.
- B. Inspect each Track and Alarm Indication Panel after it has been delivered to the job site. Only those panels which have sustained neither external or internal damage during shipment and handling shall be installed.
- C. The final operational test for the Track and Alarm Indication Panel shall be conducted, after the programming jumpers and the indicator designation cards (in their final typed form) have been installed, as part of the preliminary field testing of the location wherein the panel is installed. This test shall include verification of correct outputs at the "test plug coupler," correct indicator operation and correct audible alarm operation per selection.

#### **1.05 SUBMITTALS**

- A. Prior to purchase or fabrication of the Track and Alarm Indication Panels, the Contractor shall submit the following to the Engineer for approval:
  1. Mechanical and assembly drawings of the proposed panel and all components housed therein, including the internal arrangement plan and mounting hardware.
  2. Catalog cuts and complete performance data for the proposed arrangement plan and mounting hardware.
  3. Circuit drawings and wiring diagrams for all internal wiring of the proposed panels.
  4. Samples of all LED indicator units proposed for the panels.
  5. Factory Test Procedure for the proposed panels.
- B. Submit factory test reports for all Track and Alarm Indication Panels before shipping these panels to the job site.

### **PART 2 - PRODUCTS**

#### **2.01 BASIC PANEL REQUIREMENTS**

- A. The unit shall be constructed as a standard 19 inch rack panel of suitable height and 1/8 inch wall thickness. It shall be of dust-tight construction and shall have no ventilation holes in the top and bottom cover plates, unless the inside temperature reached in an ambient of 100 degrees F exceeds 150 degrees F. If ventilation is thus required, the dust-tight requirement will be waived, but only by written approval of the designated Resident Engineer. The front panel (faceplate) shall be as shown on the Contract Drawings, or shall be of an approved mosaic design.
- B. All indications, controls and the test plug coupler shall be front panel mounted. The program input plug couplers shall be mounted on the rear of the unit. An input plug coupler shall be used for external power and input wiring to the unit. This plug coupler shall be a male, flush

mounted receptacle, which shall mate with a female plug clamped to a flexible multiconductor cable as described in Section 16949, Signal Wire and Cable

- C. The indicators shall be Light Emitting Diodes (LEDs) types approved by the designated Resident Engineer. The LEDs shall be front panel, push-in type. Threaded retaining rings shall be used to secure the LEDs in their sockets. As an alternative, integral unit LED indicators may be used, mounted on a supporting mosaic grid. The indicators shall be provided in the colors previously specified, as approved by the designated Resident Engineer. One complete set of spare indicators shall be furnished with each panel. This indicator set shall be separately packaged and taped to the designated panel. LEDs shall be subject to type acceptance testing.
- D. A solid-state annunciator (mounted in a nominal one-inch hole) which emits a moderately loud, but not painful tone at approximately 1000-2000 Hz shall be provided in the front panel. It shall be controlled by a four-position, three-pole switch as shown on the Contract Drawings. The positions for the three-pole switch shall be labeled:
  - 1. OFF;
  - 2. SILENCE (annunciator only off);
  - 3. NORMAL (indicators, recorder, and annunciator operable), and;
  - 4. TEST (all indicators, all recorder outputs, and annunciator on).
- E. Two program jumper plug couplers shall be provided on the rear panel. They shall consist of female receptacles of 50 pins each. For each indication on the front panel there shall be an output at these plug couplers which may be connected to a mating plug with a jumper (to be provided) to either of two adjacent or nearby pins. The first of these pins shall connect the indicator energy (through appropriate circuitry) to the audible alarm bus so that when the indicator is illuminated by a controlling contact in the control room, an alarm will sound. The second pin shall be connected to the same alarm bus except that it shall include in its circuitry an inverter which allows the monitoring of a normally energized contact in the control room and sounds the alarm when this contact opens and the associated indicator is extinguished. These jumpers shall be movable by use of a simple tool such as a contact extractor which shall be supplied with each panel.
- F. Each Track and Alarm Indication Panel shall be complete in all respects and shall provide operational characteristics as described in these Specifications.
- G. Solid state equipment used in the circuitry of the unit shall be designed to utilize semiconductors which are either inherently self-protecting from transients or are protected by devices approved by the designated Resident Engineer. Some conditions which might present problems are the back-EMF generated by event recorder pen motors or casual transients inductively coupled to the power supply or input leads of the unit.
- H. Fifteen pins on the test plug coupler shall be wired to the input plug coupler. When two or more units are installed in a location, these pins shall be connected in parallel at the input plug coupler terminals to allow the recorder outputs of one unit to be jumpered to another unit where the recorder is connected.
- I. The front panel shall be arranged in the manner shown on the Contract Drawings or in an alternate manner previously approved by the Engineer.
- J. The unit shall be circuited as indicated on the Contract Drawings or in an alternate manner previously approved by the designated Resident Engineer which provides equivalent operation as specified herein.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. The Track and Alarm Indication Panels shall be installed at eye level plus or minus one foot as approved by the designated Resident Engineer.
- B. The panels shall be connected to contacts of relays which reflect the operations specified herein through the plug couplers and cable specified herein.

### **3.02 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. Track and Alarm Indication Panels will be measured for partial payments based upon the number of such required panels delivered, installed and accepted.
- B. The following factors will be considered when measuring Track and Alarm Indication Panels for partial payments:
  - 1. Delivery of the specified Track and Alarm Indication Panels and all accessory items by the Contractor and approval of the applicable factory test reports by the designated Resident Engineer.
  - 2. Proper installation of the Track and Alarm Indication Panels by the Contractor.
  - 3. Approval of the installation and operation of the panels by the designated Resident Engineer.

**END OF SECTION**

**SECTION 16956**

**ATC - INTERLOCKING CONTROL PANEL**

**PART 1 - GENERAL**

**1.01 SECTION INCLUDES**

- A. This Section specifies the furnishing and installation of rack-mounted or wall-mounted Interlocking Control Panels (I.C.P.s) and their mounting enclosures in Train Control Rooms which have one or more interlockings within their control limits, and for the furnishing and installation of table-mounted Interlocking Control Panels in Dispatcher's Rooms at terminal and temporary terminal locations. All of these panels shall be designed to permit convenient local monitoring of track occupancy, switch position, signal aspects, and traffic direction established for all tracks in the vicinity of the interlocking, and for local auxiliary switch control and local manual "entrance-exit" control of route selection through the interlockings. These panels shall also include facilities for controlling and monitoring terminal operation and/or snowmelter layouts, where applicable.
- B. The Contractor shall design each of the Interlocking Control Panels in accordance with the style established by the Contract Drawings. The appearance of the face of the Interlocking Control Panel shall be aesthetically pleasing.
- C. Interlocking Control Panels for TCRs at end-of-route terminal locations shall also include facilities for the local control and indication of Terminal Mode Selection, and, where applicable, for hold-out signals. In addition to the Interlocking Control Panel provided in the terminal TCR, the Contractor shall provide one or more table-mounted, plug connected Interlocking Control Panel Assemblies in the Dispatcher's Room at each terminal location. These panels shall also include facilities for controlling and monitoring the NEXT TRAIN Signs, where applicable.
- D. **(Where a Terminal Interlocking is included in the Project, include specific requirements for the I.C.P.s to be provided for that location.)** Example: At the (Station Name) Terminal location, the Contractor shall include facilities in both of the Interlocking Control Panels (TCR and Dispatcher's Room) to control and monitor the terminal interlocking, the automatic terminal mode selection/operation of the terminal interlocking, and the operation of (other possible interlockings in the area). The I.C.P.s. for the Train Control Room and the Dispatcher's Room shall both be equipped to take emergency control of these interlockings, with the Local I.C.P. in the TCR having priority, all as specified herein and in Section 16918, and on the Contract Drawings. The I.C.P. in the Dispatcher's Room shall control and monitor the NEXT TRAIN Signs for the **(terminal name)** Station at all times.
- E. **(Where a Tie-In location Interlocking is included in the Project, include requirements for the revision or replacement of the I.C.P. at that previously existing location.)**Example: The Contractor shall, at the appropriate time, provide a complete new Interlocking Control Panel, or a new face plate and revised/updated wiring for the existing I.C.P. in the Train Control Room at the (Name) Tie-In location, in a manner previously approved by the designated Resident Engineer.
- F. (Include a tabulation of the Type, Capability, and Location for all new I.C.P.s to be provided as part of the Project Contract.Example: The Contractor shall provide Interlocking Control Panels for the following new interlocking locations:

<u>TYPE</u>	<u>CONTROL CAPABILITY</u>	<u>PANEL LOCATION</u>
Wall	Far End Station	Far End Station

	Terminal Crossovers with Automatic Terminal Mode Operation, and the Half Pocket Storage Track Interlocking. Emergency control of same area.	Train Control Room
Table Top (2)	Far End Station Terminal Crossovers with Automatic Terminal Mode Operation, "NEXT TRAIN" Signs, and (2 <sup>nd</sup> Cabinet); Far End Half Pocket Storage Track Interlocking. Emergency control of same area.	Far End Station Dispatcher's Room
Rack	Hooterville Emergency Crossover Interlocking. Emergency Control of same.	Hooterville Station Train Control Room

**1.02 RELATED SECTIONS**

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
1. Section 16913 ATC Block Design
  2. Section 16915 Basic ATC Equipment Requirements
  3. Section 16916 Basic ATC Circuit Requirements
  4. Section 16917 Basic Interlocking Requirements
  5. Section 16918 Special ATC Requirements for Specific Locations
  6. Section 16923 TC Maintenance Telephone System
  7. Section 16924 Non-Vital AT0 & ATS Processor Systems
  8. Section 16925 Data Transmission System (DTS)
  9. Section 16928 Interlocking Vital Processor Systems (if applicable)
  10. Section 16948 Plug Connectors
  11. Section 16949 Signal Wire and Cable
  12. Section 16969 Snowmelter Layouts
  13. Section 16971 Racks and Cable Trays
  14. Section 16974 Locks and Keys
  15. Section 16980 ATC Tests, Inspections and Quality Assurance

**1.03 QUALITY ASSURANCE**

- A. The Contractor shall test each Interlocking Control Panel Assembly prior to shipment. This test shall conform to the Contractor's Factory Test Procedure as approved by the designated Resident Engineer. The results shall be recorded on the approved Factory Test Report Form.
- B. The Contractor shall inspect each Interlocking Control Panel Assembly as finally installed in the field. This inspection shall conform to the Contractor's Installation Inspection Procedure as approved by the designated Resident Engineer.
- C. The final operating tests to determine the acceptability of each Interlocking Control Panel Assembly shall be performed as described in Section 16980, and in the Sections describing the specific interlockings involved.

**1.04 SUBMITTALS**

- A. The Contractor shall submit the following Interlocking Control Panel drawings for approval within 120 days of NTP. These I.C.P. arrangement plans and assembly drawings shall include keyed parts lists.
  - 1. Drawings required for each individual Interlocking Control Panel Assembly:
    - a. Drawings showing the arrangement of the engraved track diagram, symbols and lettering, and the location of all the required control and indication hardware to be mounted thereon.
    - b. Complete circuit drawings for all the control and indication functions to be performed by each Interlocking Control Panel Assembly.
    - c. Complete control, indication and common-return energy wiring diagrams for each Interlocking Control Panel Assembly.
  - 2. Drawings common to all Interlocking Control Panel Assemblies:
    - a. Drawings showing the details of all the various items of control and indication hardware required for the Interlocking Control Panels and the method of mounting these devices on the panel or in the enclosure.
    - b. Drawings showing the details of material and construction for the panel enclosures and the location and method of mounting plug connectors in the enclosures.
    - c. Drawings showing the details for mounting the enclosures in a rack or on the wall.
    - d. Drawings showing the methods of harnessing and supporting the control panel wiring.
- B. The Contractor shall not proceed with fabrication or procurement of any Interlocking Control Panel Assembly until he has obtained the designated Resident Engineer's approval of all the drawings applicable to that particular assembly.
- C. The Contractor shall submit a Factory Test Procedure for Interlocking Control Panel Assemblies. This test procedure shall be in conformance with the requirements specified in Section 16980, ATC Tests, Inspections and Quality Assurance.
- D. The Contractor shall submit an Installation Inspection Procedure for Interlocking Control Panel Assemblies. This inspection procedure shall be in conformance with the requirements specified in Section 16980, ATC Tests, Inspections and Quality Assurance.
- E. The Contractor shall submit Factory Test Reports as required by his approved Factory Test Procedure. These reports shall be submitted to the designated Resident Engineer for approval at least two weeks prior to shipment of the panels from the point of fabrication.
- F. The Contractor shall submit a Field Inspection Report for each new Interlocking Control Panel installed.

## **1.05 DELIVERY, STORAGE AND HANDLING**

- A. The Contractor shall take whatever measures may be necessary to protect Interlocking Control Panels from damage or marring during shipment, storage, installation, and testing. Panels which are marred or otherwise damaged prior to acceptance by the Authority shall be replaced by the Contractor at no additional cost to the Authority.

## **PART 2 - PRODUCTS**

### **2.01 BASIC PANEL REQUIREMENTS**

- A. Basic Controls and Indications

1. Every new Interlocking Control Panel Assembly shall have the following control and indication hardware and all wiring and logic to support the applicable function:
  - a. A MASTER LEVER key switch
  - b. A TRANSFER pushbutton (SR)
  - c. An EMERGENCY RELEASE pushbutton (sealable SR)
  - d. A Single stroke bell
  - e. An INDICATION TEST pushbutton (SR)
  - f. LED indicator units for LOCAL (W) and CENTRAL (G) Control indications
  - g. A YIELD TO CENTRAL (A) indicator LED unit
  - h. ON and OFF pushbuttons (SR) to control the PANEL LIGHTS
  - i. A SWITCH POSITION pushbutton (SR)
  - j. AUXILIARY SWITCH CONTROL pushbuttons (PPT) and switch lock indicator (R) LED units
  - k. Pushbuttons (PPT) for route entrance/exit signals, and turnback signals
  - l. LED indicator units for signals (R/W) and signal fleeting (G/G) indications
  - m. LED indicator units (R/W) for "available route exit" points
  - n. LED indicator units (R/W) for switch position indications (in track diagram)
  - o. LED indicator units (R/W) for route locked/track occupancy indications
  - p. LED indicator units (R) for track occupancy only indications
  - q. LED indicator units (W) for "traffic" indications
  
- B. Special Controls and Indications (where applicable)
  1. Additional control and indication hardware which may be required for certain Interlocking Control Panels shall be as follows:
    - a. SNOWMELTER ON and OFF pushbuttons (SR), and SNOWMELTER ON (R), and SNOWMELTER
    - b. FAILURE (A) LED indicator units
    - c. TERMINAL MODE pushbuttons (SR) and LED (W) indicator units
    - d. AUTOMATIC SIGNAL OPERATION pushbuttons (PPT) and LED indicator units (W)
    - e. LED indicator units (R) for Signal LOCKOUT
    - f. LED indicator units (A or W) for DISPATCHER control
    - g. LED Indicator units (W) for the NEXT TRAIN destination stored in the Train Destination Storage Registers
    - h. CLEAR REGISTER pushbuttons (SR)
    - i. Special control function pushbuttons and special indication function LED units as applicable, as specified in Section 16918, and as shown on the Contract Drawings.
  
- C. Panel Construction and Arrangement
  1. All Interlocking Control Panel face plates shall be constructed of black/white/black laminated phenolic at least 1/4 inch thick, supported at suitable intervals. As an alternative, the face plates shall be composed of an assembly of small, individually engraved, 1/8-inch-thick black/white/black phenolic plates, supported on a three dimensional metal grid carrier structure, which shall also support the alternative control and indication hardware as further specified herein. The engraved phenolic face plates shall be as shown on the Contract Drawings and as manufactured by Mauell Corporation, Dillsburg, PA, or approved equal.
  2. Each panel face plate shall be engraved with a track diagram of the interlocking and its approaches and with symbols for the interlocking signals and passenger station platforms. The track diagram for each panel shall be oriented with track 2 located above track 1. An arrow pointing in the relative direction of Metro Center Station (or Gallery Place Station for the "E", "F" and "J" Routes), and the word "INBOUND" shall be engraved at the top of each panel face plate above the location code and the name of the location.
  3. Lettering shall be engraved into the white core of the phenolic to identify the name

and number of the interlocking, switch numbers, signal numbers, track circuit numbers, the functions of the various controls and indications included, and all other information necessary for effective use of the control panel. See the Contract Drawings.

- D. Control and Indication Requirements
1. Pushbuttons for route entrance and exit points (wayside signal locations), and turnback "signals", shall be located in the track diagram at points representing the location of wayside signals and turnback-point signs.
  2. Two "PANEL LIGHTS" pushbuttons, one labeled "ON", and the other labeled "OFF", shall be provided on the lower portion of each Interlocking Control Panel to control the panel indication lights.
  3. An INDICATION TEST pushbutton shall be located near the PANEL LIGHTS pushbuttons to initiate a brief, computer controlled energization of all LED indicators on the applicable panel(s).
  4. TRANSFER, AUXILIARY SWITCH OPERATION, and EMERGENCY RELEASE pushbuttons, the MASTER LEVER key switch, and, where applicable, SNOWMELTER (ON-OFF) pushbuttons and the NEXT TRAIN SIGN control switch, shall be located on the control panel below the track plan unless otherwise indicated. For terminal locations, TERMINAL MODE pushbuttons and indicators, AUTOMATIC SIGNAL OPERATION pushbuttons, and signal LOCKOUT indicators shall be located above the track diagram unless otherwise indicated. All these controls and indications shall be identified by suitable panel engraving as shown on the Contract Drawings.
  5. Track circuit occupancy indications shall, as a minimum, be provided on the Interlocking Control Panel for all track circuits within Approach Locking Limits as well as for all track circuits within interlocking limits and all track circuits within the limits established by turnback points. In addition, track circuit occupancy indications shall be provided for each Advance Approach section in approach to the interlocking and for at least one track circuit beyond each turnback point.
  6. Track circuit indications shall be provided by LED line-of-light bar indicators mounted in the track diagram. These units shall be mounted close to one another so that, when illuminated, they will give a nearly continuous line-of-light through the track circuit they represent. At least three LED line-of-light indicators shall be provided for each switch. One indicator shall be used to indicate the Normal, and one the Reverse position of the switch, while the third indicator shall be located in the diverging approach to the switch.
  7. Signal indications shall be provided by round spotlight LED indicator units located in each interlocking signal symbol and adjacent to each turnback point pushbutton. Another round spotlight LED indicator shall be located in the immediate vicinity of each signal or turnback point light to indicate fleeting of the associated signal.
  8. Arrow-shaped LED traffic indicators shall be located adjacent to their associated track line.
  9. Round spotlight LED indicators shall be provided for other indications, such as switch locked, snowmelter control, snowmelter failure, signal lockout, and stored route destinations.
  10. The shapes for the respective LED indicator lights shall be as shown on the Contract Drawings. The colors for all LED indicator lights shall be as close as possible to the colors indicated on the Contract Drawings, as approved by the designated Resident Engineer prior to installation.
  11. The Contractor shall use the Contract Drawings as a guide for the arrangement of the Interlocking Control Panels. Each panel shall contain all of the equipment required to provide the functions specified.

## 2.02 CONTROL HARDWARE

- A. Basic Types
  - 1. Four basic types of control devices shall be used on the Interlocking Control Panels:
    - a. Key switches
    - b. Pushbuttons (push/pull/turn type) (PPT)
    - c. Pushbuttons (spring-return type) (SR)
    - d. Rotary switches
- B. Key Switch
  - 1. One two-position, key operated, electrical switch shall be mounted on each Interlocking Control Panel to serve as a MASTER LEVER to activate and deactivate the panel. This electrical switch shall be as specified in Section 16974, Locks and Keys.
- C. Pushbuttons
  - 1. Pushbuttons used for AUXILIARY SWITCH OPERATION, route entrance and exit designation (signals), turnback signal control and AUTOMATIC SIGNAL OPERATION shall be of the push-pull, turn-right, turn-left, center-return type (PPT). Simple spring-return (SR) pushbuttons of uniform contact arrangement shall be used for the remaining control functions specified.
  - 2. The external appearance of all the various pushbuttons shall be identical except for the color of the discs attached to their operating knobs. The colors of the identifying discs shall be as indicated on the Contract Drawings. The knobs of pushbuttons shall be shaped to facilitate rotary manipulation.
  - 3. A male plug connector shall be an integral part of each pushbutton assembly. All contacts on each type of pushbutton shall be wired or directly connected to this plug connector. Electrical connections between the pushbutton and other equipment shall be made via a female plug connector. Each pushbutton contact assembly shall be protected by a dust cover. The pushbutton assembly and its cover shall be made of noncombustible materials.
- D. Rotary Switches
  - 1. A three-position rotary switch shall be provided to control the NEXT TRAIN signs at certain terminal locations. The arc between successive position detents shall be 90 degrees. The control knob on the switch shall have an engraved arrow indicator.
- E. Alternative Control Hardware
  - 1. Specialized multi-function control switches shall be mounted securely in the grid carrier.
  - 2. Each control switch shall be mounted individually through the use of a rear mounting plate, front mounting disc and threaded bushing nut.
  - 3. When assembled, a disc and nut shall clamp the switch body (with mounted rear plate) to the rear plane of the grid carrier in an indexed position.
  - 4. Each switch bushing nut shall be tightened to 20 foot pounds of torque in order to mount the switch in the grid carrier.
  - 5. The switch shall be able to be mounted in any open unit in the grid carrier.
  - 6. Switches shall be able to be mounted in adjacent grid openings without interference from other devices.
  - 7. The shaft and bushing when installed shall protrude through the face of the phenolic surface, having sufficient clearance to use a standard blocking pin and mount the operator knob.
  - 8. This alternative control hardware shall be as manufactured by Mauell Corporation, Dillsburg, PA, or approved equal.

## 2.03 INDICATION HARDWARE

- A. Light Unit Indicators
1. All illuminated indications on the Interlocking Control Panels shall be provided by means of identical individual unit, dual-LED type indicators. These indicators shall have the capability to produce two different colored indications where necessary. The indications shall be produced by means of LEDs and colored filters, or by means of appropriately colored LEDs without filters. In either case, the variously colored indications produced shall be of approximately the same intensity.
  2. The LEDs used shall be of the low-voltage, low-wattage, long-life type. LEDs shall be replaceable from the rear of the panel only. Replacement of an individual LED shall require the loosening of no more than two screws. LEDs shall be SP940112-R (red), -A (amber or, with lens, white), or -G (green), as applicable, as manufactured by Data Display products of E1 Segundo, California, or approved equal.
  3. Indicator housings shall be made of a material which is suited to housing LEDs of the rated wattage and which will not exhibit signs of overheating (discoloration or melting) after an extended period of time. The LED housings shall be so designed and mounted that LEDs may be replaced without loosening or disturbing other parts of the indicator or adjacent equipment on the panel. LED replacement shall not require the use of special extractor tools.
  4. Shaped, translucent, non-colored panel inserts shall be provided between the indicators and the panel face. Individual shapes shall be provided for various types of indications as shown on the Contract Drawings. The exposed face of the panel inserts shall be flush with the front of the panel with no space between the edges of the inserts and the cutouts provided for them in the panel.
- B. Bell
1. A 28 volt, single-stroke bell shall be mounted within the panel enclosure and wired to serve as an annunciator for the YIELD TO CENTRAL indicator.
- C. Alternative Indication Hardware
1. All status indications shall be illuminated by discrete solid state high intensity light emitting diodes (LEDs) mounted in special LED holder units.
  2. The LEDs, voltage dropping resistors, diodes, jumpers and connectors shall be mounted to a LED holder designed to snap into any opening of the grid carrier system.
  3. The discrete LED devices shall be directly connected (no plug-in sockets) to the electronic components which provide the proper voltage and current for each LED.
  4. LED holders shall be non-conductive, held firmly in place without any separate mounting hardware (i.e., clips, screws, springs) and shall be easily removable without requiring the use of any tools.
  5. Each unit shall have a 3x3 matrix of mounting holes which allows a 5mm discrete LED to be mounted in any of nine positions in a 24mm square.
  6. The LEDs shall be rated for 100,000 life hours and shall be available in colors of red, green, yellow and white (light yellow).
  7. The LEDs shall have a maximum current consumption of 50 milliamps at 24 VDC.
  8. The LEDs, when installed in the panel, shall not protrude above the phenolic surface.
  9. All track occupancy and "traffic" LEDs shall be mounted behind shaped, water clear lenses.
  10. The alternative indication hardware shall be as manufactured by Mauell Corporation, Dillsburg, PA, or approved equal.

## 2.04 MISCELLANEOUS HARDWARE

- A. One TC Maintenance Telephone Jack, as specified in Section 16923, shall be mounted in one end of the enclosure for each wall-mounted and table-mounted Interlocking Control Panel enclosure. This jack shall be so located that it shall be easily accessible by any person

operating the panel.

- B. The back or end panel of each table-mounted Interlocking Control Panel enclosure shall be equipped with one or more plug couplers to interface the internal wiring with a plug-coupled cable from the Train Control Room.
- C. Grid Carrier Requirements for Alternative Hardware
  - 1. The grid carrier system shall consist of stamped steel shapes assembled using grid screws to form an assembly of incremental units, each 24mm square. When assembled, the grid carrier system shall be rigid, providing a three-dimensional module for mounting the 1/8 inch engraved phenolic panel faceplate, and also providing mounting and support for special control and indication devices.
  - 2. Components of the grid carrier shall be as follows:
    - a. Cross Sections
    - b. "T" Sections
    - c. Corner Sections
    - d. Grid Standoffs
    - e. Grid Screws
    - f. Grid Spacers
  - 3. Cross, "T," and corner sections shall be 1.5mm thick fabricated from cold rolled steel, electrogalvanized zinc plated with a bi-chromate zinc coating according to ASTM Specification B633-85.
  - 4. Grid screws shall be fabricated from cold rolled steel round stock with a tensile strength of 470 to 720 N/mm<sup>2</sup>, and shall be electroplated with a bi-chromate plating according to ASTM Specification B633-85.
  - 5. Grid spacers and standoffs shall be fabricated from MS-58 Brass alloy with a tensile strength of 390 to 670 N/mm<sup>2</sup>.
  - 6. The finished grid assembly shall be mounted in a frame which is part of the panel cabinet. The frame shall be finished in the manufacturer's standard finish and shall provide strength and support to the outer perimeter of the phenolic faceplate.
  - 7. The grid carrier system shall be as manufactured by Mauell Corporation, Dillsburg, PA, or approved equal.

## 2.05 INTERLOCKING CONTROL PANEL ENCLOSURES

- A. Basic Construction
  - 1. Interlocking Control Panel Enclosures shall be of dust-tight design and rigid metal construction.
  - 2. The enclosures for Interlocking Control Panels to be mounted on racks or tables shall have a removable or hinged metal back panel.
  - 3. The enclosures for wall mounted Interlocking Control Panels shall include a metal angle perimeter frame to support and stiffen each individual phenolic panel making up the total display. Each of these support frames shall be hinged continuously along the bottom edge. The front panel(s) shall be prevented from lowering beyond a horizontal position by folding brackets attached to the inside of the enclosure. The top corners of each wall mounted panel shall be equipped with captive thumb screws or other approved devices to secure the panel(s) at the top edge of the enclosure.
- B. Locking
  - 1. A key-operated cabinet lock shall be mounted on each wall-mounted or table-top I.C.P. in such a manner that access to the interior of each Interlocking Control Panel enclosure can be achieved only after the lock has been unlocked. The lock shall be as specified in Section 16974.
- C. Wiring

1. Plug connectors of the solderless crimp type shall be mounted in the back or sides of the enclosure to permit connecting rack wiring to the panel mounted electrical equipment. Plug connectors shall be as specified in Section 16948. Wiring from the pushbuttons, indicators and other equipment mounted on the control panel shall be terminated on the internal portions of the plug connector blocks. Wiring shall be harnessed in such a manner that it does not bind or interfere with the opening or closing of the access panel or interfere with the replacement of pushbuttons, lamps or other panel components. The Contractor shall use single conductor, 19 strand wire, as specified in Section 16949, no smaller than No. 22 AWG, for all internal panel wiring other than telephone jacks. The TC Maintenance Telephone jacks installed in wall-mounted and table-mounted panel enclosures shall be wired as specified in Section 16923.
- D. Finish
1. The finish for Interlocking Control Panel Enclosures shall be a non-chipping, hard gloss gray enamel.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. The I.C.P.s in TCRs shall be located where their faceplate can be seen by technicians working on the Remote Terminal Unit. Where practicable, the I.C.P.s shall be mounted in geographical alignment with the trackage they control.
- B. Small Interlocking Control Panel enclosures for Train Control Rooms shall be mounted in relay racks. The location of the rack selected and the location of the panel enclosure in the rack shall permit convenient use of the control panel by an operator standing in front of it.
- C. Interlocking Control Panel enclosures too large for rack mounting shall be mounted on a wall of the TCR in a position permitting convenient use of the panel without interfering with other equipment or access to the room.
- D. Table Top Interlocking Control Panel enclosures (for use primarily in Dispatcher's Rooms at terminal locations) shall support the control panel at an angle of 75 degrees from horizontal when standing on top of a table or desk.

#### **3.02 OPERATION**

- A. The Interlocking Control Panel indications and controls shall operate as specified herein and as indicated by the circuitry shown on the Contract Drawings and described in Section 16916, Basic ATC Circuit Requirements. It shall not be necessary for the MASTER LEVER KEY Switch to be turned on in order to have the Panel Lights turned on, or to test the visual indicators, or to check switch position.
- B. Indications
  1. The following indications, as applicable, shall occur whether the Panel Lights are turned on or not:
    - a. When pushed, the SWITCH POSITION pushbutton shall cause line-of-light track indicators associated with all unoccupied switches or crossovers shown on the panel to become illuminated in such a way that the position of the switches or crossovers is indicated.
    - b. The SNOWMELTER ON indicator light shall display a steady red when all applicable snowmelters are on in correspondence with a control request. The SNOWMELTER ON indicator shall display a flashing red when

- snowmelters are not all on in correspondence with a control request. When this occurs, one or more SNOWMELTER FAILURE indicators (located adjacent to the individual switches on the track panel) should illuminate to indicate which snowmelter layout is not functioning properly.
- c. When pushed and held in, the INDICATION TEST pushbutton shall cause the interlocking processor to attempt to alternately energize for 2-second intervals:
    - 1) One of the green LEDs in each dual-green fleeting indicator, together with all "white" LEDs on the I.C.P. and;
    - 2) The other green LED in each dual-green fleeting indicator, together with all other ("non-white") colored LEDs on the I.C.P.
2. The following indications shall appear on the panel only when the Panel Lights are turned on:
- a. The green CENTRAL indicator shall be illuminated when Central has control of the interlocking.
  - b. The white LOCAL indicator (and the amber TCR indicator on the I.C.P. in the Dispatcher's Room at terminal locations) shall be illuminated when the Interlocking Control Panel in the TCR has control of the interlocking.
  - c. At terminal locations, the white DISPATCHER indicator on the Dispatcher's Interlocking Control Panel (and the amber DISPATCHER indicator on the I.C.P. in the TCR) shall be illuminated when the Dispatcher's I.C.P. has control of the interlocking.
  - d. When a route entrance is requested, the line-of-light units at all available-exit buttons shall be illuminated white. The illuminated units shall be the ones adjacent to the exit buttons in the direction toward the originating entrance button. When an available-exit point is selected, the line-of-light indicator for that exit shall remain illuminated white and any other available-exit indicators illuminated by the entrance request shall be extinguished.
  - e. The signal indicator adjacent to an entrance/ exit pushbutton shall be illuminated red after a route has been requested at that entrance point, but before the signal has cleared. It shall also be illuminated red after the signal has been set to STOP, but while Approach Locking or Time Locking is still in effect. This indicator shall be illuminated white whenever the associated signal is CLEAR.
  - f. Fleeted signal indicators shall be illuminated green when their associated signals are fleeted.
  - g. The line-of-light indicator units located in the track diagram shall be illuminated red whenever their associated track circuits are occupied. The line-of-light indicators representing tracks located within interlocking limits shall also be capable of producing a white indication. Whenever an entrance/exit route between two opposing interlocking signals is established, but not occupied, the line-of-light indicators for the tracks between those signals shall be illuminated white. When such a route is canceled without being occupied, these units shall remain illuminated white until Approach Locking or Time Locking is released. When the positions of one or more switches (or crossovers) of a requested route are out of correspondence with the called positions, the indicator units representing the called positions of the out-of-correspondence switches shall display flashing red indications as long as the switches remain out of correspondence. When the positions of switches (or crossovers) are in correspondence with the called positions, these same indicator units shall be illuminated white. These flashing red and steady white indications shall be displayed whether the switch call is originated by the Route Selection circuits or by the AUXILIARY SWITCH OPERATION buttons.
  - h. The arrow-shaped traffic indicators shall be illuminated white pointing in the direction of traffic only when the applicable traffic is established and locked.

- i. The round spotlight indicator adjacent to an AUTO SIGNAL OPERATION button shall be illuminated white when automatic route initiation is enabled for that signal.
- j. Signal LOCKOUT indicators for certain signals shall be illuminated red when a route which prevents any other route from being initiated through the area governed by these signals, has been lined and locked.
- k. Each appropriate switch lock indicator, located below the AUXILIARY SWITCH OPERATION pushbuttons, shall be illuminated red whenever its respective switch or crossover is locked.
- l. At terminal locations, the appropriate TERMINAL MODE indicator shall be illuminated white to indicate the terminal mode currently selected.
- m. At terminal stations located on tail tracks, the appropriate Next Train Sign TRACK indicator on the DISPATCHER'S CONTROL PANEL shall be illuminated white to indicate which track is currently designated to have the next revenue train departure.
- n. Where applicable, the appropriate indicator in a NEXT TRAIN Destination Register shall be illuminated white when a train is approaching its respective diverging route signal.
- o. Where applicable, PLATFORM TRACK LOCKOUT indicators shall be illuminated red when a terminal station platform track is not available as a destination for an outbound route due to the establishment of an opposing inbound route from a storage track to the applicable platform track.

C. Control Transfer

- 1. To transfer interlocking control to LOCAL (or to DISPATCHER in the case of a Dispatcher's (I.C.P.) in the normal manner, it is first necessary to turn the (appropriate) MASTER LEVER Key Switch clockwise. The TRANSFER button on the (applicable) Interlocking Control Panel shall then be pressed and held in. This action shall transmit the REQUEST LOCAL CONTROL indication to Central. When Central approves the transfer, it will transmit a TRANSFER TO LOCAL CONTROL control back to the interlocking. When the TRANSFER button is still being pressed at the time this control is received, control shall be transferred to LOCAL (or to DISPATCHER, as applicable). When the TRANSFER button is not being pressed at the time this control is received, no transfer shall take place. When the MASTERLEVER Key Switch for a location which is in LOCAL control is returned to the position designated to deactivate the local I.C.P., control shall automatically transfer back to Central
- 2. When a location is in Local Control and Central desires transfer of control to CENTRAL, Central will transmit a REQUEST CENTRAL CONTROL control to the location currently in control. With the MASTER LEVER Key Switch in the position designated to activate the Interlocking Control Panel, the single-stroke bell on the local panel shall sound and the YIELD TO CENTRAL indication on the control panel shall be illuminated to show that a request to transfer control to CENTRAL has been received. When the MASTER LEVER Key Switch on the applicable Interlocking Control Panel is returned to the position designated to deactivate the panel, control shall automatically be transferred to CENTRAL.
- 3. The EMERGENCY RELEASE pushbutton(s) on an Interlocking Control Panel shall be sealed. When the seal is broken and the button is pushed, control of the applicable interlocking shall be immediately transferred from CENTRAL to the requesting I.C.P. Restoration of control to CENTRAL shall be accomplished by the means described above.
- 4. Operation of the TRANSFER and EMERGENCY RELEASE pushbuttons shall be effective only if the applicable MASTER LEVER Key Switch is in the position designated to activate the Interlocking Control Panel.
- 5. The LOCAL CONTROL indication shall be transmitted from the interlocking to Central Control when local control of the interlocking is in effect; the CENTRAL

CONTROL indication shall be transmitted when local control of the interlocking is not in effect.

6. The same indications which appear on the Interlocking Control Panel shall continue to be transmitted to Central Control when control has been transferred to a local Interlocking Control Panel.
7. ***(Include all special, site-specific requirements for I.C.P. operation.)*****Example:** At the (***Far End Station***) TCR I.C.P. (and the Dispatcher's Room I.C.P.), the Control Transfer specified in paragraphs 1 through 6 above shall apply to control of both the Terminal Interlocking, and the Pocket/Storage Track Interlocking.

D. Route Initiation and Auxiliary Switch Control

1. Operation of the local manual controls described below shall be effective only if the MASTER LEVER Key Switch on the Interlocking Control Panel is in the position designated to activate the control panel and control has been transferred to the local Interlocking Control Panel from Central. At terminal locations, control from the Interlocking Control Panel in the TCR, or from the Interlocking Control Panel in the Dispatcher's Room, shall be mutually exclusive, as indicated on the Contract Drawings. The local control circuits at terminal locations shall be arranged in such a manner as to give priority to the Interlocking Control Panel in the Train Control Room rather than to the Interlocking Control Panel in the Dispatcher's Room. See the Contract Drawings for the interfacing circuits between these two panels.
2. An entrance-exit type manipulation scheme shall be incorporated into each Interlocking Control Panel to provide route initiation by local manual control.
3. Route initiation shall be performed by pushing the button corresponding to the signal at the entrance point of the desired route and then pushing the button corresponding to the desired available exit point. For those entrance points from which a choice of route never exists, it shall not be necessary to push an exit pushbutton. Cancellation of a route or an entrance point designation shall be performed by pulling the button used as the entrance button.
4. Fleeting of a route shall be performed by pushing the entrance button and then, while it is still in, turning it in a direction so that the top of the button moves in the same direction that a train would move as it passes the signal represented by the button. Fleeting shall be performed either at the time that the entrance of the route is defined or after the route has been selected. Fleeting shall be canceled by pulling the entrance button. This operation shall also cancel the route which was fled. Fleeting shall also be canceled by pushing the entrance button and then, while it is pushed, turning it in the direction opposite to that for fleeting. This operation shall cancel the fleeting but shall not cancel the route.
5. The AUXILIARY SWITCH OPERATION buttons shall be wired for auxiliary control of individual switches or crossovers. Turning one of these buttons clockwise or counterclockwise shall control the operation of the associated switch or crossover to the Normal or Reverse position, respectively, unless a route is already locked over that switch. Such auxiliary operation shall remove control of the switch or crossover from the Route Initiation and Route Selection circuits, and shall cause the illumination of the line-of-light units denoting the position of the switch or crossover. Pulling this button shall restore control of the switch or crossover to the Route Selection circuits.
6. For those wayside signals at terminal or diverging route interlockings from which a route can be chosen automatically (by train destination, or by track circuit occupancy), the initiation of routes by these means from a given signal shall be enabled by pushing the AUTO SIGNAL OPERATION button representing that signal, and then, while it is pushed, turning it in the direction of traffic (as indicated by the engraved arrow on the panel). Performing this operation shall not cancel a route that was previously established from the signal.
7. The initiation of routes by automatic means from a given signal shall be inhibited by

pulling the AUTO SIGNAL OPERATION button representing that signal.

- E. Snowmelter Control
  - 1. Local control of the snowmelter layouts in the interlocking area shall be achieved any time the MASTER LEVER Key Switch is turned clockwise, whether the panel is in LOCAL control or not.
- F. Terminal Mode Selection
  - 1. Pushing one of the applicable three TERMINAL MODE pushbuttons when either of the local I.C.P.s (TCR or Dispatcher) is in control shall cause the applicable mode of terminal operation to take effect if it is safely possible to do so.
- G. NEXT TRAIN Sign Control
  - 1. The three-position NEXT TRAIN SIGN rotary control switch (provided on the Dispatcher's Control Panel at locations where the terminal interlocking is on the revenue service end of the passenger platform) shall be wired in such a manner that the center (upward) position results in automatic control of the NEXT TRAIN signs, while the left (counterclockwise) position results in a TRACK 1 indication, and the right (clockwise) position results in a TRACK 2 indication. This switch shall be energized to give the Dispatcher control of the NEXT TRAIN signs at all times, i.e., whether the Dispatcher has control of the terminal interlocking or not.

### **3.03 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. Interlocking Control Panels, complete with their mounting enclosures, will be measured for partial payments as units, based upon the number and type of such required units which have been delivered, installed and accepted.
- B. Factors which will be considered when determining partial payments will include the following:
  - 1. Delivery of the control panel assemblies and associated Factory Test Reports by the Contractor and approval of the Factory Test Reports by the designated Resident Engineer;
  - 2. Installation of the control panel assemblies by the Contractor and approval of the installation by the designated Resident Engineer.
  - 3. Approval by the designated Resident Engineer of the final system level testing of the applicable location.

**END OF SECTION**

**SECTION 16960**

**ATC - EQUIPMENT LAYOUTS**  
(Table of Contents)

**PART 1 - GENERAL**

**1.01 SECTION INCLUDES**

- A. This SECTION lists the various 16960-series Train Control Equipment Layout
1. Specification Sections:
    - a. Audio Frequency Track and Loop Circuit Layouts (Section 16961)
    - b. Impedance Bond Layouts (Section 16962)
    - c. Track Circuit Layouts (Section 16963)
    - d. Track Switch Operating Layouts (Section 16964)
    - e. Signal Layouts (Section 16965)
    - f. Wayside Pushbutton Layouts (Section 16966)
    - g. Marker Coil Layouts (Section 16967)
    - h. Track Bonding Layouts (Section 16968)
    - i. Snowmelter Layouts (Section 16969)

**PART 2 - PRODUCTS**  
NOT USED

**PART 3 - EXECUTION**  
NOT USED

**END OF SECTION**

## SECTION 16961

### ATC - AUDIO FREQUENCY TRACK AND LOOP CIRCUIT LAYOUTS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. Specifications for the design, furnishing and installation of Audio-Frequency (AF) Track and Loop Circuits to perform the two basic ATP functions of train detection and speed command transmission, and to meet certain other requirements.
1. Design AF track circuit equipment in such a manner that normal track circuit maintenance activity shall not require adjustment of the AF track transmitter, i.e., AF track circuits shall normally be adjusted at the receiver end rather than at the transmitter end.
  2. Provide Audio-Frequency (AF) Track Circuits for train detection in all areas except crossover tracks in interlockings. The minimum contiguous length of track in each of these circuits shall be 50 feet.
  3. Provide Audio-Frequency Loop Circuits to transmit speed commands through wire loops installed in conjunction with power-frequency train-detection track circuits at crossover tracks in interlockings. When AF circuits are used in this manner, ensure that the circuits and loops are designed, installed and controlled in such a manner that no speed command can be transmitted (within the interlocking) behind a train which still occupies a portion of the interlocking.
- B. Specifications for the two basic types of inductive track loops and their subtypes, as follows:
1. Prefabricated, multiple-turn loops encased in epoxy filled molded fiberglass channel, and used to transmit speed command signals to the running rails at turnout locations:
    - a. A WMATA Mini-Loop 32 inch by 24 inch D-shaped configuration for use in conjunction with a shunt bar between the running rails.
    - b. A four-foot by fifty - seven inches rectangular configuration for use in pairs, in conjunction with an untuned, receive-only impedance bond
  2. Single-turn loops of heavy wire encased in rubber hose; used in conjunction with single- rail, power frequency track circuits at interlockings to transmit speed commands directly to the transit vehicles.
- C. All wayside AF track and loop devices that contain enclosed, internal air-filled cavities shall conform to the requirements of Section 16914, Environmental Requirements.

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
- |     |               |  |
|-----|---------------|--|
| 1.  | Section 16905 | Current Automatic Train Control System       |
| 2.  | Section 16914 | Environmental Requirements                   |
| 3.  | Section 16943 | Vital Relays                                 |
| 4.  | Section 16946 | Transformers                                 |
| 5.  | Section 16949 | Signal Wire and Cable                        |
| 6.  | Section 16953 | ATP Track Modules                            |
| 7.  | Section 16962 | Impedance Bond Layouts                       |
| 8.  | Section 16963 | Power Frequency Track Circuit Layouts        |
| 9.  | Section 16972 | Junction Boxes                               |
| 10. | Section 16973 | Conduit                                      |
| 11. | Section 16980 | ATC Tests, Inspections and Quality Assurance |

##### 1.03 QUALITY ASSURANCE

- A. All AF track and loop circuit equipment shall be factory tested in conformance with the applicable approved factory test procedure.
- B. All AF track and loop circuits shall be field tested after installation as specified in Section 16980, ATC Tests, Inspections and Quality Assurance.

#### **1.04 SUBMITTALS**

- A. Submit to the designated Resident Engineer for approval, 120 days prior to purchase or fabrication of any AF track or loop circuit equipment, and within 90 days of NTP; schematic representations, operating descriptions, and inter-connection diagrams of the AF track and loop circuit equipment and methods proposed to be used to install and operate this equipment. Include also:
  - 1. Drawings showing the physical characteristics of the proposed inductive loops with their moisture control devices, junction boxes, and impedance matching transformers.
  - 2. Drawings and descriptions of the proposed cable, plug connectors, and splicing materials to be used to wire the loops.
  - 3. Drawings showing the details of the methods and equipment to be used to mount the loops in the trackway.
- B. Submit factory test reports for the prefabricated inductive track loops prior to their shipment to the work site. Only those loops that pass the factory test shall be shipped.
- C. Submit a complete description of the physical properties of the hose to be used to protect single-turn inductive track loops.
- D. Submit drawings and descriptions of the operating characteristics of the impedance-matching transformers for the loops and details of the transformer mounting.
- E. Submit detailed drawings for the installation of each single-wire inductive track loop.

### **PART 2 - PRODUCTS**

#### **2.01 BASIC COMPONENTS**

- A. Each AF track circuit shall consist of the following basic components:
  - 1. A device for generating the proper train detection frequency and coded speed command signals. (ATP Track Module or Slave Module.)
  - 2. A device (ATP Track Module or Receiver Module) for receiving the proper train detection frequency and driving a vital, biased neutral track relay when this frequency is received.
  - 3. A device (Impedance Bond or Inductive Track Loop) for injecting train detection and speed command signals into the running rails.
  - 4. A device (Impedance Bond or Terminating Receiver) for receiving train detection signals from the running rails.
  - 5. Twisted pair interconnecting cable between the track side equipment and the equipment located in the Train Control Rooms.
- B. Each AF loop circuit used for transmitting speed commands only, (in conjunction with power-frequency train-detection track circuits) shall consist of a device for generating the proper coded speed command signals (ATP Track Module or Slave Module) and a single-turn inductive track loop.
- C. ATP Track Modules, Slave Modules, and Receiver Modules shall be as specified in Section

16953, ATP Track Modules, and as shown on the Contract Drawings.

- D. Impedance Bonds shall be as specified in Section 16962, Impedance Bond Layouts, and as shown on the Contract Drawings.
- E. Inductive Track Loops shall be as specified herein, and as shown on the Contract Drawings.
- F. Interconnecting cable shall be as specified in the External Cable portion of Section 16949, Signal Wire and Cable, and as shown on the Contract Drawings.

## **2.02 MULTIPLE-TURN INDUCTIVE TRACK LOOPS**

- A. Each multiple-turn inductive track loop shall consist of a single length of 30 turns of insulated conductor no smaller than 19 AWG and no greater than 16 AWG encased in a one-piece molded fiberglass reinforced, epoxy U-channel. This cable shall meet the requirements of internal cable as specified in Section 16949, Signal Wire and Cable.
- B. The channel shall be formed in a rectangular ("four-foot loop") or a "D" shaped ("WMATA Mini-Loop") configuration and dimensioned as shown on the Contract Drawings. Minimum channel wall thickness shall be 0.155 inch. Minimum channel height and width shall be 1.5 inches. Maximum channel height and width shall be 2.0 inches. Minimum inside radius on corners shall be 2.0 inches.
- C. The two leads for the multi-turn loop thus formed shall be terminated to a weatherproof, quick-disconnect, two-pin, male plug connector mounted near the center of one transverse leg of the loop and facing into the center of the loop as shown on the Contract Drawings. The track loop connector shall mate to the same style threaded field connector used to connect control wires to impedance bonds under this contract.
- D. The formed channel with the 30 turns shall be completed by a hardened epoxy resin fill to strengthen the loop and displace all air cavities.
- E. The finished loop shall include a permanently attached metal embossed manufacturer's part number and serial number name plate near the connector.

## **2.03 SINGLE-TURN INDUCTIVE TRACK LOOPS**

- A. Each single-turn inductive track loop layout shall consist of a single conductor size 10 AWG flex cable loop encased in 1/2 inch I.D. hose hardware for attaching the hose-encased loop to the track structure in the required configuration, and a wayside junction box.
- B. Hose construction shall be molded lead-press process, vertically braided, oil resistant, non-porous, resistant to the effect of aging with braided lay-on yarn and a cover of oil, abrasion, and age resistant red neoprene, as manufactured by American Biltrite Rubber Co., or approved equal.
- C. Cable for the single-turn loop layouts shall be as specified in the External Cable portion of Section 16949, Signal Wire and Cable.

## **2.04 LOOP JUNCTION BOXES**

- A. Wayside junction boxes for all inductive track loop layouts shall be as specified in Section 16972, Junction Boxes.

## **2.05 IMPEDANCE MATCHING TRANSFORMERS**

- A. Impedance matching transformers for the inductive track loop layouts shall meet the basic transformer requirements specified in Section 16946, Transformers.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. Train detection and AF speed command generating apparatus shall be rack-mounted in the Train Control Rooms. Only equipment such as impedance bonds, cables, junction boxes and inductive loops shall be installed at trackside.
- B. Install all AF track circuit equipment as required by the section in which the equipment is specified.
- C. Install inductive track loop layouts of the required type at the locations shown on the Contract Drawings.
- D. Install prefabricated, multi-turn loops in conformance with the approved installation drawings.
- E. Install single turn Speed Command loops in loop configurations as indicated on the Contract Drawings, and in conformance with the approved installation drawings. The loops so formed shall be transposed, as required, to minimize coupling to the rails. Where the No. 10 AWG loop wires serve as leads between the track loop itself and an adjacent wayside junction box or the TCR, they shall be hand twisted to minimize induction radiation.
- F. Interconnect all AF track circuit equipment as shown on the Contract Drawings and on the approved circuit drawings.

### **3.02 ADJUSTMENT**

- A. Final train detection sensitivity adjustment shall be made at the receiver end of the track circuit, i.e., at the receiver portion of the ATP track module.
- B. Set cab power levels according to WMATA approved standards.
- C. At the time of acceptance by the Authority, no AF track transmitter shall be set higher than 85 percent of maximum output level.

### **3.03 MEASUREMENT FOR PAYMENT**

- A. Audio-Frequency Track and Loop Circuits will not be measured for payment as such. The cost of Audio-Frequency Track and Loop Circuits shall be included in the cost of the various ATC components used to provide them.

**END OF SECTION**

## SECTION 16962

### ATC - IMPEDANCE BOND LAYOUTS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section includes Specifications for the furnishing and installation of the various types of impedance bond layouts that are required under this Contract.
- B. Impedance bond layouts shall perform one or more of the following basic functions:
  - 1. Inject train detection, speed command, door command, and/or TWC signals into the running rails.
  - 2. Receive train detection or TWC signals from the running rails.
  - 3. Carry negative propulsion return current from the running rails to track cross-bonding cables or substation return connections via center tap connections on the bonds.
  - 4. Carry negative propulsion return current around insulated joints in the running rails via center-tap connections on the bonds.

##### 1.02 RELATED SECTIONS:

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16914 Environmental Requirements
  - 2. Section 16924 Non-Vital ATO and ATS Processor Systems
  - 3. Section 16949 Signal Wire and Cable
  - 4. Section 16961 Audio-Frequency Track and Loop Circuit Layouts
  - 5. Section 16968 Track Bonding Layouts
  - 6. Section 16978 Miscellaneous ATC Components and Material
  - 7. Section 16980 ATC Tests, Inspections and Quality Assurance

##### 1.03 QUALITY ASSURANCE

- A. Factory test each impedance bond for conformance with the requirements of these Specifications. Where an ancillary trackside device is required for the proper operation of the bond, this device shall be factory tested along with the bond and shall be shipped and installed with the same bond after passing the factory test. Record the results of these factory tests on forms previously approved by the designated Resident Engineer.
- B. Conduct installation and operational tests of each impedance bond layout as required by test procedures previously approved by the Engineer and record the results of these tests for submittal to the designated Resident Engineer. The field test procedures shall meet the requirements specified in Section 16980, ATC Tests, Inspections and Quality Assurance.

##### 1.04 SUBMITTALS

- A. Submit the following to the designated Resident Engineer for approval prior to fabrication or procurement of the impedance bonds, and within 90 days of NTP:
  - 1. Scale drawings of the proposed impedance bonds and any ancillary trackside devices required, to include all mounting details for both direct-fixation and ballasted track mounting.
  - 2. Schematic circuits and detailed wiring diagrams of the proposed impedance bonds and any ancillary trackside devices required.
  - 3. Physical and operating characteristics of the proposed impedance bonds and any

- ancillary trackside devices required.
  - 4. A factory test procedure for the proposed impedance bonds and ancillary devices.
  - 5. A detailed listing of the chemical, mechanical and environmental characteristics of the encapsulating, bonding, and corrosion preventive materials to be used in the fabrication of the impedance bonds.
- B. Submit completed factory test reports of the approved type prior to shipment of the impedance bonds and ancillary devices.
  - C. Submit field test procedures and reports for the impedance bond layouts in accordance with the applicable requirements specified in Section 16980, ATC Tests, Inspections and Quality Assurance.

**PART 2 - PRODUCTS**

**2.01 IMPEDANCE BOND LAYOUT COMPONENTS**

- A. Each impedance bond layout shall consist of the following basic components:
  - 1. An impedance bond of the required type as specified herein and as indicated on the Contract Drawings.
  - 2. Any ancillary trackside device required, such as a tuning unit for the impedance bond.
  - 3. Cables of the required type, number, size and length for rail connections to the impedance bond, and bond center-tap connections where required.
  - 4. Terminating lugs, compression eye fittings, bolts, nuts and other hardware required to connect the cables to the impedance bond.
  - 5. Rail clamps, terminating lugs and welding lugs required to connect the cables to the running rails and/or to negative return moles.

**2.02 IMPEDANCE BONDS**

- A. Each impedance bond shall consist basically of a center-tapped, single turn track coil (composed of two heavy copper "J" bars) around which the applicable coils for train detection, speed command, and TWC signals are wound. The signal coils and signal coupling devices for external cable connections shall be contained in an epoxy- encapsulated assembly on the track coil. The "J" bars of the impedance bond shall be bonded to the body of the impedance bond. This bonding shall prevent rotation of the "J" bars, and shall prevent moisture and dirt from penetrating between the "J" bars and the body of the bond. The exposed portions of the two "J" bars forming the single-turn copper coil shall be thoroughly cleaned, treated and coated at the factory to prevent corrosion. The corrosion preventive coating shall be as approved by the designated Resident Engineer.
  - 1. **At Substation Return locations a configuration of two married impedance bonds may be used to increase the DC return current capacity. No insulated joints shall be used between impedance bonds in this configuration. Track circuit shunting sensitivity shall not be diminished by the configuration. The married bonds may share a track-side mounted coupling unit to separate and couple track and train frequencies to and from the correct impedance bond.**
- B. The impedance bonds shall be sized such that they can be mounted between the running rails on all types of road-bed construction included under this Contract without any part of the impedance bond extending above the top of rail.

- C. The impedance bonds shall weigh less than 80 pounds each.
- D. Track coil terminal lugs shall be provided to connect the required number of rail connection cables to the ends of the track coil, and center tap terminal lugs shall be provided to connect the required number of 1000 KCMIL cables from the center-tap for negative propulsion return feeders and cross-bonding. The Contractor shall provide all material including the protective lugs for connection to moles installed by others.
- E. The track coil shall be rated for 3,000 amperes DC from each rail to center tap (6,000 amperes total) continuously for no less than 3 hours. At Substation Return installations the impedance bond configuration current capacity shall be increased to 4,000 amperes per rail
- F. The bond and associated track circuit shall function properly with an imbalance of 12 percent in the negative return current in the running rails. The imbalance shall be equivalent to 360 amperes DC passing through the track winding from one rail to the other.
- G. The DC resistance of the track coil of the bond shall not exceed 30 micro-ohms.
- H. The impedance bonds shall operate in conformance with all specified requirements when subjected to the extremes of environmental conditions described in Section 16914, Environmental Requirements.
- I. DC Current capacities dependent on temperature rise of copper j-bars shall be based on ambient temperatures of 50 degrees Celsius in direct sun and based on 30 degrees Celsius for tunnel applications.

### 2.03 BOND ANCILLARY DEVICE

- A. The size, weight, and environmental requirements for any trackside impedance bond ancillary device shall be the same as for the impedance bond. All components of such a device shall be appropriate for dependable operation of the unit in the applicable environment.

### 2.04 BOND CONNECTION CABLES

- A. All cables connecting impedance-bond end taps to the rails at a given bond location shall be the same length, as specified in the Negative Return Bonding portion of Section 16968, Track Bonding Layouts.
- B. The type and size of cable used for track and center-tap connections shall be as specified in the External Cable portion of Section 16949, Signal Cable and Wire.
- C. The number of cables used for track and center-tap connections shall be as specified herein and in the Negative Return Bonding portion of Section 16968, Track Bonding Layouts, and as indicated on the Contract Drawings.

### 2.05 BOND CONNECTING HARDWARE

- A. Rail clamps, compression eye fittings, and other hardware required to make track and center-tap connections shall be as specified in Section 16978, Miscellaneous ATC Components and Material, as shown on the Contract Drawings.
- B. Terminals for control cable connection to the impedance bond and any ancillary device required shall be of the pressure-clamp or locking plug connector type, and shall readily accept the appropriate cable specified.

- C. Any exposed fastening hardware such as cover bolts and name tag screws shall be stainless steel, brass or monel.

## **2.06 BOND MOUNTING HARDWARE**

- A. Bond mounting studs and nuts shall be stainless steel or brass.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. Install impedance bond layouts of the required configuration at the following specified types of locations as shown on the Contractor's approved double-line track plans:
  - 1. Negative propulsion return locations near traction power substations (indicated on the Contract Drawings by the letters SSR).
  - 2. Locations where negative propulsion return crossbonding is required between tracks.
  - 3. Boundaries of the audio-frequency (AF) track circuits required by:
    - a. Interlocking limits and end-of-track locations;
    - b. Logic codes established by the block design;
    - c. Passenger station platforms (both ends);
    - d. Automatic routing and train supervisory control considerations, and;
    - e. Mainline/Yard negative return propulsion power isolation requirements.
- B. Mount the impedance bonds and any required ancillary devices on the track structure in the manner previously approved by the designated Resident Engineer. All bolted surfaces that are to carry negative return currents, including those on J-bars, T-bars and lugs, shall be polished to a bright finish and a conductive coating (Kopr-Shield Coat or equivalent) applied prior to assembly.
- C. Install appropriate protection for any exposed connectors on the impedance bonds to prevent damage from being inflicted by dragging equipment.
- D. Rail-To-Bond Connections
  - 1. Install the electrical connections between all impedance bond side taps and the running rails. At impedance bonds which are used to provide a connection between a substation (or tiebreaker station) negative propulsion return bus and the rails, two 1000 kcmil cables (or their equivalent) shall be used to connect each side tap terminal ear of the impedance bond track winding to its adjacent running rail. Unless otherwise specified, one 1000 kcmil cable (or its equivalent) shall be used to connect each rail to the impedance bond track winding at all other impedance bonds. See Section 16968, Track Bonding Layouts, and the Contract Drawings.
  - 2. One end of each of these cables shall be clamped to the running rail with a base-of-rail clamp. The other end of each of these cables shall be equipped with a compression eye terminal lug and shall be securely bolted to one of the side tap terminal ears on the impedance bond. See Section 16968, Track Bonding Layouts, and the Contract Drawings.
  - 3. All terminals and electrical connection taps on impedance bonds and negative-return cables shall be thoroughly cleaned immediately before being connected.
  - 4. Once track connections are installed, the resistance between the impedance bond track winding and the rail, including contact resistance at the impedance bond and at the rail, shall be less than 120 percent of the combined resistance of the installed cable or cables, when measured using the following criteria:
    - a. Resistance of 24 inches of conductor containing a connection shall not exceed the resistance of 30 inches of plain conductor.

- b. Tests shall be made by the ammeter, milli-voltmeter or Kelvin Bridge method of low-resistance ohmmeter. Tests shall be made with direct current at a value not exceeding 100 amperes. All test values shall be corrected to 68 degrees F for comparative purposes with tables of cable resistance.
- E. **Bond Center Tap Connections**
  - 1. Install all electrical connections to impedance bond center taps. Where more than two cables must be attached to a single impedance bond center tap, provide a copper adapter plate having one hole for bolting to the bond center tap and four holes for bolting cables or pairs of cables to be connected. This plate shall be rated for twice the current-carrying capacity of the bond track winding. All of the center-tap connection cables at a given location shall be the same length.
- F. For cross-bonding purposes, install two cables of the required size in conduit furnished by other disciplines, as indicated on the Contract Drawings. These cables shall be equipped with compression-eye terminal lugs on both ends.
- G. For substation return or yard isolation purposes, furnish and install a minimum of four Class D (127 strand) 1000 kcmil cables between the bond center tap adapter plate ("T" connector) and the appropriate negative propulsion return energy mole furnished by others, all as indicated on the Contract Drawings. Where no mole is furnished by other disciplines, connect all of the substation return cables (by other disciplines) directly to the bond center tap adapter plate in the specified manner.
- H. The installed resistance of center-tap connections, including the resistance of all cable end connections and any adapter plates required, shall be less than 120 percent of the combined resistance of the installed cables, when measured using the criteria specified in Part 3.01-D.4. above.

### **3.02 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. Impedance bond layouts will be measured for partial payments based upon the number and type of such required layouts which are delivered, installed, and accepted.
- B. Factors that will be considered before partial payments for impedance bond layouts are made will include, but not be limited to the following:
  - 1. Delivery of the impedance bonds and all required ancillary devices, and approval of the impedance bond Factory Test Reports by the designated Resident Engineer;
  - 2. Installation of the layouts and Level A partial system acceptance of the location involved, and;
  - 3. Level C partial system acceptance of the location involved.

**END OF SECTION**

## SECTION 16963

### ATC - POWER FREQUENCY TRACK CIRCUIT LAYOUTS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing and installation of balancing impedance type, single-rail track circuit layouts, utilizing 60 Hz energy, for train detection in crossover tracks within interlockings.
- B. These circuit layouts shall be as specified herein, and as shown on the Contract Drawings.
- C. Minimum track circuit length, per operating track, shall be 50 feet.

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16914 Environmental Requirements
  - 2. Section 16917 Basic Interlocking Requirements
  - 3. Section 16941 Basic Component Requirements
  - 4. Section 16943 Vital Relays
  - 5. Section 16946 Transformers
  - 6. Section 16949 Signal Wire and Cable
  - 7. Section 16968 Track Bonding Layouts
  - 8. Section 16980 ATC Tests, Inspections and Quality Assurance

##### 1.03 QUALITY ASSURANCE

- A. Components of the power frequency track circuits furnished by the Contractor shall be factory tested in accordance with procedures previously submitted by the Contractor and approved by the designated Resident Engineer.
- B. Test insulated rail joints (provided by other disciplines) which define the limits of power frequency track circuits, and promptly notify the designated Resident Engineer of any such joints not functioning properly.
- C. Field test power frequency track circuits as specified in Section 16980, ATC Tests, Inspections and Quality Assurance.

##### 1.04 SUBMITTALS

- A. Submit, 120 days prior to fabrication or procurement of the following items, drawings showing the physical characteristics, ratings and operating characteristics for the proposed track feed transformers, adjustable resistors, balancing impedances and track fuses.
- B. Submit factory test procedures for the above items 90 days prior to fabrication or procurement of the items.
- C. Submit factory test reports for the above items prior to shipment of the items to the job site.

#### PART 2 - PRODUCTS

## **2.01 TRACK TRANSFORMERS**

- A. Track transformers shall be as specified in Section 16946, Transformers.

## **2.02 BALANCING IMPEDANCE**

- A. The balancing impedance shall consist of a three-terminal device containing an inductor and a resistor in series, with the center, connecting point brought to a terminal. The inductor shall be of the laminated iron type having an impedance of 24.0 ohms at 60 Hz plus-or-minus 10 percent. The resistor shall have a value equal to the dc resistance of the inductor within plus-or-minus 2 percent (approximately 0.67 ohms).

## **2.03 ADJUSTABLE RESISTORS**

- A. Adjustable resistors shall meet the requirements specified in Section 16941, Basic Component Requirements, and be as described below:
  - 1. The resistor in the feed end shall be 3.0 ohms with a continuous capacity of 200 watts. It shall be capable of a current of 10 amperes and shall have taps allowing the selection of 0.5, 1.0, and 1.5 ohms.
  - 2. The resistor at the relay end shall be 25 ohms with a continuous capacity of 100 watts. It shall be capable of a current of 3 amperes and have taps allowing the selection of 12, 8 and 4 ohms.

## **2.04 TRACK FUSES**

- A. Fuses shall be as specified in Section 16941, Basic Component Requirements, and as described below:
  - 1. The fuse in the feed end of the track circuit shall be 600 volt, 8 amperes.
  - 2. The fuse in the relay end of the track circuit shall be 600 volt, 2 amperes.

## **2.05 TRACK RELAY**

- A. The ac track relay shall be as specified in Section 16943, Vital Relays.

## **2.06 WIRING**

- A. Wiring for power frequency track circuits shall be in accordance with Section 16949, Signal Cable and Wire.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. Power frequency track circuits shall be arranged to provide continuous train detection.
- B. All power frequency track circuit equipment shall be located in the local Train Control Room, with the exception of wayside junction boxes and cabling.
- C. The track feed transformer and the local coil of the track relay for each power frequency track circuit shall be fed from the same energy source and phase.
- D. Power frequency track circuits shall be installed as shown on the Contract Drawings.

### **3.02 OPERATION**

- A. Shunting sensitivity of power frequency track circuits shall be .06 ohms or more under dry weather conditions.
- B. Power Frequency track circuits shall operate in a satisfactory manner under the environmental conditions described in Section 16914, Environmental Requirements.

### **3.03 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. For purposes of measurement for partial payments, each power frequency track circuit will be considered to include:
  - 1. Track feed transformer
  - 2. Feed and relay end adjustable resistors
  - 3. Balancing impedance
  - 4. Track fuses
  - 5. Vital ac track relay
  - 6. Cables and wayside junction boxes
  - 7. Track connection hardware and signal rail bonding
  - 8. Insulated rail joints (provided by other disciplines)
- B. Power frequency track circuits will be measured for partial payments based upon the number of such required circuits installed and accepted.

**END OF SECTION**

## SECTION 16964

### ATC - TRACK SWITCH OPERATING LAYOUTS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing and installation of Track Switch Operating Layouts at the various locations indicated on the Contract Drawing track plans.
- B. Each Switch-and-Lock Layout shall be designed to perform the specified functions for WMATA switch point throws of either 5 inches or 3¾ inches, plus or minus ¼ inch in conformance with applicable parts of AREMA Communications & Signals Manual, Sections 12, 13, and 16.
- C. Each Track Switch Operating Layout shall consist of:
1. A Switch-and-Lock Movement
  2. All the necessary arrangement of rods, insulators and hardware to connect the Switch-and-Lock Movement to the switch points for throwing, locking, and detecting purposes, including but not limited to the following separate rods and associated equipment:
    - a. Hinged or swivel front (#0) rod lug,
    - b. Operating ("throw") rod and lost motion device ("basket"),
    - c. Lock rod,
    - d. Detector rod,
    - e. Front (#0) insulated switch rod to connect switch points to the lock rod.
  3. All the necessary cable, wire, junction boxes and electrical fittings required to connect the Switch-and-Lock Movement electrically to the TCR for operation and indication purposes.
  4. All the necessary arrangement of tie straps and fastening hardware to stabilize the switch ties for reliable operation of the Switch-and-Lock Layout for ballasted track installations.
  5. All necessary hardware to secure the Switch-and-Lock Movement to the switch ties for ballasted installations or to the gage plate extensions for direct fixation installations.
  6. Two cast metal letters, "N" and "R", at least three inches high, painted white, and affixed to the #0 cross-tie or corresponding direct fixation location to denote the Normal and Reverse open switch point positions.
- D. All Track Switch Operating Layouts shall have all similar parts interchangeable insofar as possible and practical.

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
- |    |               |  |
|----|---------------|--|
| 1. | Section 16923 | TC Maintenance Telephone System              |
| 2. | Section 16949 | Signal Cable and Wire                        |
| 3. | Section 16954 | Switch-and-Lock Movement                     |
| 4. | Section 16972 | Junction Boxes                               |
| 5. | Section 16980 | ATC Tests, Inspections and Quality Assurance |

### 1.03 QUALITY ASSURANCE

- A. Quality assurance for Switch-and-Lock Movements, external signal cable, and junction boxes included in Track Switch Operating Layouts shall consist of the quality assurance requirements specified for those components in Sections 16954, 16949 and 16972, respectively.
- B. Factory inspect all rods, connecting hardware and electrical fittings in accordance with the inspection procedures approved by the designated Resident Engineer.
- C. Upon installation of each Track Switch Operating Layout, conduct a mechanical inspection and perform a circuit breakdown test in conformance with the installation inspection procedures approved by the designated Resident Engineer. This inspection shall also ensure that the switch-and-lock movement is electrically isolated from both running rails.
- D. The final operating tests and inspections for Track Switch Operating Layouts shall be performed as specified in Section 16982, Preliminary and Interlocking Tests (Level A).
- E. Establish and execute a monthly maintenance schedule per the O&M Manual until such time as the equipment has been accepted by the Authority at the time of SCI.
- F. All supplied Switch-and-Lock Layout components and systems are Class A type equipment and shall conform to all environmental requirements as identified in AREMA Communications & Signals Manual, Part 11.5.1. for such equipment.

### 1.04 SUBMITTALS

- A. Submit mechanical and electrical drawings for each type of Track Switch Operating Layout proposed for this Contract. The mechanical drawings shall include keyed material lists complete with part numbers. The drawings to be submitted shall include, but not be limited to:
  - 1. Overall mechanical layouts showing relative location of major components
  - 2. Detailed drawings of the various rods, connecting hardware and electrical fittings
  - 3. Control, operating, indicating and internal heating circuits
  - 4. Detailed wiring diagrams for the Switch-and-Lock Movement mechanism and its associated wayside junction box.
- B. The Contractor shall not proceed with the manufacture or procurement of this equipment, except at his own risk, before obtaining the designated Resident Engineer's written approval of the equipment proposed.
- C. Submit factory inspection procedures for the various rods, connecting hardware and electrical fittings included in the layout. These procedures shall be in conformance with the requirements of Section 16981, Basic ATC Test and Inspection Requirements.
- D. Submit an installation inspection procedure which shall include a breakdown test of all field wiring included in the Track Switch Operating Layout. This procedure shall be in conformance with the requirements of Section 16981, Basic ATC Test and Inspection Requirements.
- E. Submit the required factory inspection reports prior to shipment of the junction box, electrical fittings, rods and connecting hardware for Track Switch Operating Layouts.

- F. Prior to the installation of any track switch operating layout, submit a maintenance procedure which outlines the monthly and any other periodic maintenance which shall be performed by the Contractor until such time as the Authority takes possession of the Train Control System. This procedure shall include maintenance as specified in Section 16954, Switch and Lock Movements, and the applicable O&M Manual.
- G. Submit a breakdown test report for each Track Switch Operating Layout installed.
- H. Submit a monthly report certifying that monthly maintenance has been performed per the O&M Manual.

## 1.05 DELIVERY, STORAGE AND HANDLING

- A. All unpainted ferrous metal surfaces of Track Switch Operating Layout equipment shall be coated with NO-OX-ID "E" grease, petroleum jelly or an approved equivalent, before the equipment is shipped from point of manufacture. Parts constructed of a non-ferrous material or having a painted finish will not require this protective coating.

## PART 2 - PRODUCTS

### 2.01 - SWITCH-AND-LOCK MOVEMENT

- A. A Switch-and-Lock Movement shall be provided as part of each Track Switch Operating Layout. See Section 16954.

### 2.02 RODS

- A. Provide the following separate, insulated rods and associated equipment as part of each Track Switch Operating Layout:
  1. Hinged or swivel front rod
  2. Throw rod and throw rod basket
  3. Lock rod and lock rod lug
  4. Detector rod and point detector lug
- B. No welded components will be allowed. All rods and lugs shall be forged unless otherwise directed in writing by the designated Resident Engineer.
- C. When offsets are required in the rods, the rods shall be offset during manufacture. At least 15 inches of threaded area shall be supplied on each rod to accommodate a wide latitude of operating adjustments.
- D. The circuit controller point detector shall be connected to the point detector lug attached to the near side switch point.
- E. The lock rod shall be connected to the middle of the insulated front rod.
- F. Insulation shall be provided in the Number Zero switch Rod to electrically isolate the switch points from one another. Insulation required for the above rods and equipment shall be of the type recommended in Part 8.5.3. of the AREMA Communications & Signals Manual.
- G. The rods shall be of appropriate length to provide the specified distance from centerline of track to centerline of switch-and-lock movement. Any modifications necessary to meet this

requirement shall be performed by the Contractor in a manner satisfactory to the Engineer at no additional cost to the Authority. (See Section 16954, Switch and Lock Movements.)

### **2.03 JUNCTION BOX**

- A. Each Track Switch Operating Layout shall include a junction box suitable for terminating the interconnecting wire and cable adjacent to the Switch-and-Lock Movement.
- B. A cast iron, pedestal mounted junction box shall be furnished for layouts to be situated in ballasted construction areas. A NEMA 4X cast metal or 14 gauge stainless steel junction box shall be furnished for use in direct fixation areas, except that a fiberglass junction box shall be furnished for installation on tunnel walls. See Section 16972, Junction Boxes.
- C. A TC Maintenance Telephone jack shall be installed in the junction box. See Sections 16972 and 16923.
- D. If the switch machine junction box or WJ is located on the opposite side of the track from the switch machine, or if the WJ is located at a distance greater than 12 feet from the switch machine, an additional TCM phone jack (which is accessible without removing any covers) shall be installed at or near the switch machine.

### **2.06 PULL BOX AND ELECTRICAL FITTINGS**

- A. Where embedded conduit stubs up on the side or end of the switch-and-lock machine opposite to the entrance opening to the machine, provide a stainless steel pull box and liquidtight flexible conduit at no additional cost to the Authority.
- B. Each Track Switch Operating Layout shall include all the conduit, connectors, terminal blocks and other electrical fittings required for the switch control, operation and indicating wiring between the Switch-and-Lock Movement and the TCR.

### **2.07 MISCELLANEOUS HARDWARE**

- A. Two cast metal letters, "N" and "R", at least three inches high, painted white, and drilled to provide a means of attaching them, shall be furnished to denote the Normal and Reverse positions of the switch points.
- B. Furnish all screws, bolts, nuts, washers, pins, cotter keys, shims, plates and other hardware required to connect the rods to the Switch-and-Lock Movement and to the switch points. In ballasted track areas the Contractor shall also furnish tie straps as shown on the Contract Drawings.

### **2.08 PAINTING**

- A. All equipment described in this Section shall be painted in accordance with the recommendations of Part 1.5.10 of the AREMA **Communications & Signals** Manual. The finish color shall be black.

### **2.09 EQUIPMENT PROVIDED BY OTHER DISCIPLINES**

- A. The Number One and Number Two insulated vertical switch rods of each track switch will be furnished by other disciplines.

- B. Two switch ties will be furnished by other disciplines for each Track Switch Operating Layout in ballasted track areas.
- C. Two gauge-plate extension bars will be furnished by other disciplines for each Track Switch Operating Layout in direct fixation track areas.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. Track Switch Operating Layouts shall be installed as per approved installation drawings and as shown on the Contract Drawings. The Switch-and-Lock Movements shall be installed as specified in Section 16954.
- B. In ballasted construction areas, the Contractor shall be responsible for any ballast removal required to install the switch operating layouts. Excess ballast shall be spread evenly between ties in the vicinity of the track switch. Likewise, the Contractor shall be responsible for all drilling, dapping, shifting, relocating or replacement of ties that may be necessary to meet the requirements indicated on the approved drawings. Whenever ties are shifted, relocated or replaced, the Contractor shall re-tamp them to a fully stable condition. The Contractor shall be responsible for restoring the track to proper alignment and profile at no additional cost to the Authority.
- C. In direct fixation construction areas, the Contractor shall be responsible for mounting the switch-and-lock movements (switch machines) at the proper location and height on the gauge plate extension bars furnished by others. **All fixed and moving parts of the functional Switch-and-Lock Layout shall be within 3 feet 10½ inches from the gauge line (within 6 feet 2¾ inches of the centerline) of the track.**

#### **3.02 IDENTIFICATION**

- A. The two cast metal letters "N" and "R" shall be securely mounted inside the running rails, attached to the first tie adjacent to, but not supporting, the switch points (or in a similar position on the concrete in direct fixation areas) to denote the Normal and Reverse positions of the switch points. The letter "N" shall be mounted on the normally open point side as shown on the Contract Drawings.

#### **3.03 LUBRICATION**

- A. Lubricate all moving parts and bearing points of the switch machine upon switch machine installation, with lubricants approved by the designated Resident Engineer. Any moving parts of the switch layout which are frozen shall be freed prior to being lubricated.
- B. Upon installation of the layout, grease the various rod fittings, thoroughly clean, and apply an Authority approved graphite lubricant to the tie plates under the switch points, and to the inside of the joint bars holding the heels of the switch-point rails. Rusted plates shall be wire brushed to remove any scale prior to being lubricated.
- C. Apply a supplemental coating of NO-OX-ID "E" grease, or approved equivalent, to exposed threaded surfaces to prevent corrosion.

#### **3.04 ADJUSTMENT**

- A. Adjust the rods and Switch-and-Lock Movement in such a manner that the proper point detector contacts indicate switch closure when **the switch is mechanically locked and** a point is within 1/8 inch of its stock rail and no point detector contacts are closed when **the switch is mechanically locked and** both switch points are 1/4 inch or more from their respective stock rails, and **adjust the lock rods in such a manner that the Switch-and-Lock Movement cannot mechanically lock when both switch points are 1/4 inch or more from their respective stock rails** with the specified obstruction measurements being made 6 inches back from the switch points.
- B. The adjustment shall result in the switch points being at least 4-3/4 inches, and not more than 5-1/8 inches from the stock rails when in their "Open" position. For guarded-point switches, the adjustments shall result in switch points being at least 3-3/4 inches, and no more than 4 inches from the stock rails when open.
- C. Final adjustment shall result in a complete "tuck" of the point rail under the machined portion of the stock rail, with point-to-stock rail contact.
- D. These adjustments shall be maintained by the Contractor from the time of installation until acceptance by the Authority. All of these adjustments shall be verified (and corrected if necessary) by the Contractor, not more than 30 days prior to acceptance by the Authority.

### **3.05 MAINTENANCE**

- A. Track Switch Operating Layouts shall be properly lubricated, adjusted, and maintained by the Contractor on a regular timed basis until use and possession of the switches is taken by Authority Rail Systems Maintenance at the time of acceptance by the Authority. The Authority will assume responsibility for switch adjustment and maintenance at that time.

### **3.06 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. Track Switch Operating Layouts will be measured for partial payments as units, based upon the number of complete sets of properly inspected layout components delivered, installed, and properly adjusted by the Contractor, and accepted by the Authority.
- B. For measurement purposes for partial payments, the switch-and-lock movements will not be considered to be included in the switch operating layouts, but will be measured separately.

**END OF SECTION**

## SECTION 16965

### ATC - SIGNAL LAYOUTS

#### PART 1 GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing and installation of Signal Layouts at the various locations indicated on the Contract Drawings, and the final design by the Contractor of modifications to standard signal layouts where necessary.
- B. Each Signal Layout shall consist of:
  - 1. A complete color light signal unit
  - 2. All required mounting devices and related hardware
  - 3. All electrical fittings and cable required to provide the specified signal control and/or lighting circuitry for the wayside signal unit.
- C. Two basic types of Signals shall be used:
  - 1. Controlled Signals (Three Lenses - R/LW/R)
  - 2. Marker Signals (Two Lenses - R/R) (End of Track locations)
- D. All signals of a given type shall be identical, unless otherwise specified.
- E. Controlled signals shall be used to govern the movement of trains:
  - 1. Through interlocking plants (Interlocking Signals) (or as "Repeater Signals" for Interlocking Signals where sighting problems or other special situations are encountered.);
  - 2. For entrance to segments of "running tracks" between interlockings (Intermediate Signals), or;
  - 3. From tail track storage areas (Holdout Signals).
- F. Marker signals shall be used to present a permanent "STOP" aspect at end-of-track locations.
- G. Based upon the Contract Documents and on-site inspection, the Contractor shall determine, for every required signal location, if there is a potential sighting, clearance or interference problem for signals installed in the normally specified manner. For every signal location where such a potential problem exists, the Contractor shall design and submit thorough documentation for whatever alterations and/or additions to the normal installation layout are necessary to overcome the potential problem.

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16914 Environmental Requirements
  - 2. Section 16915 Basic ATC Equipment Requirements
  - 3. Section 16916 Basic ATC Circuit Requirements
  - 4. Section 16923 TC Maintenance Telephone System
  - 5. Section 16949 Signal Wire and Cable
  - 6. Section 16972 Junction Boxes
  - 7. Section 16974 Locks and Keys
  - 8. Section 16975 Foundations
  - 9. Section 16978 Miscellaneous Train Control Components and Materials

**1.03 QUALITY ASSURANCE**

- A. The Contractor shall inspect each signal unit prior to shipment. This inspection shall conform to the Contractor's Factory Inspection Procedure as approved by the designated Resident Engineer. Signal units shall be in compliance with the Specifications prior to delivery to the Authority.
- B. The Contractor shall inspect each signal layout after it has been installed in the field. This inspection shall conform to the Contractor's Installation Inspection Procedure as approved by the designated Resident Engineer. Installation will not be considered complete until the Contractor has corrected all installation defects to the satisfaction of the designated Resident Engineer.
- C. The final operating tests to determine the acceptability of each complete signal layout shall be performed as described in Section 16982, Preliminary and Interlocking Tests (Level A).

**1.04 SUBMITTALS**

- A. The Contractor shall submit complete drawings for each type of signal unit and each type of signal layout he proposes to use, to include all mounting and wiring details. A key-numbered parts list and complete material ordering reference numbers shall be included for each type of signal and layout.
- B. The Contractor shall submit complete documentation for each signal layout which has to be modified to overcome potential sighting or interference problems. This documentation shall include an explanation of how the problem is eliminated by the proposed modifications.
- C. The Contractor shall obtain written approval from the designated Resident Engineer for each type of Signal Layout prior to manufacture or procurement of the signal layout equipment.
- D. The Contractor shall submit a Factory Test and Inspection Procedure for checking complete signal units. This procedure shall be in conformance with the requirements of Section 16981, Basic Test and Inspection Requirements.
- E. The Contractor shall submit an Installation Inspection Procedure for checking the installation of signal layouts. This procedure shall be in compliance with the requirements established by Section 16981, Basic Test and Inspection Requirements.

**1.05 DELIVERY, STORAGE AND HANDLING**

- A. Signal lamps shall be shipped separately from the signals.

**PART 2 - PRODUCTS**

**2.01 SIGNAL UNITS**

- A. Each color light signal unit shall consist of the following components, all as described herein and as shown on the Contract Drawings:
  - 1. Housing
  - 2. Lenses
  - 3. Lamps and lamp receptacles
  - 4. Adjustable transformers
  - 5. Backlights

6. Terminal boards and wiring
  7. Number plate
  8. Mounting device
  9. Lens hoods - where required
  10. Mast and base or wall mounting bracket, as applicable.
  11. Ladder or pole steps, as applicable
- B. Signal units shall be similar to those depicted on Alstom Signaling Inc. (GRS) Drawing No. 45906-358, Union Switch & Signal Inc. (US&S) Part No. N451357, or an equivalent approved in writing by the designated Resident Engineer. Approval of an equivalent signal unit will be based upon:
1. Submittal of proof of the ability of the unit to meet the requirements specified in this Section;
  2. Such additional evidence and tests as the designated Resident Engineer may require to be provided or conducted, all at no additional cost to the Authority.

## **2.02 HOUSINGS**

- A. The housing for Controlled and Marker Signals shall be made of cast iron or cast aluminum and shall have three lamp compartments. The lamp compartments shall be separated from each other by partitions which shall allow the necessary wiring to pass between compartments, but which shall prevent the passage of light between the compartments.
- B. Each lamp compartment shall be of adequate size to provide ample space for the lamps, lamp receptacles, transformer, terminal blocks and other necessary apparatus. The inside of each lamp compartment shall be painted to the manufacturer's standard.
- C. Each signal housing shall have a cast aluminum or cast iron, hinged, removable door. The hinge pins shall be made of brass or stainless steel. This door shall be equipped with a gasket as recommended in Part 15.2.10 of the AREMA Signal Manual. The door shall also be provided with two ventilating openings, top and bottom, which shall be covered with fine mesh stainless steel, copper or brass screen on the inside and protected with hoods to keep precipitation out. A stop shall be provided to prevent the door from opening to an angle greater than ninety degrees. Facility shall be provided for locking the door with a standard WMATA padlock as specified in Section 16974, Locks and Keys. Each door shall be provided with a latching arrangement of such design that the door cannot be latched or locked until it is fully closed.

## **2.03 LENSES AND HOODS**

- A. Signal lenses shall be of the doublet type, 6-3/8 inches in diameter, mounted in gasket material and secured to the lamp compartments in such a manner that their removal will not affect the adjustments of the lamp receptacles. The lenses for these signals shall meet all applicable recommendations of Part 7.1.10 of the AREMA Signal Manual which do not conflict with the requirements of these Specifications.
- B. Controlled signals shall have three lenses, while Marker Signals shall have only two. For standard, three-lens Controlled Signals, red lenses shall be installed on the top and bottom lamp compartments and the middle lens shall be lunar white. For Marker Signals, the top and bottom lenses shall be red and blank plate shall be installed in place of a lens on the middle compartment.
- C. Mount a nine-inch-long sheet metal hood of copper-bearing steel to shield each lens of all signals not located in tunnels.
- D. No backgrounds shall be furnished.

- E. Provide special lenses and other devices as necessary to prevent phantom aspects and to meet the requirements specified in Section 16965 3.2.

#### **2.04 LAMPS AND RECEPTACLES**

- A. Mount two lamps in receptacles behind each lens. Signal lamps shall be manufacturer's designation RLS, 25-watt, 10-volt, S-11 bulb, SC-base, CC-6 shape lamps with a light center length of 1-1/4 inches and a tolerance of 1/64 inch. Lamps shall have a rated life of at least 2000 hours when operated at rated voltage.
- B. The lamp receptacles shall be so designed and located that proper relation of lamps to lens can be readily made and maintained. Receptacles shall be designed so that they will prevent the lamps from coming loose because of vibration.

#### **2.05 SIGNAL HEAD TRANSFORMERS**

- A. Install an individual transformer in each lamp compartment having a lens and lamps. This transformer shall supply current to the lamps in that compartment.
- B. These transformers shall have a nominal primary voltage of 120 volts, a nominal secondary voltage of 10 volts and power rating of 60 watts, all at 60 Hz. They shall have input voltage taps for 110 to 125 volts in five-volt steps, and output voltage taps for five to 12 volts in one-volt steps unless otherwise approved by the designated Resident Engineer.

#### **2.06 BACK LIGHTS**

- A. Equip controlled and marker signals with back lights approximately one-quarter inch in diameter.
- B. Place the back lights in the signal housing opposite each respective lens. The back light for a lunar white lens shall be frosted white, and the back light for a red lens shall be red.
- C. Back lights shall be made of glass, plastic or similar material.

#### **2.07 NUMBER PLATES**

- A. Equip each Controlled Signal and Marker Signal with a sheet steel number plate as shown on the Contract Drawings. These number plates shall have white reflex-reflecting lettering on a black synthetic enamel background.
- B. The number plate for each Controlled Signal shall have two lines of 2-inch high lettering. The top line shall be the route initial and location designation number, and the bottom line shall be the signal number.
- C. The number plates for Marker Signals shall be similar to those for Controlled Signals except that they shall have a white letter "X" followed by the two-digit track number in place of the lettering specified for the bottom line of Controlled Signal number plates.
- D. Number plates shall meet the applicable recommendations established by Part 14.6.1 of the AREMA Signal Manual, where the recommendations of the AREMA Signal Manual do not conflict with the requirements established in this Section.

#### **2.08 MOUNTING DEVICES**

- A. Equip each signal head with a mounting device suitable for the method of mounting required for the particular signal. An adjusting mechanism for aligning the signal shall be included in this device.

## **2.09 MAST AND BASE**

- A. The mast for each mast-mounted signal shall consist of an approved pipe pole four inches in diameter supported by an approved split cast-iron base of the appropriate type (with or without a junction box) as shown on the Contract Drawings.
- B. A suitable adapter shall be provided when the four-inch pole is used to support a signal sized for a three-inch pole. As an option, the mast for each mast-mounted signal shall consist of an approved pipe pole three inches in diameter supported by an approved split cast iron base.
- C. The mast shall be of suitable length to support the signal head at the height required by its approved layout design.
- D. For installation in ballasted-track areas, the cast-iron base shall be of the junction box type. The junction box base shall be equipped with at least six pairs of AAR terminals for the signal lamp wiring and a weatherproof telephone jack for the TC Maintenance Telephone System. The AAR terminals shall be accessible by a cover or door, equipped with provisions for padlocking. Opening this cover or door shall not require the removal of any other part of the signal assembly.
- E. Each type of base shall have four mounting holes suitable for 3/4-inch diameter foundation bolts arranged on 9-1/2 by 9-1/2 inch centers.
- F. Wherever a non-junction-box base is used, or the signal is wall mounted, the Contractor shall provide a separate junction box for installation in close proximity to the signal at no additional cost to the Authority. This junction box shall be equipped with at least six pairs of AAR terminals for the signal lamp wiring and a weatherproof telephone jack for the TC Maintenance Telephone System. The junction box and the telephone jack shall be as specified in Section 16972, Junction Boxes, and Section 16923, TC Maintenance Telephone System, respectively.
- G. Platform-Mounted Signals
  - 1. A leveling plate and a No. 60 Duro Neoprene pad, or approved equal, shall be furnished and installed beneath the base of each platform-mounted signal. The Contractor shall furnish and install 4 1-inch galvanized bolts and star masonry anchors, or approved equal, to secure the signal base to the platform.

## **2.10 LADDER OR STEPS**

- A. Provide ladders or pole steps for all signals where the upper signal lamp compartment is more than six feet from the ground or from a walkway from which convenient signal lamp replacement can be made.
- B. All prefabricated ladders shall be furnished complete with all stays, fastenings, bolts, strap-iron extensions, where required, and any other necessary mounting and fastening equipment. Side rails of ladders shall not be factory bent or drilled at the bottom but shall be furnished straight so that they can be bent and drilled in the field for best accommodation to local conditions.
- C. Ladders with a series of punched holes in the side rails will not be acceptable.

- D. Sloping ladders for mast-mounted signals shall be furnished complete with top and intermediate stays.
- E. Pole steps may be furnished in lieu of ladders for mast-mounted signals. When pole steps are used, they shall be of the double-sided type, mounted as follows:
  - 1. The top step shall not be lower than 5 feet below the top of the signal.
  - 2. The bottom step shall be 1 foot above the pole base.
  - 3. The maximum distance between steps shall not exceed 12 inches.
  - 4. Steps shall be uniformly spaced.

## **2.11 WIRING**

- A. Signal units shall be internally wired at the factory insofar as practical and possible.
- B. Signal layout wiring shall conform to the requirements of Section 16949, Signal Wire and Cable, and Section 16915, Basic Equipment Requirements, and shall be located as indicated on the Contract Drawings.

## **2.12 PAINTING**

- A. Paint the metal components of each signal layout in accordance with the recommendations of Part 2.4.30 of the AREMA Signal Manual. The finish coat of paint shall be dull black.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. Install Signal Layouts per approved drawings and as shown on the Contract Drawings. No part, either fixed or movable, of any signal layout shall project into the clearance envelope for the transit vehicles. This shall include, but not be limited to, the opened covers or doors of the signal housing and signal junction box.
- B. The signal number plate shall be placed under the lowest signal lens in the assembly, bracket-mounted to the signal housing, and shall be fastened by four brass screws, with lead and brass washers under the screw heads and under the enameled plate. The lead washers shall be installed adjacent to the enamel.
- C. Attach the base for each mast-mounted signal to the concrete invert or to a concrete foundation by means of anchor bolts cast into the concrete. See Section 16978, Miscellaneous Train Control Components and Material, and Section 16975, Foundations.
- D. Wall mounted signals shall be bolted to solid strap steel brackets which shall in turn be bolted to machine-bolt type expansion anchors driven into the concrete wall. Where the distance from the wall to the signal head exceeds four inches, a bracket having a diagonal component shall be used to provide additional vertical support for the signal head as indicated on the Contract Drawings. The diagonal component shall be attached to the wall at the top and to the signal at the bottom as shown on the Contract Drawings. The use of sheet metal channel for wall mounting brackets will not be permitted.
- E. Where ladders or steps are required in conjunction with wall-mounted signals, they shall be designed and field modified to fit each particular location in a manner approved by the designated Resident Engineer.
- F. Where local conditions beyond the control of the Contractor make it impossible or unsafe to use the standard specified methods for mounting a wayside signal, or where the standard

specified mounting would result in sighting problems for the signal, the Contractor shall, at no additional cost to the Authority, design and furnish an alternate means for mounting the signal which is acceptable to the designated Resident Engineer. Upon receiving the designated Resident Engineer's approval for the design, proceed with the fabrication of any necessary special mounting device(s) and installation of the signal in compliance with the approved design.

### **3.02 LOCATION AND HEIGHT**

- A. Install signals on the right side of the right-of-way (for the direction in which their aspects govern) wherever clearance and sighting conditions permit. Controlled signals shall be located 9 ft. 7 inches (plus or minus 1 foot 10 inches) downstream from the effective Insulated Joint (IJ), unless otherwise directed by the designated Resident Engineer. Marker signals (where applicable) shall be located at the effective IJ, which is normally located 16'-6" from the outer end of the associated service platform
- B. Where a signal cannot be installed on the right side due to clearance or sighting restrictions, the Contractor shall prepare plans for mounting the signal on the left side of the right of way, and submit these plans to the designated Resident Engineer for approval. Final installation of such signals shall be in accordance with the approved plans.
- C. Install Marker signals with their top lens 8'-6" above top-of-rail as indicated on the Contract Drawings.
- D. Mast-mounted Controlled signals shall normally be installed with their bottom lens 7'-4" above top-of-rail as indicated on the Contract Drawings.
- E. Wall-mounted Controlled signals shall normally be installed with their top lens 8'-6" above top of rail as indicated on the Contract Drawings.
- F. At locations where wayside pushbuttons are required in conjunction with wayside signals, and at all other locations where mounting signals in the normally prescribed manner causes sighting or interference problems, the Contractor shall, at no additional cost to the Authority, mount the signal(s) in accordance with an approved alternative layout which will safely eliminate the problem.

### **3.03 ALIGNMENT AND FOCUSING**

- A. Signals shall be aligned and focused, both horizontally and vertically, in such a manner that the aspects displayed, when viewed from a position seven feet above the top of the right-hand running rail, shall be distinct, unmistakable and continuously visible over a distance of 500 feet upstream from the signals, day or night, under the most adverse environmental conditions indigenous to the Washington, D.C. metropolitan area. See Section 16914, Environmental Requirements.
- B. Where track or tunnel curvature, grade change, or other conditions make sighting impossible at 500 feet, the signal shall be mounted, aligned and focused to provide continuous sighting over the greatest distance possible, but under no circumstances shall this continuous sighting distance be less than 300 feet, unless otherwise authorized by the designated Resident Engineer.
- C. Where continuous sighting from 300 feet cannot be provided, the Contractor shall provide a repeater signal as approved by the designated Resident Engineer, at no additional cost to the Authority.

### **3.04 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. Signal Layouts will be measured for partial payments based upon the number of such complete units delivered, installed, and accepted.
- B. External cable used to connect the signal unit to the TCR will not be paid for as part of the Signal Layout, but will be measured for payment separately.

**END OF SECTION**

## SECTION 16966

### ATC - WAYSIDE PUSHBUTTON LAYOUTS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing and installation of wayside pushbutton layouts at the locations indicated on the Contract Drawings, to allow train operators to select routes through interlockings.
- B. Each wayside pushbutton layout shall consist of the following:
  - 1. A pushbutton box, complete with all applicable pushbuttons, indicator lights, and identification plates;
  - 2. Brackets, or pole and base, as necessary, to mount the pushbutton box at the location indicated on the Contract Drawings,
  - 3. All fittings necessary to mount the pushbutton box, and to connect its control cable to the Train Control Room. This shall include, but not be limited to, such items as junction boxes, terminals, conduit, flexible hosing and clamps.

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16917 Basic Interlocking Requirements
  - 2. Section 16949 Signal Wire and Cable
  - 3. Section 16965 Signal Layouts
  - 4. Section 16972 Junction Boxes
  - 5. Section 16980 ATC Tests, Inspections and Quality Assurance

##### 1.03 QUALITY ASSURANCE

- A. All wayside pushbutton box assemblies shall be factory tested in conformance with the approved factory test procedure.
- B. Inspect each wayside pushbutton layout after it has been installed in the field. This inspection shall conform to the Contractor's Installation Inspection Procedure as approved by the designated Resident Engineer. Installation will not be considered complete until the Contractor has corrected all installation defects to the satisfaction of the designated Resident Engineer.
- C. Wayside pushbutton layouts shall be field tested as specified in Section 16980.

##### 1.04 SUBMITTALS

- A. Prior to purchase or fabrication of pushbutton box assemblies:
  - 1. The Contractor shall submit scale drawings of the Route Selection and Route Cancel pushbutton boxes he proposes to furnish. These drawings shall include, but not be limited to:
    - a. Enclosure details, including corrosion protection and painting,
    - b. Mounting details,
    - c. Complete, key-numbered parts list including ordering information for all components used for each type of wayside pushbutton layout to be used.
  - 2. The Contractor shall submit drawings and performance data for the pushbuttons and indicating lights he proposes to furnish.

3. The Contractor shall submit a complete Factory Test and Inspection Procedure for each type of pushbutton box assembly.
- B. Prior to shipment of pushbutton box assemblies, the Contractor shall submit Factory Test Reports of the units.
- C. Prior to installation of wayside pushbutton layouts, the Contractor shall submit detailed installation drawings for each pushbutton box and an Installation Inspection Procedure for checking the installation of the Wayside Pushbutton Layouts. The inspection procedure shall be in compliance with the requirements established by Section 16981, Basic ATC Test and Inspection Requirements.

## **PART 2 - PRODUCTS**

### **2.01 ROUTE SELECTION PUSHBUTTON LAYOUT EQUIPMENT**

- A. The route selection pushbutton layouts shall consist of:
  1. A pushbutton box enclosure,
  2. The quantity of pushbuttons and indicators shown on the Contract Drawings,
  3. Identification plates as shown on the Contract Drawings,
  4. Mounting equipment and hardware suitable for each location.

### **2.02 PUSHBUTTON BOX**

- A. Each pushbutton box shall consist of the following:
  1. An oil-tight, weatherproof enclosure,
  2. A quantity of oil-tight industrial pushbuttons and indicator lights, arranged as shown on the Contract Drawings,
  3. Identification plates for the pushbuttons and indicator lights.
- B. Pushbutton boxes shall be adaptable for mounting on columns, concrete walls, pipe masts, or special mounting brackets, as necessary.

### **2.03 ENCLOSURE**

- A. Each pushbutton box shall be a NEMA 4X stainless steel or fiberglass enclosure with a hinged or removable front panel on which the pushbuttons and indication lights shall be mounted.
- B. All enclosures used for route selection pushbutton boxes shall be of the same type.

### **2.04 PUSHBUTTONS**

- A. The pushbuttons for use in the pushbutton box layouts shall:
  1. Be equipped with a red mushroom-shaped actuator,
  2. Have contacts which shall be capable of breaking a load consisting of three vital or non-vital dc relay coils, suppressed as specified elsewhere, connected in parallel and operated at the local DC system voltage, one million times without the contact resistance exceeding 10 ohms as measured at 10 ma,
  3. Have contacts which shall have a mechanical life of at least five million operations,
  4. Be oil-tight and weatherproof,
  5. All be identical.

### **2.05 INDICATOR LIGHTS**

- A. The indicator lights for use on the route selection pushbutton box layouts shall:
  - 1. Be complete with socket, lamp, and plastic color cap,
  - 2. Be transformerless,
  - 3. All be identical.
  
- B. B. The lamps shall:
  - 1. Be clear, type 6S6/dc,
  - 2. Be rated for 120 volt, 6 watt operation,
  - 3. Have bayonet base 11 or approved equal.
  
- C. Color caps shall be white plastic.

## **2.06 IDENTIFICATION PLATES**

- A. Identification plates shall be provided for each pushbutton and each indicator light, as shown on the Contract Drawings.
  
- B. The identification plates shall be:
  - 1. Black with white lettering,
  - 2. Permanently attached,
  - 3. Suitable for use outdoors.

## **2.07 MISCELLANEOUS EQUIPMENT**

- A. Additional equipment required to complete the pushbutton box layout shall be as follows:
  - 1. At locations where any pushbutton or indicator light is more than six feet from the ground or walkway, the Contractor shall provide ladders or polesteps.
  - 2. The ladders or polesteps shall be as specified in Section 16965, Signal Layouts.
  
- B. Where field conditions dictate pole mounting, equipment shall be as follows:
  - 1. A steel pipe post with a cap and all hardware necessary to attach the pushbutton box.
  - 2. A split base. Base can be a split junction box base, as specified in Section 16965, Signal Layouts, or a plain split base. Where a split junction box base is not used, a separate junction box, as specified in Section 16972, is required.
  
- C. Where field conditions dictate wall mounting, the equipment shall be as follows:
  - 1. Brackets suitable for mounting on concrete or cinderblock walls and any extensions necessary to bring the pushbutton box layouts within easy reach of the train operator while seated in the train operator's cab.
  - 2. Suitable bolts, anchors and hardware necessary for a complete installation.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. Install pushbutton layouts at the locations shown on the Contract Drawings.
  
- B. The route selection pushbuttons shall be:
  - 1. Right hand mounted with respect to train direction for the signal with which it is associated, unless otherwise specified,
  - 2. Located 10 feet upstream of the signal with which it is associated, unless otherwise specified or specifically authorized by the designated Resident Engineer.
  - 3. Mounted as shown on previously submitted detailed drawings approved by the designated Resident Engineer.

- C. Where local conditions beyond the control of the Contractor make it impossible or unsafe to use the standard specified methods for mounting a wayside pushbutton unit, or where the standard specified mounting would result in sighting problems for the associated signal, the Contractor shall, at no additional cost to the Authority, design an alternate means for mounting the pushbutton unit which is acceptable to the designated Resident Engineer.
- D. Upon receiving the designated Resident Engineer's approval for the design, proceed with the installation of the pushbutton unit in compliance with the approved design.

### **3.02 OPERATION**

- A. The route selection pushbuttons shall operate as specified in Section 16917, Basic Interlocking Requirements, and as shown on the Contract Drawings.

### **3.03 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. Wayside pushbutton layouts will be measured for partial payments based upon the number of required pushbutton layouts furnished, installed and accepted.
- B. For measurement purposes, each pushbutton layout shall include all hardware necessary to mount the pushbutton box in an approved manner. External cable used to connect the pushbutton box to the TCR will not be paid for as part of the Wayside Pushbutton Layout, but will be measured for payment separately.
- C. Factors which will be considered when measuring pushbutton layouts for partial payments will include:
  - 1. Delivery of the pushbutton layout material and approval of its factory test reports,
  - 2. Installation of the pushbutton layout by the Contractor, to include all associated circuitry, and approval of the installation and operation by the designated Resident Engineer.

**END OF SECTION**

## SECTION 16967

### ATC - MARKER COIL LAYOUTS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing and installation of the various types of wayside Marker Coil Layouts required to transfer program station stop data to passing trains at required locations for all mainline tracks in both directions of traffic.
- B. Marker Coil Layouts under this Contract shall be designed, fabricated, located and installed in such a manner that their method of transferring information to the WMATA transit vehicles will be compatible with the method used on previous contracts without requiring any changes in the design or installation of the transit vehicle ATO equipment.

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16918 Special ATC Requirements for Specific Locations
  - 2. Section 16924 Non-Vital ATO & ATS Processor Systems
  - 3. Section 16949 Signal Wire and Cable
  - 4. Section 16972 Junction Boxes
  - 5. Section 16976 Wayside Signs
  - 6. Section 16980 ATC Tests, Inspections and Quality Assurance
  - 7. Section 16996 ATC Technical Appendix

##### 1.03 QUALITY ASSURANCE

- A. Factory test Marker Coil assemblies in accordance with his approved Factory Test Procedure for this equipment.
- B. Inspect fully installed Marker Coil Layouts in conformance with the requirements of his approved Installation Inspection Procedure for this equipment.
- C. Conduct operational tests of the Marker Coil Layouts in the manner prescribed in Section 16980.

##### 1.04 SUBMITTALS

- A. Submit, within 120 days of NTP, complete drawings and material ordering information for each component of the Marker Coil assembly equipment proposed to be furnished and installed under this Contract. Details for mounting and wiring this equipment shall be included. The Contractor shall obtain the designated Resident Engineer's approval for this equipment before proceeding with its manufacture or procurement.
- B. Submit, within 120 days of NTP, drawings for each type of Marker Coil Layout required under this Contract. These drawings shall show the type of track construction, the location and mounting details for the coil assemblies, and shall indicate how guard rail (and/or restraining rail) must be cut, where necessary. The Contractor shall also submit a complete listing of all Marker Coil Layouts to be provided, showing the track number, type of layout, the stationing and frequency of each coil assembly, and indicating the amount of offset required, if any.

- C. Submit, within 120 days of NTP, a Factory Test Procedure for the approved Marker Coil assembly equipment. This procedure shall be in conformance with the requirements of Section 16981, Basic ATC Test and Inspection Requirements.
- D. Submit, within 120 days of NTP, an Installation Inspection Procedure for checking the installation of Marker Coil Layouts. This procedure shall be in accordance with the requirements of Section 16981, Basic ATC Test and Inspection Requirements.
- E. Factory Test Reports for Marker Coil assemblies shall be submitted to the designated Resident Engineer prior to shipment of the equipment.

## **PART 2 - PRODUCTS**

### **2.01 COMPONENTS**

- A. Each Marker Coil Layout shall consist of one or two Marker Coil assemblies to include housings, coils, fixed tuning units, mounting hardware, and, where required, a variable tuning unit and the electrical cable and fittings needed to connect this tuning unit to one of the Marker Coils and to the applicable control circuitry in the TCR.
- B. The No. 1 (2700-foot) Marker Coil Layout shall have two fixed-frequency Marker Coil assemblies; the No. 2 (1200-foot) and No. 3 (484-foot) Marker Coil Layouts shall have one fixed and one variable Marker Coil assemblies, and; the No. 4 (160-foot) Marker Coil Layout shall consist of a single Marker Coil assembly having a fixed tuning coil. The frequencies of the various marker coil assemblies shall be as specified herein and as shown on the Contract Drawings.

### **2.02 MARKER COIL ASSEMBLIES**

- A. Each Marker Coil assembly shall consist of a Marker Coil unit mounted in a nonmetallic housing and, when required, a tuning unit for variable tuning of the coil unit. See the Contract Drawings.

### **2.03 MARKER COILS**

- A. Each wayside Marker Coil shall be constructed and wired in such a manner that, when properly installed, its coupling characteristics and the quality factor (Q) of its tuning circuit are adequate to interact correctly with the existing carborne Marker Coil detection equipment.

### **2.04 MARKER COIL HOUSINGS**

- A. The Marker Coil housings shall be constructed of a non-metallic, noncombustible, fiberglass reinforced plastic material, impervious to the effects of sunlight or extremes of temperatures or humidity. The housings shall support a load of 400 pounds and shall withstand, without damage, the impact of a 20-pound lead ball dropped from a height of four feet. The outer surface of the housing shall be skid-resistant. The ends of the Marker Coil housings shall be sloped as indicated on the Contract Drawings.

### **2.05 STATION OVERSPEED MARKER SIGNS**

- A. A Station Overspeed Marker Sign shall be affixed to the housing for each 160-foot platform Marker Coil assembly as specified in Section 16976, Wayside Signs, and as indicated on the Contract Drawings.

### **2.06 COIL TUNING**

A. Marker Coils shall either be tuned to one of eight fixed frequencies or shall be capable of being variably tuned to one of four of these eight fixed frequencies. Each of the wayside Marker Coils shall be identified by a code number which indicates the frequency at which it will cause the carborne Marker Coil detector to oscillate. This code number shall be marked on the exterior of the marker coil housing by means of stenciling or self-adhesive lettering applied on the side nearest the tuning unit. Letter size shall be one-half inch.

B. Fixed Tuning

1. A small capacitor unit shall be attached directly to each of the "fixed frequency" Marker Coils to create a tuned circuit for one of the eight frequencies to be received on board the transit cars within the tolerances indicated as follows:

FREQUENCY CODE NO.		CYCLES	TOLERANCE Plus or Minus
1	=	110KHz	+ 400 Hz-700 Hz
2	=	100KHz	+ 400 Hz-600 Hz
3	=	92KHz	+ 400 Hz-600 Hz
4	=	170KHz	+ 600 Hz-1100 Hz
5	(No longer used)		
6	=	130KHz	+ 500 Hz-850 Hz
7	=	140KHz	+ 500 Hz-900 Hz
8	=	160KHz	+1000 Hz-1050 Hz
9	=	180KHz	+1200 Hz-900 Hz
10	(No longer used)		

C. Variable Tuning

1. Variable tuning of a Marker Coil shall be accomplished by using a tuning unit which shall be controlled by a direct current polarity code transmitted over a three-wire circuit from the TCR. This tuning unit shall be mounted in the marker coil assembly housing and shall tune the marker coil to one of four frequencies based on the received polarity code. The three-wire dc polarity code and the resultant tuning shall be as follows:

POLARITY CODE			CODE	TUNING FREQUENCIES	
Wire Number			NO.	Cycles	Tolerance
<u>1</u>	<u>2</u>	<u>3</u>			Plus or Minus
+	+	common	6	130KHz	650 Hz
-	+	common	7	140KHz	650 Hz
+	-	common	8	160KHz	650 Hz
-	-	common	9	180KHz	650 Hz
Open circuit			9	180KHz	650 Hz

## 2.07 MARKER COMBINATIONS

A. The first or outer coil of each Marker Coil pair shall have fixed tuning and shall convey to the carborne Marker Detection System the following:

Fixed Tuning  
of First Coil

Information Conveyed

Frequency 1	2700 ft. Station Stop Marker
Frequency 2	1200 ft. Station Stop Marker
Frequency 3	484 ft. Station Stop Marker
Frequency 4	160 ft. Platform Marker (single Marker Coil)
Frequency 5	Not Used (formerly a Grade Change annunciator)

B. Where the outer coil is tuned to frequency 2 or 3, as shown above, the second or inner coil of the Marker Coil pair shall have variable tuning and shall be able to convey to the carborne

Marker Detection System the following:

Variable Tuning  
of Second Coil

Information Conveyed

Frequency 6	Skip Stop
Frequency 7	Make Type A stop
Frequency 8	Make Type B stop
Frequency 9	Make Type C stop

- C. Where the outer coil is tuned to frequency 1, the inner coil of the Marker coil pair shall have fixed tuning (frequency 8) and shall, by its location, convey to the carborne Marker Detection System the direction of movement for which the marker layout applies.

**PART 3 - EXECUTION**

**3.01 INSTALLATION**

A. Basic Requirements

- All Marker Coil assemblies shall be installed with the coils centered between the running rails, except that on curves with a radius of less than 8500 feet the coils shall be offset toward the outside of the curve by the appropriate distance indicated by the "Marker Coil Offset vs. Curve Radius" drawing in the Technical Appendix and as shown on the Contract Drawings. All Marker Coil assemblies shall be installed with their tops at least 1/4 inch and no more than 3/4 inch below the top of the running rails. The centers of the coils of a Marker Coil pair shall be located not less than 4 feet nor more than 8 feet apart. Between sets of adjacent Marker Coil pairs, the centers of the closest coils shall be no closer than 12 feet from each other.

B. Station Stop Markers

- In order to achieve the specified accuracy of station stops, the location of the distance-to-centerline coil of the three station stopping Marker Coil pairs and the two single-coil platform Marker Coils (located 160 feet on either side of the station centerline) is critical. The distance-to-centerline coil of each station stopping Marker Coil pair is the outermost, i.e., "upstream" coil of the pair, in relation to the centerline of the station platform.
- The center of the distance-to-centerline coil of each station stopping Marker shall be located at follows:

Marker Designation	<u>Distance From Platform</u>		<u>Tolerance</u>
	<u>Centerline</u>		<u>Plus or Minus</u>
"Platform" (No. 4)	160 feet		½ foot
"484 foot" (No. 3)	484 feet		½ foot (see note)
"1200 foot" (No. 2)	1200 feet		1 foot (see note)
"2700 foot" (No. 1)	2700 feet		1 foot (see note)

NOTE: All efforts shall be made to maintain the above tolerances in order to achieve the desired stopping accuracy. However, upon written permission from the Designated Resident Engineer, a tolerance of up to +20 feet for No. 1 and No. 2 Markers, and -20 feet for No. 3 Markers, will be acceptable when switches or other obstructions prevent exact location of these approach Marker Coils.

- The second or inner coil of each No. 3 (484-foot) Marker Coil pair, and of each No. 2 (1200-foot) Marker Coil pair, shall have variable tuning. The Contractor shall install a cable between each of these Marker Coil assembly tuner units and the TCR via an adjacent wayside junction box. See Sections 16949, Signal Wire and Cable, and

16972, Junction Boxes.

- C. Installation Restrictions and Variations
1. Marker Coils shall not be installed over drains or cable stub-ups.
  2. Where Marker Coil Layouts must be offset from the track center-line in track having guard rails, either the Marker Coil mounting or the guard rail, or both may have to be modified. This modification shall be performed by the Contractor, subject to the prior approval of the designated Resident Engineer. The Contractor shall design specific modifications for each situation involved, and submit the proposed modifications to the designated Resident Engineer for approval. The installation shall be performed by the Contractor in the manner finally approved.
  3. Where Marker Coil Layouts must be installed in track having restraining rail, either the Marker Coil assembly mounting or the restraining rail support mounting, or both, may have to be modified. This modification shall be performed by the Contractor, subject to the prior approval of the designated Resident Engineer. The Contractor shall design specific modifications for each situation involved, and submit the proposed modifications to the designated Resident Engineer for approval. The installation shall be performed by the Contractor in the manner finally approved.
  4. Wherever a turnout closure rail and/or its fastening hardware interferes with the normally specified placement of a No. 3 marker coil layout, the Contractor shall install the marker layout on the centerline of the through (main) track at the first location less than 484 feet from the centerline of the applicable passenger station platform track where it is possible to do so without interfering with the operation of the turnout. No attempt shall be made to provide a separate No. 3 marker layout for trains approaching the passenger station by way of the crossover track.

### **3.02 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. Marker Coil Layouts will be measured for partial payments based upon the number and type of complete, individual coil assemblies delivered, installed, and accepted. For purposes of measurement, Marker Coil assemblies of the variable tuning type will not be considered installed until all their controlling circuitry and interconnecting cables have been installed as well.
- B. Factors which will be considered when measuring Marker Coil Layouts for partial payments will include:
1. Delivery of the appropriate Marker Coil assemblies and approval of their Factory Test Reports
  2. Installation of the appropriate Marker Coil Layouts by the Contractor and approval of the installation by the designated Resident Engineer
  3. The number and type (fixed or variable tuned frequency) of individual marker coil assemblies included in the Marker Coil Layouts accepted.

**END OF SECTION**

## SECTION 16968

### ATC - TRACK BONDING LAYOUTS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. Negative Return Bonding
  - 1. This Section specifies the furnishing and installation of all negative return bonding required to complete the negative propulsion return system.
- B. Signal Rail Bonding
  - 1. This Section specifies the furnishing and installation of "signal rail" joint, switch jumper, and transposition bonding for power frequency track circuits.

##### 1.02 NEGATIVE RETURN BONDING

- A. Negative Return Bonding is required as follows:
  - 1. Around all negative-return-rail bolted or "glued," non-insulated rail joints in special trackwork areas;
  - 2. To and around trackwork frogs in the negative-return rail, and to isolated pieces of running rail in the frog assemblies;
  - 3. To the heels of negative-return-rail track switch points;
  - 4. As a signal transposition and current-equalizing bond between the stock rails of the diverging tracks at individual main line turnouts using audio frequency track circuits;
  - 5. As a transposition bond in the middle of single crossovers using power frequency track circuits and wherever else the location of negative-return rails must be transposed;
  - 6. As cross bonding between parallel main line track impedance bonds, and between through-track and diverging-track impedance bonds at junction switches;
  - 7. Between impedance bonds and running rails;
  - 8. Between track-mounted negative return device (mole) (usually by others) and impedance bond center tap at substation locations and yard isolation locations;
  - 9. From both ends of segments of restraining rail to their associated running rail;
  - 10. In Audio Frequency Track Circuit territory, from segments of restraining rail to their associated running rail at locations where impedance bonds are connected to the running rails. (Current "balancing" cable (by others) shall also be bonded to its running rail at impedance bond locations);
  - 11. Around all extraneous or abandoned insulated joints in negative-return running rails, whether these joints are indicated on the Contract Drawings or the trackwork drawings or not, and;
  - 12. Between the two closure rails of each turnout adjacent to the turnout frog.
  - 13. At such other locations as necessary to provide an electrically bonded path of adequate capacity for the negative propulsion current around non-insulated, bolted connections in the negative return running rails.

##### 1.03 SIGNAL RAIL BONDING

- A. All signal rail within the limits of power frequency track circuits to be provided under this Contract shall be properly bonded to provide complete power frequency track circuits having the greatest degree of broken-rail protection and shunt detection practicable. This bonding, which is shown on the Contract Drawings, shall meet the following criteria:
  - 1. Provide all signal rail bonding necessary to provide a series path for the track circuit current through the greatest length of signal rail practicable.

2. Do not bond around frogs in the signal rail, but provide signal rail bonding to the ends of the frog castings where necessary, or to frog-flangeway/signal-rails which are continuous through the frog.
  3. Provide signal rail bonds between the extremities of the two legs of the track circuit signal rail which extend to insulated joints beyond each signal frog of a diamond crossover.
  4. Provide all signal rail bonds and transpositions necessary, whether specifically shown on the typical Contract Drawings or not, to produce a single, continuously bonded, maximum-length path through the signal rail and around all bolted or "glued" non-insulated joints in the signal rail.
  5. Where restraining rail is used in conjunction with a signal running rail, bond each end of each individual rail segment of restraining rail to its associated running rail.
- B. Typical signal-rail bonding details are shown on the Contract Drawings. Signal rail bonding connections shall be made as close to the rail joints as practicable to ensure maximum broken rail detection.

#### **1.04 RELATED SECTIONS**

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
- |    |               |  |
|----|---------------|--|
| 1. | Section 16917 | Basic Interlocking Requirements                      |
| 2. | Section 16949 | Signal Wire and Cable                                |
| 3. | Section 16962 | Impedance Bond Layouts                               |
| 4. | Section 16963 | Power Frequency Track Circuit Layouts                |
| 5. | Section 16978 | Miscellaneous Train Control Components and Materials |
| 6. | Section 16980 | ATC Tests, Inspections and Quality Assurance         |

#### **1.05 QUALITY ASSURANCE - NEGATIVE RETURN BONDING**

- A. Upon completion of the installation of Negative Return Bonding at each location, the Contractor shall conduct field inspections of the installation in accordance with pre-approved procedures and furnish documentation of the inspection results, all as specified in Section 16981, Basic ATC Test and Inspection Requirements.
- B. Test each clamped bond, each bolted bond and each welded bond in accordance with the requirements of Section 16980, ATC Tests and Inspections.

#### **1.06 QUALITY ASSURANCE - SIGNAL RAIL BONDING**

- A. Upon completion of the Signal Rail Bonding installation at each location, the Contractor shall conduct field inspections of the installation in accordance with pre-approved procedures and furnish documentation of the inspection results, all as specified in Section 16981, Basic ATC Test and Inspection Requirements.
- B. The Contractor shall demonstrate that the signal rail bonding is in accordance with the requirements specified herein, as shown on the approved installation drawings, and as recommended in Part 8.1.20 of the AREMA Signal Manual.

#### **1.07 SUBMITTALS - NEGATIVE RETURN BONDING**

- A. Prepare and submit detailed installation drawings showing the configuration of negative return bonding for each type of layout encountered. Wherever special, non-standard layout conditions exist, a drawing shall be submitted for each special condition. A list of materials with ordering reference numbers shall be included with each of the submitted drawings.

- B. Submit documentation of resistance tests performed by the Contractor in compliance with Section 16980 to the Designated Resident Engineer within ten days of performance of the required tests.

#### **1.08 SUBMITTALS - SIGNAL RAIL BONDING**

- A. Prepare and submit detailed installation drawings showing the configuration of signal rail bonding for each type of layout encountered. Wherever special, non-standard layout conditions exist, a drawing shall be submitted for each special condition. A list of materials with ordering reference numbers shall be included with each of the submitted drawings.
- B. Submit samples and data for at least two types of protector clips for restraining signal rail joint bonds.

### **PART 2 - PRODUCTS**

#### **2.01 NEGATIVE-RETURN-RAIL JOINT BONDS**

- A. Negative-return-rail joint bonds shall be fabricated for compression bolting to the web of the rails. They shall consist of 500 kcmil size, insulated, ropelay cable, 48 inches long with Burndy type YA34-L terminal lugs on each end, two for each location, except only one for switch point rail heels.

#### **2.02 1000 KCMIL CABLE BONDS**

- A. Each negative return bond used for impedance bond-center-tap-to-running-rail bonding, substation-return bonding, cross-bonding or switch bonding (to include running-rail-transposition bonding at single switches), shall consist of a 1000 kcmil cable which meets the requirements of Section 16949, with an appropriate connector which meets the requirements of these Specifications, on each end, unless otherwise specified herein.
- B. As an alternative to each single 1000 kcmil base-of-rail clamped bond specified for impedance bond-to-running-rail connections, the Contractor may use a prefabricated, dual-500 kcmil bond with an integral connecting lug on one end for attachment to the impedance bond and individual Burndy type YA34-L terminal lugs on the other ends of the two 500 kcmil cables. These two 500 kcmil bond leads shall be separately compression-bolted to the web of the running rail using 5/8-inch diameter fasteners of the appropriate length.

#### **2.03 CABLE-TO-RAIL CLAMPS**

- A. Base-of-Rail clamps for connecting impedance bond leads and other negative propulsion return cables to the running rails shall be sized to accommodate 115 RE rail and 1000 kcmil cable, as shown on the Contract Drawings. Rail clamps shall be Part Number 115-1000, as manufactured by Connector Products, Inc., Camden/Pennsauken, New Jersey, or approved equal.

#### **2.04 COMPRESSION EYE FITTINGS**

- A. Compression-eye type terminal fittings shall be used to attach 1000 kcmil cable to impedance bonds and certain other terminating devices. The compression terminal shall be made of drop-forged copper and formed for compression onto the strands of the cable in accordance with approved methods used by manufacturers experienced in this class of manufacture. Terminals shall be of soft ductile copper, drilled for bolting onto the ears of the impedance bonds or other terminating devices without cracking. Care shall be taken in compressing terminals to strands so as not to reduce the cross section of the conductor or to injure any of the individual strands. The strands, at the point where they leave the terminal, shall be

sufficiently soft to permit being bent to an angle of 90 degrees with the axis of the cable and back to their normal position without breaking. Auxiliary sleeves of the terminal shall be so arranged as not to pinch the wires entering the sleeves. Samples of the terminals shall be submitted for the approval of the designated Resident Engineer before installation.

## **2.05 "T" CONNECTORS**

- A. Copper adapter plates ("T" connectors) for multiple-cable connections to impedance bond center taps shall be fabricated as shown on the Contract Drawings, from 3/4-inch copper bus bar stock of 98 percent conductivity.

## **2.06 WELDED RAIL HEAD NEGATIVE RETURN BONDS**

- A. Prefabricated rail head bonds for welding around joints between consecutive rails shall be 250 kcmil size, 13 inches long, two for each location; as manufactured by Erico Products, Inc., Cadweld Type C bond, or approved equal.
- B. Negative return rail head bonds for welding between adjacent, non-consecutive rails or to frog wing rails shall be 250 kcmil size, of appropriate length for each individual location, with appropriate components as manufactured by Erico Products, Inc., or approved equal.
- C. The welding material shall consist of a copper exothermic mixture appropriate for the types of rail to which the bonds are to be welded.

## **2.07 MISCELLANEOUS NEGATIVE RETURN BONDING HARDWARE**

- A. Bolts, nuts and washers used to connect compression eye fittings to the end and center taps of impedance bonds and to "T" connectors, shall be made of Naval Bronze or Silicon Bronze.
- B. Fasteners for compression-bolted bond connections shall be 5/8-inch diameter compression fasteners, Huck MFG. Co. C50LR-BR20-16 (for two bonds) or C50LR-BR20-12 (for one bond).

## **2.08 SIGNAL RAIL JOINT BONDS**

- A. Non-insulated signal rail joint bonds shall be commercial bonds as manufactured by Erico Rail Transportation Producers Type SBPAJB-"A" or approved equal, consisting of sixteen extra-galvanized steel wires and three copper wires.
- B. Insulated signal rail joint bonds shall be assembled by the Contractor and shall consist of two commercially available track connectors and the required length of insulated cable. The track connectors and cable shall be as close as practicable to the same size/gauge and composition as the non-insulated signal rail joint bonds.
- C. Signal bond wires shall be as recommended in Part 8.1.25 of the AREMA Signal Manual except as otherwise specified herein.
- D. Signal rail switch jumper and transposition bonds shall be as shown on the Contract Drawings.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION OF NEGATIVE RETURN BONDING**

- A. Negative return bond cables shall be connected to the end and center taps of impedance bonds as specified in Section 16962, Impedance Bond Layouts, but only after certain

specified tests (Section 16980) have been made. Each negative return bond shall be installed with a sufficient amount of slack to accommodate rail movement due to expansion and contraction.

- B. Unless otherwise specified, one 1000 kcmil negative return bond (or one dual-500 kcmil bond) shall be installed between each impedance bond end tap and its adjacent running rail. The bond cables for the two ends of each individual impedance bond shall always be of the same size and type and shall be of equal length.
- C. At substation return locations and yard isolation locations, two 1000 kcmil negative return bonds (or two dual-500 kcmil bonds) shall be installed between the impedance bond and each running rail. All four of these bonds shall be of the same size and type and shall be of equal length.
- D. Install a minimum of four 1000 kcmil negative-return bond cables of appropriate length between each substation negative-propulsion-return junction device ("mole" - by others) and a center-tap "T" connector on its adjacent impedance bond. (The mole will be arranged to accept at least eight connections.) The Contractor shall provide and install all necessary connectors, lugs, cables and hardware to make the installation complete between each impedance bond and its appropriate junction device for each return to the substation. The length of each substation negative-return connection shall be kept to the minimum required to reach between the two points without undue strain.
- E. No cross bond shall be provided at a substation return location.
- F. Two 1000 kcmil negative-return bonds (cables) shall be installed in parallel at each cross bond location between main line parallel tracks. One 1000 kcmil negative-return bond (or two 500 kcmil bonds) shall be installed between the center taps of the first impedance bonds of the two diverging tracks of each junction switch. Where applicable, one 1000 kcmil negative-return, base-of-rail clamped bond (or two 500 kcmil compression-bolted rail-web bonds) shall be installed (as a transposition for both signal and negative return purposes) between the "through" running rail and the "isolated" running rail of individual turnouts having AF track circuits throughout.
- G. Provide negative-return bonding around all non-insulated negative-return rail joints and around all extraneous or abandoned insulated joints, both in running tracks and within interlocking limits. Two 500 kcmil insulated cable, compression-bolted rail web bonds (one on each side of the web of the rail) shall be used for this purpose wherever possible. These bonds shall be properly bolted to the center of the web of the rails in the positions indicated on the Contract Drawings. The Contractor shall drill and de-bur 21/32-inch holes at the center-line of the web of rails for the 5/8-inch fasteners.
- H. Should conditions be encountered where it is not practicable to install either compression-bolted bonds or clamped, base-of-rail bonds, appropriate bond connections of the expansion pin type or the welded rail-head type shall be used if specifically pre-approved by the Engineer for that location.
- I. Install all negative return rail joint bonds, rail transposition bonds, and switch, frog, and cross bonds as specified herein. Joint bonds shall be installed close to the ends of the rail joint bars in order to maximize broken rail detection. All 500 kcmil rail bonds shall be compression-bolted to the rail at the centerline of the web of the rail.
- J. For all rail-head and rail-web bonding, the bond terminal lugs and the surfaces of the rails which are to come in contact with the molten metal or the terminal lugs shall be ground clean with a vitrified grinding wheel. The rail brand shall also be ground off in areas where rail-web bolted bonds are to be applied. After grinding, terminal lugs and rails shall be cleaned with Inhibisol, or other approved, non-toxic solvent, to remove all traces of grease and dirt. The

applicator brush shall be kept free of dirt and debris during cleaning operations.

- K. Welded rail-head bonds shall be attached to the rail by an approved exothermic process in such a manner as to ensure the necessary mechanical and electrical connection. The welding mixture shall be appropriate for the type(s) of rail to which the bonds are to be welded.
- L. After thoroughly cleaning the applicable surfaces of the rail and the connector hardware for compression-bolted bonds and base-of-rail clamped bonds, the Contractor shall liberally coat the surface of the copper conductor, and the mating surfaces of the rail and the connector hardware with an anti-oxidation compound before assembly. This compound shall be "Kopr-Shield" Part No. CP128, as manufactured by Thomas & Betts or approved equal. The bond shall then be attached to the rail in such a manner as to ensure the necessary mechanical and electrical connection.
- M. Base-of-rail cable clamps, as shown on the Contract Drawings, shall be installed as per manufacturer's instructions. The torque recommended by the manufacturer shall be applied by torque wrench to ensure the necessary mechanical and electrical connection.
- N. Compression-bolted rail web bonds shall be installed as per the manufacturers instructions, using the recommended equipment to attach properly sized terminating devices to the center of the web of the rail.
- O. Where impedance bond locations do not align properly with substation return layouts; the Contractor shall adjust the bond layout(s) or provide additional equipment and cable as necessary to accomplish the required substation return connections at no additional cost to the Authority.

### **3.02 INSTALLATION OF SIGNAL RAIL BONDING**

- A. Install all signal rail joint bonds, jumpers and transposition bonds as specified herein, in accordance with the manufacturer's instructions, and as shown on the detailed installation drawings submitted by the Contractor and approved by the designated Resident Engineer.
- B. For all signal rail bonding, no hole shall be drilled through the rail brand. Holes shall be drilled perpendicular to the rail by an approved rail drilling machine within plus or minus three-sixteenths inch of the neutral axis of the rail. Holes shall be a maximum of three-eighths inch in diameter. All holes shall be cleaned and deburred before the bonds are installed. Bond wires shall be installed the same day as the hole is drilled. In the event bond wires cannot be installed the same day, the bond hole shall be protected with a suitable plug for protection against the elements. Plugs shall be driven with a hammer approximately three pounds in weight and when in place shall be tight to provide the best possible contact with the drilled surface in the web of the rail. The bond pin shall not be driven to the pin's shoulder. Where a pin is driven to the shoulder, a new hole shall be drilled and a new bond shall be provided. After the bond pin has been driven, a coating of no-oxide grease shall be applied to the surface of the bond where it contacts the rail. Under no circumstances shall any lubricant be applied before the bond has been driven.
- C. Where space does not permit the drilling of the hole into the web of the rail for installation of switch bonds, the hole shall be drilled into the base of the rail as directed and approved by the designated Resident Engineer.
- D. It shall be the Contractor's responsibility to ensure that signal bonding for each given track circuit does not cause the signal rail to become grounded or to contact some extraneous energy source or the signal rail of another track circuit. Where such a possibility exists, the

Contractor shall use insulated signal bonds, or shall take such other approved action as may be necessary to prevent such contact, at no additional cost to the Authority.

- E. Any signal bond which is found to be defective, shall be removed and a new bond shall be installed at no additional cost to the Authority.
- F. Signal rail joint bonds shall be held in place by a protector clip of a type which has been approved by the designated Resident Engineer.

### **3.03 MEASUREMENT FOR TRACK BONDING PARTIAL PAYMENTS**

- A. For measurement purposes only, negative return bonding and signal rail bonding will include all electrical fittings, bonds, and cable used for this purpose, and all labor and miscellaneous material and equipment required to make the required connections as specified.

### **3.04 PARTIAL PAYMENTS**

- A. Factors which will be considered when measuring track bonding for partial payments will include:
  - 1. The proportional amounts of the required types of bonding shown in the Contract Drawings which has been properly installed and accepted.
  - 2. Proper installation of negative return bonding for all extraneous unbonded or improperly bonded rail joints not shown in the Contract Drawings, if any.

**END OF SECTION**

## SECTION 16969

### ATC - SNOWMELTER LAYOUTS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing and installation of snowmelter layouts for all track switches within the limits of this Contract which are located out-of-doors or have their switch points located within 100 feet of a tunnel portal. These locations are indicated on the Contract Drawings.
- B. Each snowmelter layout shall consist of:
  - 1. a contact rail fuse box;
  - 2. two tubular electric heating elements (switch point snowmelters) for attachment to the stock rails of turnouts in the switch point area
  - 3. two power-limiting (auto-therming) switch rod heater units for installation under the throw rod and lock rods;
  - 4. a snowmelter control unit (case) for the wayside control and indication of the snowmelters and switch rod heaters, and;
  - 5. all external signal cable, conduit, rail connections and other miscellaneous hardware required to mount this equipment and to interconnect it with the TCR as specified herein and as shown on the Contract Drawings.

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16916 Basic ATC Circuit Requirements
  - 2. Section 16918 Special ATC Requirements for Specific Locations
  - 3. Section 16923 TC Maintenance Telephone System
  - 4. Section 16932 Spare ATC Equipment and Selectable Items
  - 5. Section 16941 Basic ATC Electrical and Electronic Components
  - 6. Section 16949 Signal Wire and Cable
  - 7. Section 16956 Interlocking Control Panels
  - 8. Section 16964 Track Switch Operating Layouts
  - 9. Section 16973 Conduit
  - 10. Section 16974 Locks and Keys
  - 11. Section 16975 Foundations
  - 12. Section 16977 Tagging and Marking
  - 13. Section 16978 Miscellaneous Train Control Components and Materials
  - 14. Section 16980 ATC Tests, Inspections and Quality Assurance

##### 1.03 QUALITY ASSURANCE

- A. Each snowmelter heating element, switch rod heater unit, snowmelter control case, and contact rail fuse box shall be factory tested. The factory tests for these items shall be conducted in accordance with procedures previously submitted by the Contractor and approved by the designated Resident Engineer.
- B. As part of its factory test, each switch point snowmelter heating element shall meet the following requirements:
  - 1. Each element must withstand a potential of 900 volts DC, applied between conductor and sheath, for 30 seconds, at an ambient temperature of 75 degrees Fahrenheit,

- without breakdown of, or mechanical or electrical injury to the heater element or its terminal connections.
2. Each element shall provide uniform heating of 400 watts ( $\pm 3\%$ ) per foot of active length when energized at 750 volts DC.
  3. Before shipment, each switch point heating element shall be completely submerged in water under hydrostatic pressure of 100 psi for 1/2 hour. Immediately upon removal from the water, the heating element must have insulation resistance of at least 1,000 megohms.
- C. As part of its factory test, each switch rod heater unit shall meet the following requirements:
1. Power Output
    - a. The heaters shall provide a minimum power output of 90 watts per square foot of top surface (100 watts nominal) when powered at 785 volts  $\pm 5$  percent when horizontally immersed in a 32 degrees F water-ice bath.
  2. Dielectric Withstanding Voltage
    - a. When tested as specified in MIL-STD-202, Method 301, the heater element shall withstand 5000 VDC for not less than one minute when immersed in tap water containing 0.1 to 0.5 percent wetting agent. The test voltage shall be applied between the heater power leads (connected together) and a ground electrode placed in the tap water bath. This test may be performed on the heater element either before or after assembly in the steel case.
  3. Self-Limiting Test
    - a. The heater shall be powered at rated voltage for a period of not less than one hour surrounded by not less than the equivalent of one inch of fiberglass insulation. Following the test, the heater shall continue to meet the previously described power output and dielectric withstanding requirements, unless otherwise specified. There shall be no burning, charring, or other permanent damage.
  4. Maximum Surface Temperature
    - a. During the Self-Limiting test (specified in Part 1.03- C.3. above), the maximum temperature indicated by a thermocouple attached to the top surface of the heater shall not exceed 212 degrees F, unless otherwise specified.
  5. Terminal Strength
    - a. The heater lead wires shall withstand a lead pull test of not less than 50 pounds.
  6. Insulation Resistance
    - a. Before shipment, each switch point heater submerged in water under hydrostatic pressure of 100 psi for one-half hour. Immediately upon removal from the water, the heater must have insulation resistance of at least 1,000 megohms.
- D. Record the results of these tests on the prescribed Factory Test Report forms for submittal to the designated Resident Engineer. Only those heating elements, fuse boxes, and control cases for which Factory Test Reports have been approved by the designated Resident Engineer shall be shipped to the job site.
- E. Each snowmelter heating element, switch rod heater unit and contact rail fuse box shall be inspected immediately prior to installation of the snowmelter layouts. Only those heating elements, rod heater units, control cases, and fuse boxes which have suffered no damage due to shipment and handling shall be installed.
- F. Quality assurance for snowmelter control case units shall be conducted as follows:
1. Factory Test

- a. The Contractor shall factory test each snowmelter control case as prescribed in a test procedure previously approved by the designated Resident Engineer, to assure mechanical, electrical and operational conformance with the requirements of these Specifications. The Contractor shall record the results of these tests on the prescribed Factory Test Report forms for submittal to the designated Resident Engineer. Only those cases for which Factory Test Reports have been approved shall be shipped to the job site.
  - b. Field Inspection
    - 1) Inspect each snowmelter control case after it has been delivered to the job site. Only those cases which have sustained neither external nor internal damage during shipment and handling shall be installed.
  - c. Final Operational Test
    - 1) The final operational test for snowmelter control cases shall be conducted as part of the field testing of snowmelter layouts. See Section 16980, ATC Tests, Inspections and Quality Assurance.
- G. Each completely installed Snowmelter Layout shall be field tested in conjunction with the snowmelter control and indication equipment located in the Train Control Rooms. See Section 16956, Interlocking Control Panels.
- H. Conduct the field test for Snowmelter Layouts in accordance with a field test procedure previously submitted by the Contractor and approved by the Engineer.
- I. The field test shall include, but not be limited to, verification of the following:
- 1. All components of the snowmelter layouts are wired and terminated properly.
  - 2. The snowmelter control contactors function properly in response to the control devices in the Train Control Rooms.
  - 3. The snowmelter heating elements and switch rod heater units function properly in response to the closing and opening of the contactor contacts.
  - 4. The snowmelter current monitors and indication relays function properly in response to energization of the snowmelter heater elements and switch rod heater units.
  - 5. The snowmelter case heater units and their control circuits function properly.
  - 6. All safety devices included in the snowmelter layouts, such as fuses and the door interlock, function properly.
  - 7. Each Snowmelter Malfunction indication circuit functions properly.

#### **1.04 SUBMITTALS**

- A. Submit the following for approval by the designated Resident Engineer prior to purchase or fabrication of the items described and within 120 days of NTP:
  - 1. Performance data for the proposed switch point snowmelter heating elements and switch rod heater units.
  - 2. Drawings showing the physical characteristics of the proposed switch point snowmelter heating elements and switch rod heater units, and the details of proposed mounting and wiring of these devices.
  - 3. Drawings showing the physical characteristics of the proposed Contact Rail Fuse Box.
  - 4. Mechanical and assembly drawings of the proposed control case housing and all major components housed therein, to include the internal arrangement plan and mounting hardware.
  - 5. Catalog cuts and complete performance data for the proposed snowmelter control contactors and current monitoring devices.

6. Circuit drawings, arrangement plans, and wiring diagrams for all internal wiring of the proposed cases.
  7. A Factory Test Procedure for the proposed cases.
- B. Submit factory test procedures for switch point snowmelter heating elements, switch rod heater units, snowmelter control cases and contact rail fuse boxes to the designated Resident Engineer for approval prior to factory testing of these devices.
  - C. Submit factory test reports for switch point snowmelter heating elements, switch rod heater units, snowmelter control cases and contact rail fuse boxes to the designated Resident Engineer for approval within two weeks of the date such tests are performed. These devices shall not be shipped from the factory until the designated Resident Engineer's approval of their respective factory test reports has been received by the Contractor.
  - D. Submit complete circuit and installation drawings for the control, operation, and indication of the snowmelter layouts prior to the installation of these layouts. These circuits and installation layouts shall be as indicated on the Contract Drawings unless otherwise approved by the designated Resident Engineer.
  - E. Submit calculations used to determine the amperage ratings for the current monitors to be used in the Snowmelter Control cases.
  - F. Submit a complete field test procedure for snowmelter layouts to the designated Resident Engineer for approval prior to installation of the layouts.
  - G. Submit a field test report for each snowmelter layout installed.

#### **1.05 SHIPPING AND HANDLING**

- A. All snowmelter heating elements furnished under this Contract shall be packed, shipped and handled in such a manor that they are delivered to the Authority work site and installed without bends, kinks or any other damage.
- B. All snowmelter layout parts furnished by the Contractor which are damaged in the course of shipment, handling or installation, shall be replaced by the Contractor at no additional cost to the Authority.

### **PART 2 - PRODUCTS AND MATERIALS**

#### **2.01 SWITCH POINT SNOWMELTER HEATING ELEMENTS**

- A. The snowmelter heating elements shall be of the incoloy sheathed tubular element type designed to operate at 750 volts DC  $\pm 20$  percent with a uniform heat dissipation rating of 400 watts per foot of active length.
- B. Each heating element shall be 0.475 inch in outside diameter,  $\pm 0.005$  inch, with the sheath to be incoloy 800 with a wall thickness of 0.030 inch,  $\pm 0.005$  inch.
- C. Each heating element for a No. 10 switch layout shall have two anti-creep collars, each 2 inches long and 5/8 inch  $\pm 1/16$  inch in diameter. One collar shall be located with its center 11 inches from the midpoint of the active length of the heating element and the other collar shall be located at the midpoint of the active length of the heating element. Each heating element for a No. 8 switch layout shall have one anti-creep collar located at the midpoint of the active length of the heating element.

- D. Each heating element shall be equipped with terminal connectors of the neoprene quick disconnect type with positive locking action. Each terminal connector shall be 7/8 inch in diameter and have an overall length of 8-1/4 inches. Terminals on heating element ends shall be male probe (female sheath), Chromalox Part #070-055910-001. These terminals shall be waterproof and shatterproof (as per MIL specification MIL S-TD-202, Method 107, Condition B), mate with Chromalox connector #070-055909-001 and be able to withstand the following test: Immersion in water for 240 hours while vibrating at 70 CPS to 80 CPS and while maintaining a minimum insulation resistance of 17 megohms.
- E. Two 8-foot, #6 AWG, flexible, rubber-insulated, neoprene sheathed connection cables shall be provided with each snowmelter heating element. The cable insulation shall be of heat-resistant rubber compound 3/32 inch thick covered with a 1/32 inch thick jacket of oil-resistant, neoprene based compound. The cable shall be Type DEL 018-2000V, as manufactured by the Okonite Company. Each connection cable shall be equipped with a mating female connector (male sheath), Chromalox Part #070-055909-001.
- F. Both the male and female mating Chromalox connectors on the switch point heaters and connecting cables shall have "DANGER 750 VOLTS" laser-etched into the connector in 3/4 inch high letters. The letters shall be painted with a non-oxidizing red paint. The type (size) of switch layout each calrod is designed for shall also be indicated in an identical manner (laser-etched in 3/4 inch high letters, painted red) on one of the rod's Chromalox connectors, e.g., "10" for a number 10 turnout.
- G. The active length of snowmelter heating elements shall be approximately one foot less than the length of the switch points for which they apply, as shown on the Contract Drawings.
- H. Snowmelter Heating Elements provided under this Contract shall be Chromalox switch point heaters designed specifically for WMATA applications, Chromalox Drawing "Track Switch Heater for WMATA".

## **2.02 SWITCH ROD HEATER UNITS**

- A. Each Switch Rod Heater Unit shall consist of an autotherming polymeric resistive element on top of a layer of foam insulation, all enclosed in a thin sheet metal case which shall provide heat conducting and radiating surfaces. The case shall be made of 16 gauge, zinc plated, bonderized steel and painted with bright, safety-yellow epoxy paint. The self-regulating conductive polymer heating element shall have a non-linear positive temperature coefficient of resistance which shall limit the heater power output and the maximum heater temperature attained.
- B. The Switch Rod Heater Unit case shall be no more than one inch thick nor seven inches wide. Cases for Switch Rod Heater Units to be installed in ballasted track areas shall be six feet long. Cases for Switch Rod Heater Units to be installed in direct fixation track areas, i.e., on concrete slab, shall be 4.5 feet long.
- C. The Switch Rod Heater Units shall be rated for operation at 750 volts dc  $\pm$ 20 percent, and shall not be damaged when subject to operation at voltages up to 900 volts dc.
- D. All terminations and connections shall be water tight, and the leads shall be secured to the case with strain reliefs.
- E. Each Switch Rod Heater Unit shall have two six-foot, 1000-volt, flexible leads of No. 10 AWG copper cable of the type specified in Section 16949, Signal Wire and Cable. Each lead shall terminate in the male portion (female sheath) of an insulated quick-disconnect plug and socket connector, Chromalox Part #070-055910-001. The female portion of each of the two

quick-disconnect connectors (Chromalox Part #070-055909-001) shall be provided with a 15-foot pigtail of flexible No. 10 AWG, 1000 volt class copper cable, one to be used as the permanent negative return connection, and the other to be spliced to the power feed wire emanating from the snowmelter control case, all as shown on the Contract Drawings.

- F. The switch rod heater units shall provide a minimum power output of 80 watts per square foot of top surface (100 watts normal) when powered at 750 +/-10 volts dc with the top surface exposed to an ambient temperature of 32 degrees Fahrenheit.
- G. Each heater unit case shall bear the following legend on its top surface in three-inch high red letters:
  - 1. DANGER - HIGH VOLTAGE - THIS SIDE UP
- H. The manufacturer's name and part number shall be painted on the top surface of the case in one-inch high letters.
- I. Switch Rod Heater Units provided under this Contract shall be type GPR-SL-PL72C (for ballasted track), or GPR-PL54C (for direct fixation track), as manufactured by Thermon Manufacturing Company of San Marcos, Texas, or an approved equal.

## **2.03 SNOWMELTER CONTROL UNITS**

- A. Each Snowmelter Control Unit shall consist of a fiberglass case containing all the components specified herein to control and indicate the operation of the snowmelter heating elements and switch rod heater units for a maximum of two track switches.
- B. Case Housing
  - 1. The housing for all snowmelter control cases shall be of weatherproof design and single-door, fiberglass construction not exceeding 28 inches in width. The thickness of the housing walls shall be one-eighth (1/8) inch minimum, with the door and back being one-quarter (1/4) inch thick. The finish of the housings shall be Pleogen 2907 ISO Gel-Coat, or similar polyester base material, in a thickness of 15 to 20 mils. The outside color shall be light gray. The inside color shall be white.
    - a. Door and Hinge
      - 1) Each snowmelter control housing door shall be fastened to its housing with a minimum 16 gauge stainless steel hinge continuous over the full height of the door. The hinge shall be concealed when the door is closed. A print pocket shall be mounted on the inside of the door. The door shall swing through an angle of 90 degrees. A latching device shall be provided to hold the door in its fully open position.
    - b. Door Latch and Interlock
      - 1) The door for each snowmelter control housing shall be equipped with a latching mechanism of a three-point lock design. The handle for this mechanism shall be designed for the use of a standard WMATA padlock. The housing shall be equipped with an interlock device which shall, whenever the door of the control case is opened, disconnect both sides of the circuit which remotely controls the snowmelter contactors. The plunger of the door interlock device shall bear against and be depressed by a solid surface on the housing door when the door is closed.
    - c. Ventilators
      - 1) Each housing shall be equipped with at least two ventilators. Each of the ventilator openings shall be hooded or protected by a rain guard on the outside and shall be covered with a fine mesh

screening of stainless steel, copper or brass on the inside. These ventilators shall be so designed and located that an object cannot be inserted through the vent and make straight line contact with energized components inside the housing.

d. Backboard

- 1) A non-metallic, fire-resistant backboard panel shall be mounted on fiberglass channels inside the housing to support the snowmelter control and indication equipment.

2. Uniformity

- a. All snowmelter control housings provided under this Contract shall be of the same size and external appearance.

3. Type

- a. Snowmelter control case housings shall be of a type approved by the designated Resident Engineer, as manufactured by Robroy Industries of Belding, Michigan, or approved equal

C. Contactors

1. Each snowmelter control case shall be equipped with two 2-pole contactors having normally open contacts. The contactors shall be so designed that arcing between their contacts shall be suppressed and voltage breakdown between their coils and contacts is precluded. All snowmelter contactors installed shall be identical in size and rating. The two contactors in each housing shall be wired in parallel as shown on the Contract Drawings.

2. The snowmelter control contactors shall have coils suitable for operation from a 120 Vdc source, but shall be capable of successful continuous operation without resultant damage at voltages of 140 volts plus-or-minus 15 percent. The contactor coil shall have a nominal resistance of 750 ohms. The coil of each contactor shall be equipped with arc suppression which shall prevent the load presented to a relay contact controlling that contactor from exceeding the following values during steady state or switching conditions:

- |                             |             |
|-----------------------------|-------------|
| a. Maximum volt-ampere load | 100 VA      |
| b. Maximum load current     | 2.25 amps   |
| c. Maximum switched voltage | 75 volts DC |

3. Contacts

- a. Each contactor contact shall be able to control 8,000 watts of heater element load continuously without resultant damage at 550 to 900 volts DC, and shall be rated for operation at 1000 volts DC maximum.
- b. Snowmelter contactors shall be 60 Amp. 750 Vdc, Part No. LTHS60, as manufactured by *Microelettrica Scientifica*, or approved equal.

D. Snowmelter Current Monitoring Devices

1. One current monitoring device shall be provided for each snowmelter heating element/switch rod heater unit combination controlled from each snowmelter control case.
2. Each of these monitoring devices shall have a normally open contact which shall be used in a low voltage indication circuit.
3. Each of these units shall monitor the current flow in the snowmelter heating element/switch rod heater unit combination it is to indicate. Its contact shall be closed only when its snowmelter/rod heater combination is drawing at least its normal working current.
4. Each current monitoring device shall be insulated for 1000 volts between its operating and indicating components.
5. Snowmelter current monitoring devices shall be DC Current Monitors, Series 930400 of appropriate amperage as manufactured by Gort Electronics Company, or approved equal.

- E. Case Heaters
  - 1. Each snowmelter control case shall be equipped with two 100 watt, 500 ohm, 120 volt insulated strip heaters, wired in parallel and mounted as shown on the Contract Drawings to control moisture condensation within the housing.
- F. Local Disconnects
  - 1. Provide a manual knife switch (rated at 1000 volts DC, 100 amps) in an insulated enclosure to enable maintenance personnel to control all high voltage energy to the case, as indicated on the Contract Drawings.
  - 2. Provide an enclosed 250 volt manual breaker switch disconnect for the case heaters, mounted in the case as indicated on the Contract Drawings.
- G. Fuses
  - 1. All fuses used in snowmelter control cases shall be of the non-renewable, fiber or fiberglass case, time-lag, fusion type, rated for 1000 volt operation.
  - 2. The snowmelter contactors and current monitors shall be protected by 1,0 amp, 1000 volt fuses as shown on the Contract Drawings.
  - 3. One 10 amp, 1000 volt fuse shall be provided for each No. 8 switch point/switch rod heater element combination controlled from the case, and one 15 amp, 1000 volt fuse shall be provided for each No. 10 switch point/switch rod heating element combination.
  - 4. Fuses shall be Gould-Shawmut A100X form 101 type 4, as manufactured by the Gould-Shawmut Company, of Newburyport, Massachusetts.
- H. Wire
  - 1. All snowmelter control case internal wiring shall be insulated for 1000 volts and shall meet the applicable requirements specified in Section 16949, Signal Wire and Cable.
  - 2. Low voltage control, indication and communication wiring shall be run separately from all the 750 volt heater element wiring.
- I. Terminals
  - 1. Solderless screw type terminals of the appropriate size shall be provided at the bottom or on the hinge side of the control case backboard for the 750 volt wiring terminations.
  - 2. Standard AAR binding post terminals shall be provided at the top of the latch side of the control case backboard for the low voltage control, indication, case heater, and communication wiring terminations.
- J. Telephone Jack
  - 1. A Train Control Maintenance telephone jack with a weatherproof external jack cover shall be mounted in the latch side of each snowmelter control case as specified in Section 16923, TC Maintenance Telephone System, and as shown on the Contract Drawings.
  - 2. This telephone jack shall be of the type specified in Section 16923, and shall be wired as shown on the Contract Drawings.

#### **2.04 CONTACT RAIL FUSE BOX**

- A. One contact rail fuse box shall be provided to feed each snowmelter control case required.
- B. Each contact rail fuse box shall be constructed of one-half inch minimum thickness of GPO-3 grade fiberglass laminate, or material of equal strength and insulating quality, rated for maximum service voltage of 1200 volts.

- C. The fuse box shall be equipped with fuse clips for an appropriately sized, 1000 volt Gould-Shawmut Type 4 fuse.
- D. The fuse box shall be so constructed that the lifting of the cover shall open the circuit by removing the fuse.
- E. The openings for cable entering and leaving the box shall be equipped with water-tight seals and strain-relief devices for the cables.
- F. Both sides of the contact rail fuse box shall be permanently and prominently labeled, "DANGER - 750 VOLTS". In addition, an embossed metal tag which identifies which track switch(es) snowmelters the fuse box serves shall be fastened securely to one side of the box.
- G. Contact Rail Fuse Boxes to be provided under this Contract shall be Fused Disconnect, Part No. 350000-8X (up to 60 Amp fuse) or Part No. 350000-9X (60-150 Amp fuse), as manufactured by UniTrac Systems Inc., 100 Impulse Way, P.O. Box 889, Mount Olive, NC 28635, or approved equal.

## **2.05 WIRE AND CABLE**

- A. Wire and cable for snowmelter layouts shall be as specified in Section 16949, Signal Wire and Cable, and as shown on the Contract Drawings unless otherwise specified. All heater element and switch rod heater unit wiring shall be insulated for 1000 volts.

## **2.06 CONDUIT**

- A. Conduit used to protect snowmelter wire and cable surface runs in direct-fixation areas, and for entrance to the snowmelter control cases, shall be schedule 80 PVC or fiberglass reinforced epoxy (FRE), as specified in Section 16973, Conduit, and as shown on the Contract Drawings.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION OF SNOWMELTERS**

- A. Install all snowmelter heating elements on the field side of the stock rails in a manner which meets the following requirements:
  - 1. The heater shall be located on the stock rail with the active part extending from two feet ahead of point-of-switch to the vicinity of the heel block.
  - 2. The heater shall be secured to the lower half of the web of the rail by means of supports spaced 18 inches to 24 inches apart (except at the anti-creep collar). One support shall be located on the rail ahead of the switch point. Special support clamps shall be provided for securing the heater half of the separable connectors to the rail in such a manner that the alignment rib on the connector is visible.
  - 3. A heater support shall be placed against each end of the anti-creep collar on the heater to prevent longitudinal movement. All other supports shall be arranged to allow longitudinal movement of the heater as a result of expansion and contraction.
  - 4. All supports shall be secured by means of 3/8 inch corrosion-resistant bolts.
  - 5. Drill 13/32 inch holes in the web of the stock rails (at the neutral axis) for the 3/8 inch bolts used to secure the heater support clamps and terminal housing support clamps. The bolts shall be inserted from the gauge side of the rail with the washers and nuts installed on the field side of the rail.

6. Leads between the heating elements and the control case shall be so located as to minimize possible damage. Where necessary, mechanical protection shall be provided.
- B. The Contractor shall be responsible for the removal and replacement of rail wedges where necessary. This shall include returning the rail and wedges to their initial adjustments.

### **3.02 INSTALLATION OF SWITCH ROD HEATER UNITS**

- A. Install Switch Rod Heater Units and all associated control, operation and indication wiring as specified herein and as indicated on the Contract Drawings.
- B. Two Switch Rod Heater Units shall be provided as part of each Snowmelter Layout. One unit shall be installed under the switch throw rod and the other unit shall be installed under the switch lock rod.
- C. In ballasted track areas, the Contractor shall remove the ballast to the level of the bottom of the ties in the two cribs under the switch rods, and in a direct line beyond these cribs to provide a drainage path for the crib.
- D. The heater units shall be centered in each crib, with the energy leads located on the end away from the switch machine, as indicated on the Contract Drawings. The distance from the bottom of the switch rod to the top of the heater unit shall not exceed two inches.
- E. Plug-connect the heater units to their appropriate energy and negative-return leads and secure the leads and plug connectors to the ties, or to the surface of the concrete slab, as applicable, to prevent the leads from catching on carborne equipment or presenting a tripping hazard to maintenance personnel, all as indicated on the Contract Drawings. There is no "polarity" requirement for the individual switch rod heater units, but each unit must be connected in parallel with a snowmelter heating element. See paragraph 3.06-C.
- F. Install tie straps or brackets of a design approved by the designated Resident Engineer above each crib containing a Switch Rod Heater Unit to prevent the heater unit from being drawn upward out of the crib by suction created by passing transit cars.
- G. Each Switch Rod Heater Unit for a given switch shall be wired in parallel with one of the Snowmelter Heating Elements for that switch, all as indicated on the Contract Drawings.

### **3.03 INSTALLATION OF SNOWMELTER CONTROL UNIT**

- A. Each snowmelter control unit shall be located more than ten feet from other signal and electrical equipment, if practicable, but no closer than six feet from other signal and electrical equipment, and no more than 75 feet from the snowmelter heating elements and switch rod heater units it controls.
- B. Snowmelter control cases shall be mounted on foundations of the type specified in Section 16975, Foundations.
- C. The snowmelter control cases shall be mounted with the front, back and sides vertical and the top and bottom horizontal, all within a tolerance of 1/8 inch.
- D. The cases shall be installed in such a manner that their doors shall open, close, seal and lock properly without binding.

- E. Upon installation, each snowmelter control case shall be locked with a padlock of the type specified in Section 16974, Locks and Keys.
- F. Snowmelter control cases shall be so located that no part of the case including its open door, can intrude upon the clearance envelope of the transit vehicles.

### **3.04 SNOWMELTER CONTROL CASE CONNECTIONS**

- A. Make two openings in the bottom of each snowmelter control case and install vertical conduit to protect external wiring as shown on the Contract Drawings. Install all high voltage wiring in the conduit near the hinge side of the case and all low voltage control, indication and communication wiring in the conduit near the latch side of the case.

### **3.05 INSTALLATION OF FUSE BOX**

- A. The contact rail fuse box shall be installed as indicated on the Contract Drawings.

### **3.06 RAIL CONNECTIONS**

- A. The snowmelter energy supply cable to the contact rail fuse box shall be connected to the power third rail by means of an exothermic weld as shown on the Contract Drawings.
- B. The negative return lead for each snowmelter heating element shall be connected to the neutral axis of the nearest negative propulsion return rail by means of an exothermic weld as shown on the Contract Drawings.
- C. The negative return lead for each switch rod heater unit shall be connected to the neutral axis of the same negative propulsion running rail as the negative return lead of its parallel-connected snowmelter heating element, or to the nearest impedance bond center tap in the applicable track. Under no circumstances shall the negative return lead for a switch rod heater unit be connected to the opposite running rail from the negative return lead of its parallel-connected snowmelter heating element.

### **3.07 IDENTIFICATION**

- A. The identification letters "SM" and the number(s) for each snowmelter layout controlled from that case shall be stenciled on both the inside and outside of the case door. (The identification number(s) shall correspond to the number(s) of the track switch(es) for which snowmelters are controlled from that case.) The lettering shall be at least two inches high. This stenciling shall be in addition to the embossed metal name tag required on the outside of the case door.
- B. The positive and negative leads of each snowmelter heating element, switch rod heater unit, and both high voltage cables emerging from the contact rail fuse box shall be provided with brass tags engraved with the legend "DANGER - 750 VOLTS".
- C. The brass tags shall be securely attached to the power cable or wire with No. 14 AWG stainless steel wire in such a manner that the insulation on the power leads is not damaged.
- D. Each contact rail fuse box shall have an approved type of label or stencil applied to an outside end of the box, designating the number(s) of the applicable track switch snowmelter layout(s) energized from that box.

### **3.08 SURFACE MOUNTED CONDUIT**

- A. When Snowmelter Layouts are installed in direct-fixation track construction areas, in tunnels or outdoors, the Contractor shall install heavy duty fiberglass reinforced epoxy (FRE) conduit on the surface of the concrete slab in a manner approved by the designated Resident Engineer to protect the external snowmelter cable runs.
- B. Dedicated conduit runs shall be provided for high-voltage snowmelter energy cables.

### **3.09 DOCUMENTATION**

- A. Place a complete, AS-BUILT set of drawings for the applicable snowmelter layout(s) in the print pocket on the door of each snowmelter control case.

### **3.10 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. For measurement purposes only, each Snowmelter Layout will be considered to consist of a contact rail fuse box, a snowmelter control unit complete with foundation, all the switch rod heater units and tubular electric rail heating elements controlled from that snowmelter control case, and all cable, conduit, rail connections and miscellaneous hardware and labor required to mount and interconnect the above items with the TCR and the snowmelter control case as specified. Snowmelter Layouts will not be measured for payment as such.
- B. For measurement and payment purposes, each Snowmelter Control Unit will be considered to include the furnishing and installation of a housing containing all field components and internal wiring necessary for the control and indication of up to four snowmelter heating element/switch rod heater unit combinations (as required) in the manner specified herein. Snowmelter control units will be measured for partial payments based upon the number and type of such units delivered and properly installed, and upon approval by the designated Resident Engineer of the installation and testing.
- C. For measurement and payment purposes, each contact rail fuse box will be considered to consist of the unit described in Part 2.04 of this Section installed as shown on the Contract Drawings. Contact rail fuse boxes will be measured for partial payments based upon the number of such units delivered and properly installed, and upon the approval by the designated Resident Engineer of the installation and testing.
- D. External cable, foundations, conduit and padlocks used as part of Snowmelter Layouts, and final field testing of Snowmelter Layouts will be measured for partial payments separately as described in the Specification Sections describing those items.
- E. Factors which will be considered when determining partial payments for Contact Rail Fuse Boxes, Snowmelter Control Units, Snowmelter Heating Elements and Switch Rod Heater Units will include the following:
  - 1. Delivery of each approved item by the Contractor and approval of its Factory Test Report by the designated Resident Engineer.
  - 2. Complete installation of the respective items by the Contractor in the manner specified, and approval of the installation by the designated Resident Engineer.
  - 3. Level E partial system acceptance by the Authority of the interlocking involved.

**END OF SECTION**

## **SECTION 16970**

### **ATC MECHANICAL COMPONENTS** (Table of Contents)

#### **PART 1 - GENERAL**

##### **1.01 SECTION INCLUDES**

- A. This SECTION lists the various 16970-series ATC Mechanical Components Specification Sections:
- |    |  |                 |
|----|--|-----------------|
| 1. | Racks and Cable Trays                                | (Section 16971) |
| 2. | Junction Boxes                                       | (Section 16972) |
| 3. | Conduit  | (Section 16973) |
| 4. | Locks and Keys                                       | (Section 16974) |
| 5. | Foundations  | (Section 16975) |
| 6. | Wayside Signs  | (Section 16976) |
| 7. | Tagging and Marking                                  | (Section 16977) |
| 8. | Miscellaneous Train Control Components and Materials | (Section 16978) |
| 9. | Surface Trench                                       | (Section 16979) |

#### **PART 2 - PRODUCTS** NOT USED

#### **PART 3 - EXECUTION** NOT USED

**END OF SECTION**

## SECTION 16971

### ATC - RACKS AND CABLE TRAYS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. Racks:
  - 1. This Section specifies the furnishing and installation of free standing, shock mounted metal racks in the Train Control Rooms to support various types of ATC equipment. Three basic types of racks shall be provided as follows:
    - a. Entrance racks
    - b. Power Racks
    - c. Equipment Racks
  - 2. Cable Trays:
- B. This Section specifies the design, furnishing, installation and inspection of cable tray systems above and adjacent to racks in and about the Train Control Rooms and at such other locations as they may be required.

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16911 Scope of ATC Work
  - 2. Section 16915 Basic Equipment Requirements
  - 3. Section 16921 ATC Power Distribution Systems
  - 4. Section 16922 Lightning/Surge Protection and Grounding Systems
  - 5. Section 16923 TC Maintenance Telephone System
  - 6. Section 16945 Plugboards and Cabinets for Relays and PC Cards
  - 7. Section 16948 Plug Connectors
  - 8. Section 16949 Signal Wire and Cable
  - 9. Section 16977 Tagging and Marking
  - 10. Section 16980 ATC Tests, Inspections And Quality Assurance

##### 1.03 QUALITY ASSURANCE

- A. Factory test all racks as prescribed by the factory test procedure previously approved by the designated Resident Engineer.
- B. Conduct a field inspection of all racks after they have been installed in the field. This inspection shall be conducted in conformance with the Installation Inspection Procedure approved by the designated Resident Engineer.
- C. Inspect each completed cable tray layout after it has been installed. This inspection shall be conducted in conformance with the requirements of the Contractor's Installation Inspection Procedure as approved by the designated Resident Engineer.

##### 1.03 SUBMITTALS

- A. Prior to Fabrication or Procurement of Racks
  - 1. Submit complete drawings and parts lists for the basic shock-mounted rack shell and bases and for all accessory mounting bars, rods, brackets and other equipment-mounting devices which will constitute part of the various rack

- configurations required.
2. Obtain the designated Resident Engineer's written approval of rack components and assembly before proceeding with fabrication or procurement of racks.
- B. Prior to Installation of ATC Equipment on Racks
1. Submit plans showing the proposed arrangement of terminals, power supplies, relay plugboards, fuses, and other ATC equipment on each rack to be provided.
  2. Submit drawings showing mounting details for each type of equipment to be mounted on the racks.
  3. Obtain the designated Resident Engineer's written approval of rack arrangement plans and mounting details before mounting equipment on the racks.
- C. Prior to Shipment of Racks
1. Submit a Factory Test Procedure for Wired Racks for approval by the designated Resident Engineer.
  2. Submit factory test reports for the wired racks.
- D. Prior to Installation of Racks
1. Submit rack arrangement plans showing the proposed arrangement of racks in each Train Control Room to be equipped under this Contract. These arrangements shall be compatible with the actual physical characteristics of the TCRs as determined by on-site inspection by the Contractor and shall conform to the requirements specified herein.
  2. Coordinate the proposed rack arrangement with the lighting arrangement in each TCR in such a manner that:
    - a. Racks are not installed under light fixtures;
    - b. The front and back of each rack is well illuminated, and;
    - c. The rack arrangement and spacing complies with the requirements specified in Part 3 of this Section.
  3. Submit an Installation Inspection Procedure for racks. The purpose of the prescribed inspection shall be to ensure that:
    - a. The racks have been positioned, secured, insulated and grounded as specified.
    - b. All required equipment has been mounted on the racks as specified.
- E. Upon completion of installation of racks in each applicable TCR, submit a written report listing all discrepancies noted and remedial action taken.
- F. Prior to Fabrication or Procurement of Cable Trays:
1. Submit drawings showing designs and details of the entire tray layout for each Train Control Room and special cable tray location for approval by the designated Resident Engineer.
  2. Submit documentation to the designated Resident Engineer for approval, to substantiate that ceilings, walls, racks, and any other surface or structure used for cable tray support will safely support the load which the fully loaded cable tray will impose on these surfaces or structures. The Contractor shall base his cable weight and space calculations on the Contractor cable requirement plus 100 percent for possible future load.
- G. Prior to Installation of Cable Trays
1. Submit a cable tray "fill" tabulation with the tray system layout for the designated Resident Engineer's determination that the 100 percent additional space requirement has been met throughout the system.
  2. Submit an Installation Inspection Procedure for cable trays within 120 days of NTP.

- H. Upon completion of the installation and inspection of the cable tray system and cables in a given TCR, submit a written report listing all discrepancies noted and remedial action taken.

#### **1.04 DELIVERY, STORAGE AND HANDLING**

- A. Cable trays shall be disassembled prior to shipment and packed in cartons to prevent damage.
- B. Any cable tray sections damaged during shipment, storage, or handling shall be replaced by the Contractor at no additional cost to the Authority.

### **PART 2 - PRODUCTS**

#### **2.01 BASIC RACK CONSTRUCTION**

- A. All racks shall have frame weldments constructed of 14-gauge cold-rolled steel and designed to mount standard 19-inch equipment panels. Neither the width nor the depth of the frame unit shall exceed 24 inches. The frame weldment shall be designed to accept universally adjustable panel mounting hardware. The panel mounting angles shall be constructed with standard EIA hole spacing.
- B. The racks shall be mounted on and secured to 12-gauge cold-rolled steel bases, floor-supported to make free-standing units. These bases shall be 24 inches deep (front to back) and the same width as the rack, and shall be 3-1/2 inches high. These bases shall provide an insulation resistance between the rack frame and ground of at least 100,000 ohms.
- C. Chassis supports or guides shall be provided for auxiliary support of heavy equipment such as power supplies. The chassis supports shall be made of 11-gauge cold rolled steel. They shall be capable of being mounted directly to the panel-mounting angles and shall permit side-to-side guide adjustment.
- D. Each rack shall be equipped with a ground connector of the bolted type to permit removal of the ground connection for testing insulation between racks. See Section 16922.
- E. The overall height of each rack shall not exceed 7-1/2 feet.
- F. Each rack shall be equipped with two TC Maintenance Telephone Jacks of the type specified in Section 16923, and as shown on the Contract Drawings.
- G. All racks shall be painted gray.
- H. Each rack shall be identified by its manufacturer's standard nameplate, as specified in Section 16977, Tagging and Marking. This nameplate shall not extend beyond the edge of the supporting metal to which it is attached.
- I. Each rack shall be further identified, front and back, with its identifying type and location number by means of a painted stencil. (See Section 16977, Tagging and Marking). The "type" and "location" letters and numbers shall be at least 1 inch in height. The various rack types shall be designated as follows:
  - 1. "E" - Entrance Racks
  - 2. "P" - Power Racks
  - 3. "C" - Station Support Racks

- 4. "T" - Speed Command Logic Racks
- 5. "TM" - ATP Track Module Racks
- 6. "B" - Vital Interlocking Support Racks
- 7. "J" - Non-Vital Interlocking Support Racks

J. Rack location stenciling shall be on the racks and not on modules in the racks.

## **2.02 POWER RACKS**

- A. The rear of the panel shall be open for ventilation but all live, metal parts shall be completely shielded from contact with any external object by small plastic covers, mounted in place over each part, or group of parts. These covers shall be made of 1/4 inch thick shatter-proof plastic material which will not support combustion or emit poisonous or corrosive gases when exposed to flame or extreme heat. Other approved material may be utilized. These covers shall be easily removed and replaced, but the fastenings shall be secure.
- B. The front of each power rack shall have an 1/8-inch cold-rolled steel sheet for mounting the voltmeters, ammeters, switches, test jacks, circuit breakers, and other equipment necessary to control and monitor the TCR power distribution system. See Section 16921, ATC Power Distribution Systems.
- C. The Contractor shall permanently mount high-voltage warning signs on the back, front and exposed sides of each power rack.

## **2.03 EQUIPMENT RACKS AND ENTRANCE RACKS**

- A. Equipment racks and Entrance racks shall be enclosed with formed 16-gauge cold-rolled sheet metal on the top, bottom and on both ends of each row of adjacent racks.
- B. Entrance racks shall be equipped with molded terminal blocks which conform to the recommendations of Part 14.1.5 of the AREMA Signal Manual and such other terminal blocks and plug connectors as may be required by these Specifications.

## **2.04 EQUIPMENT ARRANGEMENT AND MOUNTING**

- A. The arrangement of equipment on the racks shall present a neat and orderly appearance. Equipment serving similar functions shall be in the same relative location on all racks.
- B. Unless otherwise approved by the designated Resident Engineer in writing, relays and equipment modules shall not be mounted at a height exceeding 6 feet from the floor.
- C. Provide a minimum of 10 percent spare module, component and relay spaces, spare terminals, and spare plug-connector points on each rack or group of racks serving a common function. This 10 percent spare equipment space, terminals and plug-connector points shall be in addition to any space, terminals and plug-connector points reserved for specifically designated possible future additions to the TCR, such as additional track relays and modules which will be required when revenue service is extended beyond a temporary terminal location, or when an anticipated future junction is added to a location being equipped under this Contract.
- D. ATP track modules and track relays for a given track shall be so located on the racks that they reflect the geographical sequence of the actual track circuits they represent wherever practicable.

- E. Track repeater relays shall be located adjacent to the track or repeater relays they repeat or parallel unless there is some compelling reason for locating them elsewhere.
- F. Repeater relays for other than track relays shall be located wherever their contacts are most needed in order to keep wire runs to minimum length.
- G. Terminal blocks and plug connectors for inter-rack and external wiring connections shall be located in the top row of each equipment rack. Where terminal blocks or plug connectors are mounted on swing-out "doors," the Contractor shall provide a means to prevent accidental contact between such terminals or plug couplers and adjacent equipment. This shall be accomplished either by providing insulated protective covers on the "door" equipment, or by limiting the opening arc of the "door," or both.
- H. Terminal boards, plug connectors, power supplies, fuse buses, relay plugboards and cabinets, and all other ATC equipment modules shall be mounted on the racks in conformance with the arrangement plans and mounting methods previously approved by the designated Resident Engineer.

## **2.05 RACK WIRING**

- A. Racks shall be pre-wired, insofar as possible, prior to installation in the Train Control Rooms.
- B. Intra-rack wiring shall be accomplished as specified in Section 16949, Signal Wire and Cable.

## **2.06 CABLE TRAYS**

- A. Cable trays shall be of the "ladder" type, constructed of aluminum or other suitable material commercially available and approved by the designated Resident Engineer. Where applicable a cantilevered single "wall-support" type of tray shall be provided.
- B. Cable trays shall be P-W Industries Cable Tray System 064D02, as manufactured by P-W Industries, Inc. (Cornwell Heights, PA 19020), or approved equal, with the following requirements:
  - 1. Rung spacing shall be six inches maximum where rack-to-rack wiring consists of individual conductors of size 14 AWG or larger wire tied into bundles to form unjacketed multiconductor cable routed via the cable trays. Rung spacing shall be six inches minimum where cable tray is used exclusively for jacketed multiconductor cables.
  - 2. Minimum tray width shall be 6 inches.
  - 3. All fittings, supports and accessories shall be furnished in accordance with the manufacturer's recommendations.
  - 4. There shall be no sharp edges or corners on the cable trays which could damage the cables or present a safety hazard to humans.
- C. Cable trays shall not be purchased or fabricated by the Contractor until wiring plans for the applicable Train Control Room(s) are complete and tray layout drawings are approved by the designated Resident Engineer.

## **2.07 FIBERGLASS SUPPORTS FOR CABLE TRAYS**

- A. Where the Contractor's cable tray layout includes any support mounting to the equipment

and entrance racks, such mounting shall be by means of approved fiberglass arms or stand-offs in order to insulate the cable tray assembly from the equipment and entrance racks.

- B. Fiberglass support arms, where required to insulate the cable tray from the equipment racks, shall be flame retardant, reinforced polyester laminate Class "B", 130 degrees C electrical sheet, meeting NEMA GPO-2 requirements, ASTM Specification D1532-67T, as manufactured by Hayside Division of Alco Standard Co., or approved equal.

## **PART 3 - EXECUTION**

### **3.01 RACK INSTALLATION**

- A. Arrange the racks in the Train Control Rooms in a manner previously approved by the designated Resident Engineer.
- B. The Contractor shall install the racks in rows with a spacing of 5 feet between centerlines of rows and from wall to row centerline wherever possible. Where 5 foot spacing cannot be obtained, the Contractor shall attempt to maintain 4.5 foot minimum spacing for front-to-front oriented rows and 3.5 foot minimum spacing for back-to-back oriented rows. Under no circumstances shall rack row spacing be less than 3.5 feet unless otherwise authorized by the designated Resident Engineer.
- C. Rows of racks shall be oriented to have adjacent rows either front-to-front or back-to-back wherever possible.
- D. A minimum 2-foot aisle shall be provided between the walls of the TCR and the ends of the rack rows unless otherwise authorized by the designated Resident Engineer.
- E. The row of racks nearest the wall, if closer than five feet to the wall, shall not face the wall.
- F. The Contractor shall shim rack bases as necessary to maintain level rack height within each row.
- G. The Contractor shall ground each individual rack to a room ground bus provided and installed by the Contractor. See Section 16922. The racks shall be insulated from each other and from any supporting framework and shall only be electrically connected via the common ground connection. The value of the insulating resistance shall be at least one megohm.
- H. Rack-to-rack wiring shall be accomplished as specified in Section 16949.

### **3.02 CABLE TRAY DESIGN**

- A. The Contractor shall design and provide a complete ATC cable tray system for each Train Control Room newly equipped under this Contract.
- B. The Contractor shall design and provide all modifications necessary to the cable tray systems in TCRs at tie-in locations to adapt them to new requirements imposed by this Contract.
- C. The Contractor shall design special cable tray systems as required for certain other locations where ATC cables cannot be supported in the normal manner. See Section 16911, Scope of ATC Work.

- D. Based upon field inspections and inspection of the Authority's structural drawings, determine the extent to which it will be necessary to relocate existing conduit, lighting fixtures and/or other facilities in order to permit proper installation of the cable tray systems. Include all such relocation of existing facilities in the design of the cable tray systems and include the cost of all such work in the bid price.
- E. Each cable tray system shall be designed to support (and allow usable spare space for) a load of 100 percent in addition to the cable requirement for this Contract. The usable spare space is defined as that unobstructed area in the cable tray measured from the top of the Contract cable requirement to the top of the tray side rails.
- F. The design of each tray system shall be based on the manufacturer's recommendations unless otherwise specified herein.
- G. The tray supports shall be a maximum of 4 feet on centers.
- H. Make a load analysis to ensure that only those ceilings, walls, racks or other surfaces or structures are used for cable tray support which will safely support the load which the fully loaded cable tray will impose on these surfaces or structures.
- I. Each cable tray system shall be so designed that continuous runs without gaps may be installed using a minimum number of sections in accordance with the manufacturer's standards.

### **3.03 CABLE TRAY INSTALLATION**

- A. Perform all work required to relocate existing conduit, lighting fixtures, and other facilities to permit proper installation of the cable trays, at no additional cost to the Authority.
- B. Perform all special concrete or metal work necessary in connection with the installation of the cable trays. To avoid spalling, aluminum shall be installed so that it does not come in contact with concrete.
- C. The cable trays shall be assembled at the site of the work in accordance with the manufacturer's instructions and the approved installation drawings.
- D. Sufficient support shall be provided to keep the loaded cable tray deflection to one-quarter inch maximum at midspan. Tray supports and trays shall be mounted plumb and level.
- E. Tray supports shall be anchored to ceilings or walls by machine-bolt type expansion anchors and one-half inch minimum diameter bolts.
- F. Cable trays shall be bolted to support members. The Contractor shall not use any method of connecting or supporting cable trays which would reduce the rated load carrying capacity of the trays or could possibly result in damage to cables placed in the trays.
- G. Where cable tray splice joints occur in a run, trays shall be supported immediately adjacent to and on both sides of the splice fitting.
- H. All metal cable trays shall be bonded and grounded as described in Section 16922.
- I. All metal cable trays shall be insulated from all walls, ceilings, racks and conduit runs. The value of the insulating resistance shall be at least 1000 ohms.

- J. To the extent practicable, the final position of cable on the trays shall result in minimal loading eccentricity.
- K. Maximum deflection of the runs shall not exceed 0.25 inches when fully loaded. A fully loaded cable tray is defined as a load consisting of the Contract cable requirement plus the 100 percent for the possible future load.

#### **3.04 MEASUREMENT FOR PARTIAL PAYMENTS FOR RACKS**

- A. For purposes of measurement only, each power rack and equipment rack will be considered to consist only of the open frame weldment, complete with shock-mounting base and all sheathing, telephone jacks, support brackets and other hardware required to mount the terminal boards, power-supply modules, relay plugboards or other types of ATC equipment modules it is designed to support.
- B. For purposes of measurement only, each entrance rack will be considered to consist of the basic components defined above for power and equipment racks plus all the molded terminal blocks and other terminating and support hardware required to constitute a complete entrance rack.
- C. Racks will be measured for partial payments based upon the number of such required units furnished, installed and accepted.
- D. The following factors will be considered when measuring racks for partial payments:
  - 1. Delivery of the specified racks by the Contractor and approval of the rack Factory Test Reports by the designated Resident Engineer.
  - 2. Proper installation of the racks by the Contractor and approval of the installation by the designated Resident Engineer.

#### **3.05 MEASUREMENT FOR PARTIAL PAYMENTS FOR CABLE TRAYS**

- A. Cable trays will be measured for partial payments based upon the linear footage of required tray furnished, installed and accepted.
- B. Factors which will be considered when determining partial payments for cable trays will include, but not be limited to:
  - 1. Furnishing and installation of approved cable trays and all appurtenances by the Contractor in the manner specified herein;
  - 2. Correction of all installation discrepancies by the Contractor and final approval of the installation by the designated Resident Engineer.

**END OF SECTION**

## SECTION 16972

### ATC - JUNCTION BOXES

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing and installation of track-side junction boxes associated with track switch layouts, signal layouts, program stop marker coil layouts, power frequency and audio frequency track circuit layouts, terminating receivers, inductive track loop layouts, pushbutton layouts, interlocking cable distribution, and other necessary wayside ATC equipment.

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16923 TC Maintenance Telephone System
  - 2. Section 16925 Data Transmission System (DTS)
  - 3. Section 16961 Audio Frequency Track and Loop Circuit Layouts
  - 4. Section 16962 Impedance Bond Layouts
  - 5. Section 16963 Power Frequency Track Circuit Layouts
  - 6. Section 16964 Track Switch Operating Layouts
  - 7. Section 16965 Signal Layouts
  - 8. Section 16967 Marker Coil Layouts
  - 9. Section 16974 Locks and Keys
  - 10. Section 16977 Tagging and Marking

##### 1.03 QUALITY ASSURANCE

- A. Each junction box shall be factory tested to ensure conformance with the requirements specified herein and shown on the Contract Drawings.
- B. The Contractor shall inspect each junction box after it has been installed and wired. This inspection shall be conducted in conformance with the requirements of the Contractor's installation inspection procedure as approved by the designated Resident Engineer.

##### 1.04 SUBMITTALS

- A. Submit drawings for each type of junction box he proposes to provide. These drawings shall include terminal boards, wiring and mounting details and all other components as required by the circuits or indicated on the applicable Contract Drawings. The designated Resident Engineer's approval of each type of junction box is required prior to manufacture or procurement of this equipment by the Contractor.
- B. The Contractor shall submit typical scale installation drawings for each type of junction box he proposes to provide. These drawings shall show hinged doors or covers in their open position and distances to related trackwork in such a manner that specified clearances can be determined. In each instance where a junction box cannot be installed in the typical manner, a separate, specific scale installation drawing shall be submitted for that situation.
- C. Submit an Installation Inspection Procedure for each type of junction box to be provided under this Contract within 120 days of receipt of NTP.
- D. Submit installation inspection documentation for each junction box installed.

## **PART 2 - PRODUCTS**

### **2.01 BASIC REQUIREMENTS**

- A. All junction boxes shall conform to NEMA-4X and U.L. requirements. Junction boxes shall be constructed of cast iron, sheet metal, or fiberglass material approved by the Engineer. Cast iron junction boxes shall have stainless steel or brass cover hardware.
- B. Sheet metal junction boxes shall be constructed of stainless steel, all seams welded.
- C. Covers shall be hinged and gasketed with a neoprene gasket to provide a dustproof and weatherproof enclosure. Covers shall be equipped with a three-point latching arrangement, complete with handle and facilities for accepting the shackle of a padlock of the type specified in Section 16974.
- D. Junction boxes shall be of sufficient size to provide ample space for the specified minimum bending radii of cables and wires.
- E. Junction boxes shall be provided complete with all necessary terminals and a weatherproof Telephone Jack as specified in Section 16923.
- F. Sheet metal and fiberglass junction boxes shall be provided complete with print pockets, sized as per manufacturer's standard, and located on the inside of the junction box cover or door.
- G. Junction boxes shall be equipped with drain plugs.
- H. Cast-iron junction boxes shall be furnished complete with appropriate pedestals.

### **2.02 SWITCH LAYOUT JUNCTION BOXES**

- A. One or more junction boxes of the appropriate type, as necessary, shall be provided as part of each Track Switch Operating Layout provided under this Contract, as shown on the Contract Drawings and as described herein.
- B. The junction boxes for direct fixation Track Switch Operating Layouts shall be made of stainless steel as specified in Part 2.01 B. of this Section, and shall be provided with all necessary mounting hardware.
- C. If the Contractor's switch layout requires an additional junction box, or pull box, for the switch circuit controller, the Contractor shall furnish this box, complete with all mounting hardware, as part of his switch layout, at no additional cost to the Authority.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. Provide junction boxes of appropriate size for the terminals and equipment required.
- B. Junction boxes shall be installed in conformance with the approved installation drawings.
- C. Install junction boxes in such a manner that no part of the junction box, including the open door or cover, can intrude into the dynamic clearance envelope of the transit cars.

- D. In those instances where it is impossible to keep the junction box door from opening into the dynamic clearance envelope of the transit cars, or where there is no room for a person between the box and the dynamic clearance envelope of the transit cars, the Contractor shall apply moisture-proof warning labels of an Authority-approved design and size to the inside and outside of the covers of the junction boxes. These labels shall consist of a background of black and luminescent yellow diagonal stripes, and shall bear the legend "NO CLEARANCE" in black letters on a white horizontal stripe.

### **3.02 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. Junction boxes will be measured for partial payments based upon the number and type delivered, installed, and accepted.
- B. The following factors will be considered when junction boxes are measured for partial payments:
  1. Delivery of the specified junction boxes by the Contractor and approval of the applicable Factory Test Reports by the designated Resident Engineer.
  2. Proper installation of the junction boxes by the Contractor and approval of the installation by the designated Resident Engineer.

**END OF SECTION**

## **SECTION 16973**

### **ATC - CONDUIT**

#### **PART 1 - GENERAL**

##### **1.01 SECTION INCLUDES**

- A. This Section specifies the furnishing and installation of conduit and associated fittings.

##### **1.02 RELATED SECTIONS**

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
- |     |               |  |
|-----|---------------|--|
| 1.  | Section 16949 | Signal Wire and Cable                                |
| 2.  | Section 16961 | Audio Frequency Track and Loop Circuit Layouts       |
| 3.  | Section 16962 | Impedance Bond Layouts                               |
| 4.  | Section 16963 | Power Frequency Track Circuit Layouts                |
| 5.  | Section 16964 | Track Switch Operating Layouts                       |
| 6.  | Section 16965 | Signal Layouts                                       |
| 7.  | Section 16966 | Wayside Pushbutton Layouts                           |
| 8.  | Section 16967 | Marker Coil Layouts                                  |
| 9.  | Section 16972 | Junction Boxes                                       |
| 10. | Section 16977 | Tagging and Marking                                  |
| 11. | Section 16978 | Miscellaneous Train Control Components and Materials |
| 12. | Section 16981 | Basic ATC Test and Inspection Requirements           |

##### **1.03 QUALITY ASSURANCE**

- A. The Contractor shall inspect conduit and fittings upon delivery and shall inspect conduit after installation. The field inspection shall be conducted in conformance with the requirements of the Contractor's installation inspection procedure as approved by the designated Resident Engineer.

##### **1.04 SUBMITTALS**

- A. Submit a detailed conduit layout for all proposed buried conduit runs, including the calculated fill and size of each run. No conduit shall be installed until the applicable plan has been approved by the designated Resident Engineer.
- B. Submit a field installation inspection procedure for each type of conduit he proposes to install under this Contract. The inspections prescribed shall determine whether conduit has been installed in conformance with the Specifications. These installation inspection procedures shall be submitted by the Contractor within 120 days of receipt of Notice to Proceed.
- C. Submit a conduit installation inspection report for all conduit installed within the area controlled from each TCR involved in this Contract.

#### **PART 2 - PRODUCTS**

##### **2.01 RIGID STEEL CONDUIT AND FITTINGS**

- A. All rigid steel conduit and fittings required by these Specifications shall be galvanized. Galvanized steel, rigid conduit shall be used at locations in passenger stations, equipment rooms, beneath paved roadways, and as hereinafter specified. This conduit shall be consistent with ANSI C80.1.

- B. Fittings for rigid steel conduit shall be of malleable iron, threaded, and shall be protected by hot-dip galvanizing. Conduit fittings designed for removable covers shall be complete with gaskets and blank covers.

## **2.02 POLYVINYL CHLORIDE CONDUIT AND FITTINGS**

- A. At outdoor or embedded locations where conduit is required, but has not been provided by other disciplines, or where it is specifically required by these Specifications and Drawings, the Contractor shall furnish and install thick-wall, Schedule 80, polyvinyl-chloride (PVC) conduit, unless otherwise specified. PVC conduit shall not be installed on concrete surfaces exposed to sunlight.
- B. Where conduit elbows are used, they shall be Schedule 80 and of the long radius type.

## **2.03 FIBERGLASS REINFORCED EPOXY (FRE) CONDUIT**

- A. In all confined areas such as tunnels where exposed conduit runs are required, the Contractor shall furnish and install appropriately sized fiberglass reinforced epoxy (FRE) conduit unless otherwise specified or directed by the designated Resident Engineer.
- B. FRE conduit installed by the Contractor shall have a minimum dielectric strength of 500 volts per mil, tensile strength (axial) of 11,000 psi, and an "HB" flammability rating.
- C. FRE conduit installed by the Contractor shall have a minimum compressive load withstand rating of 3500 pounds per foot of conduit, and a minimum average impact resistance value of 25 foot-pounds.
- D. FRE conduit and fittings installed by the Contractor shall bear nationally accepted testing laboratory approval from U.L. and C.S.A.
- E. Conduit combustion by-products shall not contain chlorine gas in excess of trace levels and always less than safe OSHA limits.
- F. Fiberglass reinforced epoxy conduit shall be FRE Rigid Non-Metallic Fiberglass Conduit as manufactured by FRE Conduit Inc., 1885 Swarthmore Ave., Lakewood, NJ 08701, or approved equal.

## **2.04 FLEXIBLE CONDUIT AND FITTINGS**

- A. Flexible conduit shall be provided only where specifically required by these Specifications or the Contract Drawings or where, at the request of the Contractor, its use has been approved by the Engineer. It shall be constructed of interlocking spiral strip steel of the best quality. The steel strips used in the construction of flexible conduit shall be thoroughly annealed, fully coated with metallic zinc, and shall have an extruded liquid-tight neoprene or PVC jacket overall. The flexible conduit shall conform to the applicable requirements of UL 360. It shall contain, in addition to the galvanized steel core, a continuous copper bonding conductor spiral wound between the convolutions of the core.
- B. Construction of the spiral steel strip shall be such as to permit bending of the conduit to a radius of 4 times its internal diameter; without spreading the strips to such extent that they will open on the outside of the bend, without compressing them to such extent that rough edges will result on the inside of the bend, and without distorting or reducing the internal diameter of the flexible conduit at the bend.

- C. The Contractor shall utilize conduit fittings supplied or recommended by the manufacturer of the brand of liquid-tight flexible metal conduit he provides.

## **2.05 CORDURA HOSE CONDUIT AND FITTINGS**

- A. Flexible hose utilized as conduit shall be furnished and installed by the Contractor where required by the Contract Drawings or Specifications. It shall be vari-purpose, internal tube hose with braided CORDURA rayon reinforcement and a "HYCAR" neoprene cover as made by the ACME-Hamilton Mfg. Corp., or approved equal. Where so required, the hose ends shall be pushed over suitable fittings which provide a snug fit, and fastened with stainless steel clamps as manufactured by the W.D. Allen Mfg. Co., or approved equal.

## **2.06 TRACK LOOP CONDUIT**

- A. Conduit for prefabricated inductive track loop layouts shall be as specified in Section 16961.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION OF CONDUIT**

- A. Conduit provided by the Contractor shall be installed as specified in the National Electrical Code or as specified herein, whichever is more restrictive. All wiring in passenger stations, external to equipment enclosures, shall be installed in rigid steel conduit.
- B. At wayside train control electrical equipment locations, the Contractor shall install lengths of the appropriate type of conduit (Schedule 80 PVC or fiberglass reinforced) to extend the embedded conduit installed by others to the proper location.
- C. In tunnels or other enclosed areas, wiring in the trackway areas shall be installed in fiberglass reinforced conduit. (It shall be understood that in tunnels the word "trackway" refers to the area between the outermost rails and includes a linear zone approximately six feet wide outside of each of the outermost running rails. The depth of the trackway area shall be understood to extend downward from the top of the highest piece of equipment mounted in the trackway area to the surface of the concrete slab in areas of direct fixation. Wiring on tunnel walls, retaining walls, or in cable troughs shall not be considered to be in the trackway.) Conduit shall not be used on the cable runs along the walls of tunnels. Where the Contractor utilizes steel conduit embedded in the floor of the tunnel by others, he shall provide, as a minimum, protective bushings for the ends.
- D. Wiring in horizontal runs in the trackway in ballasted areas, shall be in Schedule 80 PVC conduit buried at a uniform depth of 30 inches, (42 inches from the top of the rail).
- E. Unless otherwise shown on the Contract Drawings, wiring in vertical runs in the track in ballasted areas shall be in CORDURA Hose Conduit where it runs to a device on the ties or rails, and in Schedule 80 PVC in all other places.
- F. Wiring in runs attached to the sides of ties shall be in Schedule 80 PVC conduit unless otherwise shown on the Contract Drawings.
- G. Except in the trackway, or where enclosed in a cable trough, wiring on aerial structures shall be in rigid steel conduit.
- H. In general, all exposed conduit runs shall be installed parallel to walls, floors and ceilings. Conduits shall be supported at intervals not to exceed eight feet for rigid steel conduit and four feet for flexible conduit. PVC conduit (and fiberglass reinforced conduit) shall be

supported at intervals dependent upon its diameter as required in Table 347-8 of the National Electrical Code. Cast, single-hole, malleable iron, galvanized pipe straps of the proper size shall be used for the support of individual conduit runs on concrete surfaces. Where conduit is supported on concrete surfaces, rust-proof stud anchors as specified in Section 16978 shall be used. Galvanized conduit spacers (back straps) shall be used with the conduit clamps to space the conduit away from the mounting surface.

- I. Conduit shall be of sufficient size to leave, as a minimum after installation of wire, the percentage of free space specified in the National Electrical Code.
- J. All bends and offsets in rigid conduit shall be made on a forming tool to prevent damage to the conduit. Rigid conduit bends made in the field shall be in accordance with the manufacturer's recommended procedure. Care shall be taken not to overheat rigid conduit during the bending process.
- K. Steel conduit threads shall be painted with anti-seize, anti-corrosion surface treatment compound, such as Thomas & Betts KOPR-SHIELD, or an approved equal to ease assembly, make them watertight, prevent rust and enhance conductivity.
- L. Rigid or flexible steel conduit shall not be clamped or connected to equipment racks or trays in equipment rooms in any manner which results in an electrically conductive path between the conduit and the rack or tray.
- M. Fittings with removable side plates (pull boxes) shall be installed on long conduit runs at intervals of no more than 75 feet. In the less-than-75-foot conduit segments thus formed, an additional fitting of the same type shall be added each time the total number of degrees in bends exceeds 180. All such fittings shall be of sufficient length to allow the installation of wire or cable without exceeding its minimum bending radius, either as installed or during installation. The minimum bending radius shall be as specified by the manufacturer, or as specified in Articles 370-18 or 370-51 (as applicable) of the National Electrical Code, or as necessary to comply with the applicable minimum cable bending radii specified herein, whichever is more restrictive.
- N. Radii of conduit bends shall meet the requirements of the National Electrical Code.
- O. Conduit shall be connected to equipment enclosures and junction boxes in accordance with the approved installation drawings. Proper fittings with appropriate gasketing and protective bushings shall be utilized.
- P. All conduit which the Contractor utilizes, whether provided by the Contractor or others, shall be properly cleaned (before pulling wires or cables) by either blowing compressed air through the run or by swabbing.
- Q. All conduit installed by the Contractor shall be identified as described in Section 16977, Tagging and Marking.
- R. PVC fittings shall be attached to PVC conduit utilizing both pre-conditioner and cement which have been approved by the designated Resident Engineer.
- S. On long runs of PVC conduit, expansion joints shall be installed at intervals not to exceed 75 feet.
- T. A short (1 to 3 feet) section of liquid-tight flexible metal or CORDURA hose conduit shall be provided where rigid conduit is to be connected to a device which consist of, or contains, a rotating or vibrating mass.

- U. All conduits provided in the TCR for train control, but not used, shall be grounded and closed with a watertight fitting.
- V. Install metallic raceway, fittings, boxes and cabinets, free from contact with reinforcing steel.
- W. To prevent corrosion where aluminum is placed in contact with dissimilar metal or with concrete, separate contact surfaces by means of a gasket, non-absorptive tape or special coating.

### **3.02 CONDUIT PROVIDED BY OTHER DISCIPLINES**

- A. Conduit to be furnished and installed by other disciplines will be approximately as shown on the applicable drawings. It shall be the responsibility of the Contractor to verify the actual location and placement of all conduit provided by others. If it is determined that conduits which should have been provided by other disciplines are missing, defective, or cannot be located, the Contractor shall notify the designated Resident Engineer in writing. The Contractor shall not proceed with any corrective work which may be considered extra work until such work has been approved by the designated Resident Engineer. The Engineer will instruct the Contractor as to the reporting method for the corrective work at the time of approval for such. Any corrective work not brought to the designated Resident Engineer's attention in writing prior to the commencement of such work will not be considered for payment.
- B. The Contractor shall furnish and install any conduit which is necessary according to his approved design (but which was not installed by others) at no additional cost to the Authority.
- C. In the event the Contractor cannot locate conduit installed by other disciplines, the Contractor shall furnish and install the necessary conduit at no additional cost to the Authority.

### **3.03 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. The cost of all connections, fittings and fastening devices shall be included in the cost for each applicable type of conduit.
- B. Rigid steel, fiberglass reinforced, and polyvinyl chloride conduit will be measured for partial payments based upon the linear footage of each type of such approved conduit delivered, installed, and accepted at each TCR area.
- C. Flexible or CORDURA hose conduit will be measured for partial payments based upon the linear footage installed and accepted.
- D. Factors which will be considered when determining partial payments for applicable footage of rigid conduit (including associated fittings) will include the following:
  - 1. Installation of the conduit by the Contractor and approval of the installation by the designated Resident Engineer.
  - 2. Correction of all conduit installation discrepancies by the Contractor to the satisfaction of the designated Resident Engineer.

**END OF SECTION**

## SECTION 16974

### ATC - LOCKS AND KEYS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing and installation of the various types of locks, keys and key switches required to secure ATC equipment and apparatus housings furnished under this Contract.
- B. The proprietary "rights" to all locks, keys, key switches and keying combinations furnished under this Contract shall be assigned to the Authority.

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16914 Environmental Requirements
  - 2. Section 16954 Switch-and-Lock Movements
  - 3. Section 16956 Interlocking Control Panels
  - 4. Section 16965 Signal Layouts
  - 5. Section 16972 Junction Boxes

##### 1.02 QUALITY ASSURANCE

- A. Factory Test
  - 1. The Factory test for all locks, key switches and keys shall be the manufacturer's standard.

##### 1.03 SUBMITTALS

- A. Submit one key switch and one lock of each type specified herein for acceptance testing.
- B. Submit one key of each type specified herein for acceptance testing.

#### PART 2 - PRODUCTS

##### 2.01 BASIC REQUIREMENTS

- A. The locking mechanism for all locks and key switches furnished under this Contract shall be of the 7-pin cylinder type.
- B. All lock rotation shall be 90 degrees clockwise from locked position at 12 o'clock to unlocked position at 3 o'clock.
- C. The coding of the various types of locks and keys furnished under this Contract shall be identical to the coding presently in use on the WMATA Rail Rapid Transit System.
- D. All locks furnished under this Contract shall be keyed to one of two combinations and to a single master combination:
  - 1. The first combination and the master combination shall be provided to key the following locks:
    - a. Padlocks
    - b. Cabinet Locks

- c. Cam Locks
  - 2. The second combination and the master combination shall be provided to key the following locks:
    - a. Key Switch
- E. The keys supplied under the terms of this article shall not be reproducible commercially.

## **2.02 PADLOCKS**

- A. Padlocks shall be solid blocks of extruded brass or stainless steel, bored to receive the locking mechanism. The shackle shall be made of case hardened steel. The locking mechanism shall be operable from its own key and the master key, and shall be designed in such a manner that keys can be removed from the padlock in both the locked and unlocked positions.
- B. The lock shackle shall lock at both heel and toe. The steel shackle pull strength shall exceed 2500 lbs.
- C. The length and width of shackle opening shall be sufficient to allow the padlocks to be installed on all pieces of ATC equipment for which they are required.
- D. Padlocks shall be of a type and quality normally associated with railroad type outdoor services and shall be designed to operate satisfactorily in all weather conditions indigenous to the Washington, D.C. metropolitan area, as described in Section 16914, Environmental Requirements.
- E. Padlocks shall be type 21B722 with AR-3 cylinder as manufactured by Best Lock Corp., or equal.
- F. Padlocks shall be furnished without chains.

## **2.03 CABINET AND CAM LOCKS**

- A. Cabinet and cam locks furnished shall be suitable for mounting on 14 gauge sheet steel, and/or 1/4 inch phenolic panels.
- B. The locking mechanism for cabinet and cam locks shall be so designed that keys can be removed from the locks in both the locked and unlocked positions.
- C. Cabinet locks shall be type BT1004AD as manufactured by Fort Lock Corp., or equal.
- D. Cam locks shall be type N1058AD-186421-1906-49 and/or type N1058AD-186425-2508-49 as manufactured for Fort Lock Corp., or equal.

## **2.04 KEY SWITCHES**

- A. Key switches furnished shall be suitable for flush mounting on 14 gauge steel or 1/4 inch phenolic panels. Each switch shall be supplied with a special two-flange washer to prevent rotation in phenolic panels.
- B. Insertion of the proper key into the tumbler and rotation of the key in a clockwise direction shall cause an internal electrical switch to close. When the key is rotated to this clockwise position, it shall be impossible to remove the key from the tumbler.
- C. Returning the key to the normal position by counter-clockwise rotation shall cause the internal electrical switch to open. When in this position, it shall be possible to remove the key.

- D. The internal electrical switch shall have sufficient current carrying capacity to control a 28 volt (nominal) signal type relay without damage to the switch contacts.
- E. Key switch locks shall be type SW21138AXMKX2KXSC as manufactured for Fort Lock Corp., or equal, and keyed to WMATA Y1A master and appropriate Y001 or Y002 key codes.

## **2.05 KEYS**

- A. The Contractor shall furnish three types of keys as follows:
  - 1. Master keys to unlock all types of locks and key switches specified herein.
  - 2. Keys to unlock only the key switches specified herein.
  - 3. Keys to unlock only the padlocks, cabinet locks and cam locks specified herein.
- B. Each type of key shall be distinctly marked for the use intended, but in such a manner that the marking system employed cannot be used for commercial duplication.
- C. Each type of key shall be identical to the corresponding type presently in use on the WMATA rail system.
- D. Keys shall be made of brass or stainless steel.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. Padlocks
  - 1. Padlocks shall be installed at the locations specified on all signals, junction boxes, switch-and-lock movements, snowmelter control cases and other wayside ATC equipment housings not equipped with integral cabinet or cam locks.
- B. Key Switches and Cam Locks
  - 1. Key Switches and suitable cabinet or cam locks shall be installed on Interlocking Control Panels as shown on the Contract Drawings.

### **3.02 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. Padlocks will be measured for partial payments based upon delivery to the Authority of suitable padlocks and their keys as specified. The cost of padlocks shall include the cost of the associated keys.
- B. Cabinet locks, cam locks, and key switches and their keys will not be measured separately. The cost of these items shall be included in the cost of the devices they secure.

**END OF SECTION**

## SECTION 16975

### ATC - FOUNDATIONS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing and installation of foundations for ATC sign, signal, junction box and pushbutton masts, and, where applicable, for snowmelter control cases.

##### 1.02 DESCRIPTION

- A. Foundations for ATC sign, signal, junction box and pushbutton masts shall be precast, reinforced concrete and shall be of either monolithic or sectional construction.
- B. Foundations for snowmelter control cases shall each consist of two identical units, one to support each end of the snowmelter control case, or a single fabricated unit. These units shall be at least four feet high, and shall be constructed of cast iron, hot-dip galvanized steel, reinforced concrete, or some approved combination thereof.
- C. As an alternative to the materials previously specified, foundations for junction boxes and small control cases may be constructed of fiberglass if pre-approved by the designated Resident Engineer.
- D. Foundations shall not be procured or constructed by the Contractor, except at his own risk, until drawings of the proposed foundations have been approved by the designated Resident Engineer.

##### 1.03 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections
  1. Section 16965 Signal Layouts
  2. Section 16966 Wayside Pushbutton Layouts
  3. Section 16969 Snowmelter Layouts
  4. Section 16972 Junction Boxes
  5. Section 16976 Wayside Signs
  6. Section 16978 Miscellaneous Train Control Components and Materials
  7. Section 16981 Basic ATC Test and Inspection Requirements

##### 1.04 QUALITY ASSURANCE

- A. A permanent record shall be kept by the fabricator of the date and conditions of casting of each precast concrete unit.
- B. Representative test specimens of the concrete poured during the fabrication of the foundation units shall be tested according to test procedure ASTM C94 to determine the compressive strength of the concrete. These tests shall be conducted by an "Accredited Authoritative Structural Testing Laboratory" at no additional cost to the Authority.
- C. Proper control of water-cement ratio, vibration frequency, protection and curing processes shall be monitored to ensure that the concrete provided meets the minimum strength requirements specified in this Section.

- D. The Contractor shall inspect each foundation after it has been installed. This inspection shall be conducted in conformance with the requirements of the Contractor's installation inspection procedure as approved by the designated Resident Engineer.

#### **1.05 SUBMITTALS**

- A. If the Contractor proposes to furnish and install precast concrete foundations different from those shown on the Contract Drawings or specified herein, he shall submit drawings for each type of foundation, including size and details of the galvanized anchor bolts, nuts, and washers to be provided.
- B. Submit two copies of the fabricator's records showing the date and conditions relating to the manufacture of each precast unit, which shall include type of fabricator's building or enclosure, form material used, curing procedures (steam or water), temperature ranges, air entrainment content, water-cement ratio, method of finishing the units, and all other pertinent information.
- C. Submit complete mechanical drawings showing the dimensions, composition and mounting details for each type of fabricated metal foundation unit he proposes to provide.
- D. Submit installation drawings for each type of fabricated metal foundation he proposes to provide.
- E. Submit an Installation Inspection Procedure for each type of foundation provided under this Contract within 120 days of NTP.
- F. Submit a field installation inspection report for each foundation installed under this Contract.

#### **1.06 DELIVERY, STORAGE AND HANDLING**

- A. Precast concrete foundation units shall be handled with care to avoid damage in transit and at storage locations. They shall be adequately supported, cushioned and stacked to protect all edges of the units. Any chipping, cracks or other damaged caused by mis-handling of the units shall be the Contractor's responsibility. Defective foundations shall be repaired or replaced as directed by the designated Resident Engineer at no additional cost to the Authority.

### **PART 2 - PRODUCTS**

#### **2.01 BASIC COMPONENTS**

- A. Cement, aggregates, mixing water and reinforcement used for precast foundation units and cast-in-place foundation structures shall conform to the applicable requirements specified in the current edition of the AREMA Manual for Railway Engineering.
- B. Metal used for Snowmelter Control Case foundation units shall be as recommended in the applicable portions of Part 15.1 of the AREMA Signal Manual.

#### **2.02 CONCRETE FOUNDATIONS**

- A. Foundations shall be provided complete with anchor bolts, nuts and washers, all in accordance with the applicable portion of Part 14.4 of the AREMA Signal Manual and Section 16978 of these Specifications.

- B. Spacing of anchor bolts shall be as required to properly support the equipment to be mounted.
- C. Precast concrete foundations shall be made of concrete of average compressive strength of 4000 p.s.i., air-entrained for exterior locations.
- D. The concrete used in cast-in-place foundations shall have an average compressive strength of 3000 p.s.i.

### **2.03 SNOWMELTER CONTROL CASE FOUNDATIONS**

- A. Snowmelter control case foundations shall be fabricated in accordance with the detailed drawings submitted by the Contractor and approved by the designated Resident Engineer for that purpose.

## **PART 3 - EXECUTION**

### **3.01 PREPARATION**

- A. Provide properly compacted crushed stone bases for all train control equipment foundations installed in ballasted track areas under this Contract.

### **3.02 INSTALLATION**

- A. Train control equipment foundations shall be installed in accordance with the installation drawings approved by the designated Resident Engineer for that purpose. All foundations for ATC equipment shall be vertical and level as installed.
- B. When placing these foundations, exercise due care to ensure that anchor bolts are not bent or threads damaged. All anchor bolt thread, washers, and nuts shall be protected by applying friction tape, or by some other method satisfactory to the designated Resident Engineer, until such time as the train control equipment is installed.

### **3.03 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. Foundations will be measured for partial payments based upon the number of required foundations furnished, installed, and accepted. These foundations shall include all required foundation bolts, nuts and washers as indicated on the Contract Drawings and as specified herein.

**END OF SECTION**

## SECTION 16976

### ATC - WAYSIDE SIGNS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing and installation of various sheet-metal and reflective film wayside signs and markers at locations indicated on the Contract Drawings.
- B. The types of signs and markers shall include, but not be limited to:
  - 1. Wayside ATC Signs:
    - a. "S" signs (Start programmed Station Stop)
    - b. "TB" signs (Turnback points)
    - c. "START ATC" (Begin Automatic Train Control)
    - d. "END ATC" (End of Automatic Train Control)
  - 2. Berthing Markers (Numerals "2", "4", "6" and "8", or combinations thereof).
  - 3. Station Overspeed Marker Signs.
- C. The Contractor shall design any special mounting brackets necessary for the mounting of the Wayside signs in the specified manner at the locations approved by the designated Resident Engineer. These mounting brackets shall be subject to pre-approval by the designated Resident Engineer.

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16918 Special ATC Requirements for Specific Locations
  - 2. Section 16967 Marker Coil Layouts
  - 3. Section 16977 Tagging and Marking

##### 1.03 QUALITY ASSURANCE

- A. The Contractor shall inspect each sign and marker at its point of manufacture. Only those signs and markers which conform to the Specifications shall be shipped and installed.
- B. The Contractor shall inspect each wayside ATC sign and marker sign installation in conformance with the approved installation inspection procedure.

##### 1.04 SUBMITTALS

- A. Complete drawings shall be submitted for each type of sign and marker, and for each type of mounting to be used, showing all mounting and installation details.
- B. Submit a field installation inspection procedure for wayside ATC signs, berthing markers, and station overspeed marker signs within 120 days of NTP.
- C. Submit field installation inspection reports for wayside ATC signs, berthing markers, and station overspeed marker signs.

##### 1.05 DELIVERY, STORAGE AND HANDLING

- A. Signs and markers shall be protected during shipping, storage and handling, and throughout installation, from damage or marring of the painted or reflecting surface.

## **PART 2 - PRODUCTS**

### **2.01 BASIC REQUIREMENTS**

- A. Wayside ATC signs shall be made of 16 gauge sheet steel. They shall display white, reflecting lettering on a green, reflecting background. These signs shall be fabricated in accordance with the applicable recommendations of Part 14.6.1 of the AREMA Signal Manual and as shown on the Contract Drawings.
- B. Train "Berthing Marker" signs shall be made of 20-gauge sheet aluminum. They shall display silver, reflecting numerals on a green, reflecting background. The reflective material used for Wayside ATC signs and Berthing Marker signs shall be 3M Scotchlite High Intensity Grade Pressure Sensitive Reflective Sheeting, or approved equal. Lettering and numerals shall be cut from appropriately colored Series 3860 sheeting. Backgrounds shall be green Series 3800 sheeting. The sheeting shall be applied in conformance with the manufacturer's instructions.
- C. Wayside ATC signs shall be suitable for mounting on masts, or on brackets on walls, as applicable. Berthing markers shall be designed for mounting under station platforms. All ATC signs or markers of a given type shall be identical.
- D. Station Overspeed Marker signs shall consist of 10-inch wide by 8-inch high adhesive-backed, green, reflex-reflecting film background material with the number "20" in silver reflex-reflecting film displayed thereon. (See the Contract Drawing for Typical Marker Coil Layouts). The reflective film shall be 3M Scotchlite High Intensity pressure sensitive sheeting (SCOTCHLITE 510), or approved equal.
- E. The size, shape and lettering for the various types of signs shall be as indicated on the Contract Drawings. The ATC signs, Station Overspeed Marker Signs and Berthing Markers shall be readable at a distance of at least 500 feet when illuminated by a METRO car's headlights.

### **2.02 MAST AND BASE**

- A. The masts for mast-mounted signs shall consist of steel pipe poles, two inches in diameter, supported by cast iron bases. The poles shall be approximately four feet high and fitted with a threaded steel cap at the top.
- B. The cast iron bases shall have four mounting holes suitable for 5/8-inch diameter foundation bolts arranged on 6-3/4 x 6-3/4 inch centers.
- C. Masts and bases shall be painted in accordance with the recommendations of Part 2.4.30 of the AREMA Signal Manual.

### **2.03 BERTHING MARKER LAYOUTS**

- A. Each "Berthing Marker" layout shall consist of the following:
  - 1. One or more Berthing Marker signs
  - 2. A resilient neoprene backing
  - 3. A galvanized steel mounting angle
  - 4. Appropriate assembly and mounting hardware.

- B. The appropriate berthing marker sign (or signs) shall be attached to a quarter-inch neoprene backing pad with pop-rivets and reinforcing washers as shown on the Contract Drawings.
- C. The neoprene backing pad shall be attached to the galvanized mounting angle with quarter-inch bolts, nuts, washers and lock washers as shown on the Contract Drawings. A one-inch-wide reinforcing strip of 20-gauge sheet aluminum shall be used on the front of the neoprene support pad.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. Wayside ATC signs shall be installed on masts, or on brackets on walls, as indicated on the Contract Drawings and as shown specifically on the Contractor's approved drawings.
- B. Train Berthing Marker sign layouts shall normally be mounted under the edge of passenger station platforms at locations and in the manner shown on the Contract Drawings.
- C. The pole base for mast-mounted signs shall be attached to the concrete invert by means of four 5/8-inch anchor bolts.
- D. Wall mounted signs shall be attached to metal brackets bolted to the concrete wall as shown on the Contract Drawings.
- E. Provide all the masts, brackets, bolts, washers, tie wires and other mounting hardware required to mount the signs and markers as specified.
- F. The Station Overspeed Marker signs shall be affixed to the sloping face of the housings of the four 160-foot station stop marker coils facing the center of each passenger station. The sloping face of the marker coil cover shall be thoroughly cleaned and dried before the sign is applied. The film shall be applied in conformance with the manufacturer's instructions.

### **3.02 TYPE AND LOCATION**

- A. Program Station Stop Signs shall be located at the marker coil locations of the markers that normally initiate program station stops. These signs shall be provided for both directions of traffic when program station stop markers are so provided. (See Section 16967 and the Contract Drawings.) Each of these signs shall be positioned so that it can be read by the train operator on a train making the program station stop initiated by the marker at which the sign is located.
- B. Turnback signs shall be located at turnback points and shall be visible to the operators of trains to be turned back before passing that location.
- C. "START ATC" signs shall normally be located at the inbound ends of Terminal passenger station platforms to indicate to the train operators that their trains are entering Automatic Train Control territory.
- D. "END ATC" signs shall normally be located at the outbound ends of Terminal passenger stations to indicate to the train operators that their trains must be operated in a manual mode if they proceed beyond the applicable sign, i.e., that Automatic Train Control territory ends at that point.

- E. Berthing Marker sign layouts shall be located underneath the station platforms at the positions indicated on the Contract Drawings unless otherwise directed by the designated Resident Engineer.

**3.03 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. Signs and markers will be measured for partial payments based upon the number and type of required signs and markers delivered, installed and accepted.

**END OF SECTION**

## SECTION 16977

### ATC - TAGGING AND MARKING

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing and installation of identifying markings on ATC items furnished under this Contract, either directly on the item or through the use of suitable marking tags properly applied to the item.
- B. These markings shall be of the following types which are described in Part 2 of this Section.
- |     |         |                                      |
|-----|---------|--------------------------------------|
| 1.  | Type 1  | Cast Metal                           |
| 2.  | Type 2  | Sheet Steel - Reflective Coated      |
| 3.  | Type 3  | Embossed Metal                       |
| 4.  | Type 4  | Die-Stamped Nameplate                |
| 5.  | Type 5  | Printed Plastic                      |
| 6.  | Type 6  | Painted Stencil                      |
| 7.  | Type 7  | Ink Stamped                          |
| 8.  | Type 8  | Etched Copper                        |
| 9.  | Type 9  | Engraved Phenolic                    |
| 10. | Type 10 | Wire Tags Exposed to Direct Sunlight |
| 11. | Type 11 | Temporary Tags                       |
- C. Tagging and marking shall be further in accordance with specific considerations specified in the following listed Related Sections. Also listed are the marking types that generally apply to the equipment specified in each Section

##### 1.02 RELATED SECTIONS

	<u>Section</u>	<u>Title/Equipment</u>	<u>Marking Type</u>
A.	Section 16922	Lightning/Surge Protection And Grounding Systems (Grounding Cables on Room Prime Ground Bus Bars)	5
B.	Section 16941	Basic ATC Electrical and Electronic Component Requirements	7
C.	Section 16942	Printed Circuit Cards	7 & 8
D.	Section 16943	Vital Relays	5
E.	Section 16944	Non-Vital Relays and Timers	5
F.	Section 16945	Plugboards and Cabinets for Relays and P.C. Cards	5, 7, 8
G.	Section 16946	Transformers	4
H.	Section 16947	Ground Detectors	4

	<u>Section</u>	<u>Title/Equipment</u>	<u>Marking Type</u>
I.	Section 16948	Plug Connectors (Plug Couplers)	5 or 7
J.	Section 16949	Signal Wire and Cable (External Cable) (Internal Wire and Cable)	5, (10) 5
K.	Section 16951	Transfer and Bypass Equipment	3 or 4
L.	Section 16952	DC Power Supplies	4, 7
M.	Section 16953	ATP Track Modules	4
N.	Section 16954	Switch & Lock Movements	1, 5
O.	Section 16961	Audio Frequency Track and Loop Circuit Layouts (Inductive Track Loop Layouts)	3
P.	Section 16962	Impedance Bond Layouts	3
Q.	Section 16963	Power Frequency Track Circuit Layouts	3
R.	Section 16964	Track Switch Operating Layouts	1
S.	Section 16965	Signal Layouts	2, 5
T.	Section 16966	Wayside Pushbutton Layouts	3, 5
U.	Section 16967	Marker Coil Layouts	3, 5
V.	Section 16955	Track and Alarm Indication Panels	4
W.	Section 16956	Interlocking Control Panels	9
X.	Section 16969	Snowmelter Layouts	3 & 6
Y.	Section 16971	Racks and Cable Trays (Racks)	4 & 6
Z.	Section 16972	Junction Boxes	3
AA.	Section 16973	Conduit	3, 5
BB.	Section 16876	Wayside Signs	2

### 1.03 QUALITY ASSURANCE

- A. The Contractor shall check during factory test that all tags, labels, stamping and/or stenciling specified herein are present, correct and properly applied, and in the case of adhesive type tags, applied according to step-by-step instructions approved by the designated Resident Engineer.

- B. Tags and labels shall be of the same type as approved by the designated Resident Engineer.
- C. The Contractor shall, during routine field inspection, check to see that all field installed labels are present, correct and properly applied. Work will not be considered complete until all tags and markings are correct and in place.

#### **1.04 SUBMITTALS**

- A. Prior to the tagging or marking of any device or piece of apparatus requiring tagging or marking, the Contractor shall:
  - 1. Submit a sample of each type of tag or marking required by these Specifications to the designated Resident Engineer for approval. The samples shall show typical nomenclature and lettering arrangement for each device, cable, wire, or piece of apparatus requiring tagging or marking. Sufficient nomenclature shall be present on each sample tag to indicate to the designated Resident Engineer that tags supplied with the equipment will not be ambiguous.
  - 2. Submit technical information on the composition and applicable wear characteristics for each type of tag or marker to be utilized.
  - 3. Obtain written approval from the designated Resident Engineer for each type of tag and marker to be utilized.
- B. The Contractor shall submit plans, diagrams, and/or photographs showing how and where each marking will be applied to each device or piece of apparatus.
- C. The Contractor shall submit a step-by-step procedure for the application of each tag or marking requiring special techniques.
- D. When tags are to be applied by methods employing an adhesive, the Contractor shall submit evidence of having included the adhesive manufacturer's recommendations for solvent cleaning and adhesive activation in the step-by-step procedures for application and shall further certify that these steps are followed during application.
- E. When tags are to be applied by heat shrink methods, the Contractor shall submit evidence of having included the manufacturer's recommendation for printing and shrinking the tubing in a step-by-step procedure for the factory personnel.

### **PART 2 - PRODUCTS**

#### **2.01 MARKER TYPE 1 - CAST METAL**

- A. This marker (used for switch-and-lock movement layouts) shall be at least three inches high and of a thickness to ensure ruggedness. It shall be made of cast metal and shall be painted white. All edges shall be slightly rounded and free of burrs. The casting shall be free of cracks or voids.

#### **2.02 MARKER TYPE 2 - SHEET METAL REFLECTIVE COATED**

- A. This marker (used for signal number plates and wayside signs) shall be of a minimum 1/8 inch thickness and a size to allow visibility as specified elsewhere in these Specifications. The reflectorized coatings or appliques shall be applied per the manufacturer's specifications and shall be free of air pockets, cuts, tears, loose edges and blemishes of any kind.
- B. If a ferrous sheet metal is selected, the marker must be fully protected from rusting according to the Contractor's standard painting procedures as approved by the designated Resident

Engineer. This procedure must include complete corrosion proofing surface preparation before paint application.

- C. If aluminum is selected as the marker material, it must be of sufficient thickness and hardness to remain stiff and straight under field conditions.

### **2.03 MARKER TYPE 3 - EMBOSSED METAL**

- A. This type of marker shall consist of a sheet metal strip approximately one inch wide and of sufficient thickness for ruggedness and durability. It shall be embossed by a stamping machine capable of producing crisp letters approximately one half inch high. The metal shall be lead bearing, galvanized or non-ferrous so that it will not be subject to deterioration by rust.
- B. Care shall be taken to ensure that the marker is flat and straight and that it is free from sharp edges.

### **2.04 MARKER TYPE 4 - DIE-STAMPED NAMEPLATE**

- A. This marker shall be the manufacturer's standard nameplate which shall contain pertinent data such as:
  - 1. Manufacturer's name
  - 2. Serial number
  - 3. Model number
  - 4. Date of manufacture (where required)
  - 5. Drawing number
  - 6. Identifying type and location number (as applicable)
- B. The nameplate shall be made of a non-corroding material. The dies and stamping process shall provide good legibility and permanence.

### **2.05 MARKER TYPE 5 - PRINTED PLASTIC**

- A. This type of marker shall be applied to each conductor and cable not exposed to direct sunlight, and to devices not otherwise identified. (TYPE 10 Markers shall be used for wires and cables exposed to direct sunlight.)
- B. TYPE 5 Markers shall be available in two forms, sleeve and flat:
  - 1. Sleeve Tags
    - a. The sleeve form shall be of the heat shrinkable type and shall be sized from 3/32-inch through 1/2-inch diameter to properly fit the wire for which it is intended. The sleeve shall be made from radiation crosslinked polyolefin (for service to 125 degrees C) or modified fluorocarbon (for service to 200 degrees C) tubing which is white in color. The printing shall be done in black and shall be permanently set through the use of a suitable infrared heater. These sleeve tags shall be of the "TMS" type as manufactured by Raychem Corporation, or approved equal. Material submitted to the designated Resident Engineer for alternate approval will be subjected to indelibility tests and must perform at least as well as that herein specified.
    - b. The legend on the sleeve tag shall always read from left to right, with the first nomenclature indicating the "from/at" location and the second nomenclature indicating the "to" location.
  - 2. Flat Tags
    - a. The flat form shall be made of flat, white, sheet stock with slots for application to large conductors, cables, and conduits (not subject to

painting) with nylon tie-wrap fasteners. These tags shall also be used for identifying indicators, relays, and other devices where slide-in holders are provided.

- b. These tags shall be one and one-half inches long by three-quarter inches wide with one, five sixteenth inch hole located in the center of the width. The distance from the edge of tag to the hole shall be approximately nine thirty-seconds of an inch. The untreated tag shall be milk white "vinylite," or approved equal, approximately seven hundredths of an inch thick.
- c. The identifying nomenclature space shall allow for three rows of lettering. The tag material shall be capable of receiving typed-on characters by conventional means. The height of the lettering shall be not less than one-eighth inch.
- d. After lettering, the face side of the tag shall be covered with a clear plastic coating, "vinylite," or approved equal, of at least one hundredth of an inch thickness. The back of the tag shall be covered with a milk white coating "vinylite," or approved equal, of at least one hundredth of an inch thickness.
- e. The nomenclature applied to tags to go on terminal racks and boards shall show the terminal post identification on the top line. The functional nomenclature shall appear on the bottom line, or, if required, on the middle and bottom lines. The terminal posts shall be identified by geometry coordinates, such as rack, row and post number.

#### **2.06 MARKER TYPE 6 - PAINTED STENCIL**

- A. This type of marking may be utilized for identification of large objects such as racks or enclosures providing they are not subject to field painting (use type 3 in this case) and providing the mark is clearly and neatly applied. The marking paint shall provide a definite contrast with the surface on which it is applied, e.g., black paint on a gray surface would not be acceptable.

#### **2.07 MARKER TYPE 7 - INK STAMPED**

- A. This type of marking shall be utilized for the identification of components not otherwise identified. All electronic components on printed circuit cards shall be so identified. The printed circuit cards themselves shall be so identified as well as their location if not identified by another type marking. The color of the ink shall be either black or white, whichever provides the greatest contrast with the background color.

#### **2.08 MARKER TYPE 8 - ETCHED COPPER**

- A. This marker type is an alternate to type 7 which may be utilized on printed circuit cards for identification of card or components.

#### **2.09 MARKER TYPE 9 - ENGRAVED PHENOLIC**

- A. This marker type shall be utilized for all special purpose panels specified elsewhere in these Specifications. The material shall be white phenolic sheet with thin layers of black phenolic laminated to both sides. Panels shall contain no detectable filled areas resulting from errors, mistakes or changes. The panel shall be free from chips or scratches. Where the edges of the panel are visible, they shall be carefully finished with a durable matte black paint. The surface of the panel shall be buffed with a fine abrasive to remove any shininess and produce a matte finish.

#### **2.10 MARKER TYPE 10 - WIRE TAGS EXPOSED TO DIRECT SUNLIGHT**

- A. This marker type shall be utilized in lieu of Marker Type 5 to identify wires and cables exposed to direct sunlight. The identifying lettering shall be as specified for MARKER TYPE 5 for similar application, but these markers shall be made of material approved by the designated Resident Engineer which will not corrode, rot, melt, or otherwise decay or lose their legibility due to moisture or the effects of sunlight. These markers will be subject to Type-Acceptance Testing.
- B. As an alternative, the Contractor may use embossed metal markers as specified for MARKER TYPE 3 for the purpose of identifying wires and cables exposed to direct sunlight.

## **2.11 MARKER TYPE 11 - TEMPORARY TAGS**

- A. This marker type shall be utilized to identify circuit changes, apparatus or any other device when, in the course of testing, an error in the permanent tag or label is noted. These tags shall be of a size and quality to readily identify the wire or apparatus until such time as the permanent tag is available. Temporary tags shall be of the size, type, material, and color(s) previously approved by the designated Resident Engineer.

## **PART 3 - EXECUTION**

### **3.01 APPLICATION**

- A. The tags and markings shall be applied during manufacture wherever possible or in the field where necessary. The markings shall be applied in a careful, thorough and skillful manner.
- B. The following special precautions shall be observed when applying tagging and marking per above mentioned type:
  - 1. Marker Type 1
    - a. The cast metal marker shall be suitably applied with rivets or flat head screws. If the fasteners penetrate the surface to which they are applied, suitable sealant shall be utilized to ensure watertight integrity of the unit. When flat head screws are used with nuts and washers, they must be secured in such a manner as to prevent loosening due to vibration with consequent entry, into and fouling of the internal operation of the switch-and-lock mechanism.
  - 2. Marker Type 2
    - a. The sheet metal, reflective coated marker shall be securely fastened in place utilizing stainless steel hex bolts, lockwashers and nuts, of diameter appropriate for marker size. A large stainless steel washer shall be used on the front surface of the sign with a neoprene gasket between it and the reflective surface to prevent tearing or gouging of the reflectorized surface. Alternately, the sign may be fastened with a suitable bracket welded or otherwise fastened to the back surface and presenting no discontinuity of the front surface.
  - 3. Marker Type 3
    - a. The embossed metal marker shall be applied by rivets, screws, stainless steel wire, or an adhesive method, to all field equipment subject to periodic painting or obscuring accumulations of dirt or grime. Examples of this equipment are:
      - 1) Conduits
      - 2) Junction Boxes
      - 3) Impedance Bonds
      - 4) Track Loops
      - 5) Station Stopping Distance Markers
  - 4. Marker Type 4

- a. The Die-stamped Nameplate shall be applied by an approved adhesive method or rivets. This marker shall be applied to racks and all equipment or apparatus which requires a test procedure as specified in other Sections. A sample of this marker affixed to a 6-inch x 6-inch finished metal plate shall be submitted to the designated Resident Engineer for testing and approval.
5. Marker Type 5
  - a. The printed plastic marker shall be properly installed so that the printed legend indicates the proper identification of the wire terminal adjacent to the sleeve. The sleeve form shall be located at the termination of the wire and may be used as insulation over an uninsulated pressure-applied terminal. The sleeve shall be oriented on the wire so that the printed legend will start at the terminal, before the heat is applied to shrink the sleeve onto the wire. The sleeve shall be used on wires of sizes up to and including No. 0 AWG. The sleeve shall also be used to identify multiple conductor cables up to 1/2-inch in diameter where specified or appropriate. The tag form shall be securely fastened to the intended object with nylon tie-wrap fasteners inserted in the slots in a manner that does not obscure the legend, and the tag shall be positioned so that it is right side up and readable when installed. The tie-wrap shall be tight enough to prevent the tag from moving from its desired position.
6. Marker Type 6
  - a. The Painted Stencil marking shall be applied with a procedure that produces clear, legible letters without voids and without paint running between the stencil and the surface being marked. No paint shall be allowed to reach the surface being marked around the outside edge of the stencil.
7. Marker Type 7
  - a. The Ink Stamped markings shall be neatly and uniformly applied. Stamped markings that are not complete as a result of improper positioning of the stamp or that are blurred or smeared will not be acceptable.
8. Marker Type 8
  - a. The Etched Copper marking utilized on printed circuit cards, shall be legible and shall not be obscured by any component mounted on the card. Letters or numerals shall be large enough so that solder fill-in will not render them illegible.
9. Marker Type 9
  - a. The Engraved Phenolic markings on control panels shall be applied with letters, numerals and lines engraved through the black layer and well into the white base to provide clean edges and distinct letters. Panels shall be fastened in place without damage from nicking or chipping. If it is not practicable to install the panels without screwheads through the panel, the screwheads shall be flat or oval and shall have a black matte (or black anodized) finish. Screwheads that are burred with a screwdriver shall be replaced.
10. Marker Type 10
  - a. Tags which will be exposed to direct sunlight shall be attached with material which will not corrode or rot due to moisture, or decompose due to ultraviolet light.
11. Marker Type 11
  - a. Temporary tags shall be attached with string, generally in the same location as required for the permanent tag. Temporary tags shall be replaced with permanent tags before each of the Authority acceptance levels listed elsewhere in these Specifications.

### 3.02 MEASUREMENT FOR PAYMENT

- A. Tagging and marking will not be paid for separately. The cost of tagging and marking shall be included in the costs of the materials and equipment being identified.

**END OF SECTION**

## SECTION 16978

### ATC - MISCELLANEOUS COMPONENTS AND MATERIALS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing and installation of miscellaneous components and materials which form part of Train Control equipment or systems which are specified in other Sections of these Specifications.

##### 1.02 RELATED SECTIONS

- A. Related Work specified elsewhere shall include, but not be limited to, the following Sections:

1.	Section 16915	Basic ATC Equipment Requirements
2.	Section 16922	Lightning/Surge Protection and Grounding Systems
3.	Section 16940	ATC Electrical and Electronic Components and Material
4.	Section 16971	Racks and Cable Trays
5.	Section 16972	Junction Boxes
6.	Section 16973	Conduit

##### 1.03 QUALITY ASSURANCE

- A. Certify that the miscellaneous components and materials used are in accordance with the Specifications and the Contract Drawings.

#### PART 2 - PRODUCTS

##### 2.01 BOLTS, NUTS AND WASHERS FOR TRAIN CONTROL WORK

- A. All nuts and bolts furnished by the Contractor for Train Control work shall have "cut" threads and shall be purchased from an approved nut and bolt manufacturer.
- B. Nuts and threads shall be in accordance with the AREMA Signal Manual, Part 14.6.20, Recommended Design Criteria for Bolts, Nuts and Threads. Plain washers shall be in accordance with the AREMA Signal Manual, Part 14.6.21, Recommended Design Criteria for Plain and Spring Lock Washers. Steel shall be in accordance with the AREMA Signal Manual, Part 15.1.4, Section 1, Recommended Developmental Criteria for Various Types of Steel.
- C. Bolts, nuts and washers shall be hot-dip galvanized, or they shall be made of brass or stainless steel. Cold galvanizing, plating and anodizing will not be acceptable. Where regular maintenance requires periodic removal of bolts, the bolts, nuts and washers shall be stainless steel.

##### 2.02 ANCHORS

- A. Stainless steel stud anchors shall be used for mounting Train Control equipment to concrete and masonry structures.

##### 2.03 POTHEADS AND FILLING COMPOUND

- A. Potheads for multiconductor Train Control cable shall be neoprene end seals similar to those manufactured by the Okonite Co., or approved equal.
- B. The filling material shall be "encapsulating resin" as manufactured by Preformed Line Products Company, FX-70 Polymetric Joint Sealant as manufactured by Fox Industries of Baltimore, Maryland, or approved equal, and shall be applied in accordance with the manufacturer's instructions.
- C. At locations where the outdoor end of a conduit entering a TCR or other structure is at a higher elevation than the indoor end, so that water entry is a problem, the Contractor shall provide conduit sealing bushings on both ends of the conduit after removing all water and moisture from the conduit. The fitting shall be as manufactured by O-Z/GEDNEY Co., type CSBG or approved equal product. At locations known to have a problem with infiltration of water under pressure, the Contractor shall install an additional seal 10 inches inside the end of the conduit. This seal shall be the O-Z type CSBI or approved equal product. Apply Dow Corning No. 96081 RTV to the cables at the locations of the seals. Fill space between the O-Z fittings with Dow-Corning No. 3-6548 Silicone RTV Foam under pressure. O-Z seal screws shall be torqued per the manufacturer's specifications.

#### **2.04 SWITCH PLATE LUBRICANT**

- A. A suitable graphite lubricant approved by the designated Resident Engineer, shall be furnished and applied by the Contractor to lubricate switch point tie plates and the inside of the joint bars holding the heels of the switch point rails. This lubricant shall be Dylon Grade SP-MS All Weather Switch Plate Lubricant, as manufactured by Dylon Industries, Inc., Cleveland, OH 44144, or equal.

#### **2.05 CORROSION PROTECTION**

- A. Protection for machined/finished surfaces, threaded rods and nuts and other parts which are susceptible to rusting, shall be a corrosion-preventive compound, NO-OX-ID "A Special", as manufactured by Sanchem, Inc., or approved equal. The compound must have sufficient body to resist weather and rusting for at least six months.

#### **2.06 GROUNDING EQUIPMENT**

- A. Driven ground rods shall be copper-clad steel, or the non-rusting type as manufactured by Copperweld Corporation, or approved equal. Each rod shall be at least eight feet in length and at least five-eighths inch diameter.
- B. Ground rod clamps shall be bronze with tamper-proof safety set screws, as approved by the Engineer.
- C. Connections to ground rods and ground buses shall be made with No. 6 bare copper wire, No. 6 insulated copper wire, No. 4/0 copper wire, or one-eight inch by one and one-half inch flat, hard drawn, bare copper strip, as applicable to the equipment to be grounded.

#### **2.07 SEALING COMPOUND**

- A. Sealing compound shall be "Duxseal" as manufactured by the Manville Company, or an approved equal.

#### **2.08 PAINT AND FINISH**

- A. All paint and painting procedures shall be in accordance with the applicable recommendations of Part 2.4.30 of the AREMA Signal Manual, where the recommendations of the AREMA Signal Manual do not conflict with the requirements of these Specifications.
- B. The surface of equipment and material not accessible after mounting shall have the final finish coat applied prior to installation.

#### **2.09 CABLE PULLING LUBRICANT**

- A. The cable pulling lubricant shall be compatible with all cable jackets and noninjurious to cable insulation.
- B. The lubricant shall be UL (or CSA) listed.
- C. The lubricant shall contain no waxes, greases, silicones, or polyalkylene glycol oils or waxes.
- D. A 200-gram sample of the lubricant, when placed in a one-foot, split metal conduit and fully dried for 25 hours at 105°C, shall not spread a flame more than three inches beyond a point of ignition at a continued heat flux of 40 KW/m<sup>2</sup>. Total time of test shall be one-half hour.
- E. The cable pulling lubricant shall be POLYWATER® J, available from American Polywater Corporation, Stillwater, MN 55082, or approved equal.

#### **2.10 UNDERGROUND EQUIPMENT**

- A. All ATC metallic cases, junction boxes, support hardware, and fastening hardware furnished and installed by the Contractor inside tunnels or other exposed underground locations shall be made of stainless steel, ASTM A276, Type 304, or approved equal, unless otherwise directed by the designated Resident Engineer. This requirement supersedes requirements for hot-dip galvanizing, cadmium plating, epoxy coating, or other protective measures for equipment so installed, unless otherwise directed by the designated Resident Engineer.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION AND/OR UTILIZATION**

- A. Miscellaneous components, products and processes shall be installed, utilized or performed as required by these Specifications, and as indicated on approved submittal drawings.

#### **3.02 MEASUREMENT AND PAYMENT**

- A. The costs of Miscellaneous Components and Material will not be measured or paid for separately, but will be included in the prices for the devices to which they are related.

**END OF SECTION**

## SECTION 16979

### ATC - SURFACE TRENCH

#### PART 1 GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the furnishing, installation and use of surface trench as an alternative to the use of ductbank or conventional direct-burial cable trenching in certain areas of the work included in this Contract.

##### 1.02 DESCRIPTION

- A. The surface trench shall consist basically of channel sections with covers, installed in such a manner that the covers are approximately two inches above the surface of the ground.
- B. Cables shall enter and exit the surface trench runs from the bottom.

##### 1.03 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16911 Scope of ATC Work.
  - 2. Section 16918 Special ATC Requirements for Specific Locations
  - 3. Section 16949 Signal Wire and Cable

##### 1.04 QUALITY ASSURANCE

- A. All surface trench components installed by the Contractor shall be new and free of defects.
- B. The Contractor shall replace all train control surface trench components which are damaged during the time this Contract is in effect, at no additional cost to the Authority.

##### 1.05 SUBMITTALS

- A. Submit complete mechanical drawings and manufacturer's documentation for the type of surface trenching he proposes to furnish. This documentation shall include, but not be limited to, the size, shape, weight, strength and composition for each type of component required for the complete system, and the methods and hardware required to assemble these components into a working surface cable trenching system.
- B. The Contractor shall submit to the designated Resident Engineer, along with the trenching plans, three sets of plans showing all locations where he proposes to install surface trench. These plans shall designate the size, length and cable consist for each proposed surface trench cable run segment.
- C. Submit complete mechanical drawings showing installation details for each type of situation to be encountered by the proposed surface trench runs.
- D. Submit a Cable Trench Installation Inspection Procedure and a Cable Trench Installation Inspection Report form.
- E. The Contractor shall not proceed with the procurement or installation of surface cable trench until these submittals have been approved by the designated Resident Engineer.

## **PART 2 - PRODUCTS**

### **2.01 TRENCH SECTIONS**

- A. Surface trench sections shall be channel shaped and constructed of precast, high density polymer concrete, steel-reinforced concrete, or cement mortar reinforced by alkali-resistant glass fiber and high-tensile welded wire.
- B. Channel sections shall be of prefabricated, one-piece construction, or shall be fabricated on site from prefabricated support brackets and sidewall sections.
- C. Channel sections shall be open on the bottom, or shall have large drainage holes and cable-access openings in the bottom.
- D. Channel sections shall have an integral means of alignment, or shall be aligned by means of external clips, plates or brackets.

### **2.02 COVERS, END PLATES AND DIVIDERS**

- A. Trench covers, end plates and, where required, internal dividers, shall be constructed of high density polymer concrete reinforced with glass fiber; fiberglass-and-steel reinforced concrete, or; cement mortar reinforced by alkali-resistant glass fiber and high-tensile welded wire.
- B. Trench covers shall be capable of supporting a load of 500 lbs/sq. ft. when properly installed on the appropriate trench sections.

### **2.03 ASSOCIATED PARTS AND MATERIALS**

- A. Furnish and install all special channel sections, alignment hardware, brackets, corner posts, lintels, or other fastening hardware needed to provide complete surface trench runs in accordance with the manufacturer's instructions and the requirements of these Specifications.
- B. Furnish and install all material and special support structure needed to provide proper support and drainage for the surface trench runs installed under this Contract.
- C. Furnish and install all sand backfill required for cable installation in the surface trench runs.

### **2.04 MANUFACTURER**

- A. Surface trench shall be: "Plastibeton Channel System" as manufactured by Synertech Moulded Products Inc., 332 South Michigan Avenue, Chicago, Illinois 60604; "Fibercrete" as manufactured by Concast, Incorporated, 15325 Babcock Avenue, Rosemont, Minnesota 55068; "Trenwa Precast Concrete Trench System" as manufactured by Trenwa Inc., 1419 Alexandria Pike, Fort Thomas, Kentucky 41075, or approved equal.

## **PART 3 - EXECUTION**

### **3.01 DESIGN**

- A. Determine the final location of surface trenching runs based upon field inspections and subject to the criteria set forth herein and the approval of the designated Resident Engineer.
- B. The Contractor shall take the following factors into consideration when determining the proposed location of surface trenching runs:

1. Relative location of natural and man-made drainage facilities and final gradients;
  2. Relative location of trackwork, conduit, duct-banks, and manholes;
  3. Relative location of train control cases, junction boxes, signals, switch machines, snowmelter control cases, and other train control and communications equipment;
  4. Relative location of third-rail power stub-ups, building foundations, walls, fences, light posts, approach slabs and other civil, electrical, and mechanical fixed facilities.
  5. Relative location of existing, direct-buried cable.
- C. The Contractor shall size and locate surface trench cable runs to provide the most efficient and economical routing for train control cables in conjunction with the conduit, ductbank and manholes provided by others.

### **3.02 INSTALLATION**

- A. Surface trench units shall be installed in such a manner that the top surface of their covers generally follows the ground contour and is approximately two inches above the final ground level, unless otherwise directed by the designated Resident Engineer.
- B. Surface trench runs shall be installed in accordance with the manufacturer's instructions and as approved by the designated Resident Engineer. The Contractor shall take care not to disturb existing direct-buried cable while installing surface trench or installing cable therein.
- C. Where surface trench runs cannot avoid crossing over natural or man-made drainage facilities, the Contractor shall provide adequate structure to support the surface trench runs plus an additional load of 500 lbs/sq.-ft. without interfering with the function and capacity of the drainage facilities.
- D. Where surface trench runs must run parallel to natural or man-made drainage facilities, the Contractor shall provide adequate structure to prevent undermining, displacement, or other damage to the surface trench runs, and to prevent the surface trench runs from becoming part of the drainage system. This shall be accomplished by providing sufficient drainage for the surface trench runs and by installing the runs in such a manner that surface running water is prevented from entering the runs. Any gaps between the ends of the trench cover sections shall not exceed one-quarter inch.
- E. Install a bed of sand at least three inches deep in the bottom of each surface trench run before installing cable in the run.
- F. Cable shall be installed in surface trench runs in a manner similar to the installation of cable in cable trays, i.e., the cables shall be laid loosely and neatly in the trench with a minimum of crosses. Cable, during installation and as finally installed, shall not be bent to a radius less than 20 times its diameter, and shall not be pulled tightly around corners. Sufficient slack shall be provided in each cable in each cable trench segment to prevent damage to the cable.
- G. Provide longitudinal dividers in surface trench runs which will contain both high-voltage (greater than 200V) and low-voltage cables, and separate the cables accordingly.
- H. Each cable installed in a surface trench run shall be identified by a weatherproof tag at each end of its run in the surface trench and at intervals not to exceed 100 feet.
- I. Unless otherwise directed by the designated Resident Engineer, the Contractor shall not install the surface trench cover sections until the installation of the trench itself and the installation of all required cables therein has been approved by the designated Resident Engineer.

- J. Remove all trash and ballast from the surface trench before installing the trench covers.

**3.03 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. Surface trench will be measured for partial payments based upon the amount and size of such required trench which has been approved, furnished and properly installed.
- B. For measurement purposes only, surface trench will not be considered to be completely installed until the required cables have been installed therein, and the cover sections installed.
- C. Factors which will be considered when determining partial payments for surface trench will include, but not be limited to, the following:
  - 1. Delivery of the surface trench components to the work site;
  - 2. Proper installation of the surface trench base sections;
  - 3. Installation of all applicable cable in the surface trench in the specified manner;
  - 4. Installation of the trench cover sections;
  - 5. Approval of the installation by the designated Resident Engineer and correction of all applicable punch list items by the Contractor.

**END OF SECTION**

## SECTION 16980

### TESTS, INSPECTIONS AND QUALITY ASSURANCE

(Table of Contents)

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

A. This section lists the various 16980-series ATC Test, Inspection, and ATC Quality Assurance specification Sections

- |    |  |                           |
|----|--|---------------------------|
| 1. | Basic ATC Test and Inspection Requirements | (Section 16981)           |
| 2. | Preliminary and Interlocking Tests         | (Level A) (Section 16982) |
| 3. | Train Separation Tests                     | (Level B) (Section 16983) |
| 4. | ATO and Local ATS Tests                    | (Level C) (Section 16984) |
| 5. | DTS Interface Tests                        | (Level D) (Section 16985) |
| 6. | Miscellaneous Tests                        | (Level E) (Section 16986) |
| 7. | System Level Tests                         | (Level F) (Section 16987) |
| 8. | ATC Quality Assurance                      | (Section 16988)           |

#### PART 2 - PRODUCTS

NOT USED

#### PART 3 - EXECUTION

NOT USED

END OF SECTION

## **SECTION 16981**

### **BASIC ATC TEST AND INSPECTION REQUIREMENTS**

#### **PART 1 - GENERAL**

##### **1.01 SECTION INCLUDES**

- A. This Section specifies the basic criteria for factory and field tests and field installation inspections which the Contractor shall devise, perform and document on the various Automatic Train Control systems, subsystems, assemblies, subassemblies, and components provided under this Contract, to demonstrate that each is in compliance with these Specifications.

##### **1.02 DESCRIPTION OF BASIC TRAIN CONTROL TEST AND INSPECTION WORK REQUIRED**

- A. The Contractor shall review the Wayside Test Procedure (WTP) requirements described in Sections 16982 through 16987, inclusive, for applicability to the ATC system(s) and equipment he proposes to furnish under this Contract. The described test procedures or any additional wayside (field) test procedures necessary for applicability to the system(s) or equipment the Contractor proposes to furnish shall be prepared, submitted for approval, and, when approved, executed by the Contractor at no additional cost to the Authority. Wayside Test Procedures approved for previous WMATA contracts, if any, upon resubmittal, will not receive automatic approval, but will be thoroughly reviewed for conformance with the current requirements of these Specifications.
- B. The Contractor shall be responsible for the costs of his personnel and any special equipment and assistance required to conduct all required tests and field installation inspections, and complete the required documentation. When a device or system does not meet the specification requirements initially, the Contractor shall make the necessary corrections and shall be responsible for the total cost of additional tests and/or inspections required to prove compliance. The Contractor will not be responsible for the cost of train operation; these costs will be borne by the Authority to the extent agreed upon by approval of the Contractor's requirements in the test procedure.
- C. No test which requires that a potentiometer, adjustable resistor or other adjustable component be adjusted to within 25 percent of its maximum or minimum value in order to achieve the required test results will be considered satisfactorily completed except in those instances where non-compliance has been specifically approved by the Engineer. (See Section 16916, Basic Circuit Requirements.) When a component adjustment is within 25 percent of its limits, the Contractor shall notify the designated Resident Engineer, commence corrective action and schedule a retest to take place after the condition is corrected.
- D. The WTP number designations used in these Specifications are based upon numbers used for tests of the ATC system to date. The Contractor may elect, subject to the designated Resident Engineer's approval, to alter these designations in his proposed test procedures. The Contractor shall provide a detailed description in writing of the relationship between the existing and any proposed new test procedures. The proposed testing scheme shall, as a minimum, address all of the requirements of this article as well as the specific article describing the test and may include additional tests deemed necessary by the Contractor in order to meet his responsibilities of providing a complete, safe and workable system. Any such additions shall be brought to the attention of the designated Resident Engineer. Each WTP number shall be used as a file name for that test procedure.

- E. The Contractor may elect to conduct two or more of the required tests at the same time, to reduce train movements and time requirements. When two or more of the required tests are conducted at the same time, the Contractor shall provide a single test procedure with clearly designated, consecutive steps covering the combined tests and a single series of Data Sheets shall be provided, with consecutive numbering. The Contractor shall exercise care to assure that the combined tests do not require more time than the tests performed separately. In the event that they do, any additional time required will be at no additional cost to the Authority.
- F. The Contractor shall submit to the designated Resident Engineer for approval, a list of all the test equipment required for the tests. Such pieces of equipment shall be adequate for the test to be made and shall meet with the designated Resident Engineer's approval. If special test fixtures are required, sufficient documentation shall be submitted with the list to enable the designated Resident Engineer to make a judgment regarding their suitability. The special test equipment shall become the property of the Authority at the conclusion of the test requiring it. Wherever possible the test equipment shall be of the multipurpose type, thus minimizing the number of different pieces of test equipment required.
- G. A minimum of one of each item of test equipment required for testing shall be delivered to the Authority by the Contractor prior to the start of testing. Any associated or required software or special licenses shall be included with this equipment. Upon request the Contractor may utilize specialized test equipment which has been delivered under this Contract. The Contractor shall be responsible for the calibration of such equipment and shall return the equipment in like-new condition. The Contractor shall replace any equipment damaged while in the Contractor's custody.
- H. The Contractor shall give the designated Resident Engineer sufficient advance notice of all field installation inspections and field tests to enable the designated Resident Engineer to witness such inspections and tests. Field installation inspections and tests shall not proceed without prior notification to the designated Resident Engineer. The Contractor shall make any provisions necessary for the designated Resident Engineer to witness such inspections and tests. Should the designated Resident Engineer decline to witness any such inspection or test, the Contractor shall keep the designated Resident Engineer apprised of the progress and results of the inspection or test.
- I. The Contractor shall keep a master log of all field testing, with a special emphasis on all problems encountered and readjustments or revisions necessary to correct the problems. As an alternative, the Contractor shall require each individual tester to maintain individual testing logs. In either case, the log(s), or a legible copy of the log(s) shall be delivered to the Authority on a monthly basis. The original log(s) shall be available for inspection by the Authority at any time during the applicable testing period(s). Upon conclusion of all testing by the Contractor, the final logs shall be delivered to the Authority.

**1.03 RELATED SECTIONS**

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Division 1 General Requirements
  - 2. (Article IX) Commencement, Prosecution and Completion of Work
  - 3. (Article VI.A) Progress Schedules Quality Assurance
  - 4. Section 16901 Definition of ATC Terms
  - 5. Section 16904 Current Automatic Train Control System
  - 6. Section 16916 Basic ATC Circuit Requirements
  - 7. Section 16917 Basic Interlocking Requirements
  - 8. Section 16918 Special Requirements for Specific Locations
  - 9. Section 16931 ATC Maintenance and Test Facilities

10.	Section 16949	Signal Wire And Cable
11.	Section 16977	Tagging and Marking
12.	Section 16982	Preliminary and Interlocking Tests (Level A)
13.	Section 16983	Train Separation Tests (Level B)
14.	Section 16984	ATO and Local ATS Tests (Level C)
15.	Section 16985	DTS Interface Tests (Level D)
16.	Section 16986	Miscellaneous Tests (Level E)
17.	Section 16987	System Level Tests (Level F)

#### 1.04 QUALITY ASSURANCE

- A. The quality of materials, fabrication and finish of all ATC components, and their compliance with these Specifications, shall be assured by the factory tests and inspections which the Contractor shall devise and perform as specified in the various ATC Sections of these Specifications.
- B. The quality of the wayside ATC System installation shall be assured through the performance by the Contractor of tests and inspections made during the progress of this Contract and after completing the installation of equipment. These tests and inspections shall consist of, but not be limited to, factory tests, field installation inspections, circuit breakdown tests, wiring verification tests, continuity tests, resistance tests, voltage and current tests, time tests, flame tests, operating tests, simulation tests, and other electrical and mechanical tests and inspections required by the Engineer to prove that every system and device in the installation meets these Specification and design requirements.
- C. The Contractor shall devise, perform and document such factory tests as are necessary to ensure the appropriate degree of quality for items manufactured or fabricated for use on the ATC system specified herein.
- D. The Contractor shall devise, perform and document field installation inspections to ensure that all Train Control equipment furnished in association with this Contract is installed, connected and adjusted in compliance with these Specifications.
- E. The Contractor shall devise, perform and document such field tests as are required by the various Sections in Section 16980 to ensure that all wayside ATC systems, subsystems, and operating equipment, provided under this Contract, function in a safe and proper manner and as required by these Specifications.
- F. The validity of each field test shall be demonstrated to the designated Resident Engineer, either at the factory with simulated equipment or in the field on newly installed equipment. (Simulated tests at the factory for vital equipment such as track circuits will not be acceptable.) The designated Resident Engineer must be satisfied that the test procedure adequately determines that the equipment is working properly, in a safe manner, and that it meets or exceeds the requirements of the Specifications. The designated Resident Engineer will signify his satisfaction with the test procedure by placing his signature on the first page of the document. No test procedure which has not been signed by the designated Resident Engineer (as well as the Contractor) will be considered valid.
- G. Any ATC module, device or appliance, furnished or provided under this Contract, which requires power to be supplied from a power supply system, regardless of system voltage, current or frequency, shall operate satisfactorily throughout the range of plus or minus 8 percent of the rated system voltage. The Contractor shall demonstrate conformance with this requirement in either the type acceptance test or the factory test.

- H. The Contractor's Quality Assurance Manager shall ensure that the approved test procedures are on site and being executed per the requirements of the approved procedure. This information shall be conveyed to the designated Resident Engineer. The QA Manager shall initial and date any portion of the test data sheets witnessed during spot checks. The QA Manager shall stop testing activities if an approved copy of the test procedure is not on site and being utilized. Testing shall not resume until a stamped approved copy of the test procedure is on site.

## 1.05 SUBMITTALS

- A. The Contractor shall, within 90 calendar days of Notice to Proceed, submit for approval of the designated Resident Engineer, three copies of the following:
1. A list called "Master List of Factory Tests" which lists and briefly describes the inspections to be performed on each piece of equipment furnished under this Contract.
  2. A list called "Master List of Installation Inspections" which lists and briefly describes the inspections to be performed in the field upon installation of Train Control equipment. This list shall include, but not be limited to, inspections for the following items and associated components:
    - a. Wall mounted power distribution equipment:
      - 1) Circuit breaker cabinets
      - 2) Transfer and bypass equipment
      - 3) Transformers
    - b. Equipment racks to include all equipment mounted thereon:
      - 1) Rack mounted interlocking control panels
      - 2) Track and alarm indication panels
      - 3) Vital relays
      - 4) Non-vital relays and timers
      - 5) Modules and cabinets
      - 6) Power supplies
      - 7) Transformers
      - 8) Ground detectors
    - c. Cable trays
    - d. Grounding systems (all components)
    - e. External and internal cable
    - f. Negative return bonding
    - g. Signal rail bonding
    - h. Impedance bond layouts
    - i. Marker coil layouts
    - j. Inductive track loop layouts
    - k. Power frequency track circuits
    - l. Audio frequency track circuits
    - m. Signal layouts
    - n. Track switch operating layouts
    - o. Equipment and interface cases and junction boxes
    - p. Wayside signs and markers
  3. A list called "Master List of Field Tests" which lists by number and describes the various field tests that the Contractor plans to perform in the field. This list may be all-inclusive providing references to tests not to be performed at certain locations or on the current Contract. The tests to be performed at each location shall, in some manner, be delineated.
  4. Progress Schedules
    - a. The Contractor shall include in the Progress Schedules specified in Article VI.A., of Division 1 of these Specifications a complete description of the testing to be provided under this Contract. The Progress Schedule shall

delineate the order in which the various required field installation inspections and field tests are to be made and their durations. The Progress Schedules shall show how the Contractor plans to meet the installation and testing dates required by the Contract.

- b. The Progress Schedule provided by the Contractor shall conform to the following requirements:
  - 1) Supplementary data to be included with the schedule shall include an estimate of the test and train requirements, number of man-days required for each test, and the number of men the Contractor plans to utilize for testing.
  - 2) The Critical Path Installation Inspection and Testing Schedule shall take into account the number of locations included in the Contract and the fact that there will be a three week period after all Level A testing has been completed, and a three week period after Level B, C and D testing has been completed before Level F testing can be started. During these two periods, the wayside will not be available to the Contractor.
  - 3) The Contractor shall construct this schedule to allow each test to have its prerequisite testing complete before the test is started. If the resulting approved order of testing is not followed, the Contractor may be required by the designated Resident Engineer to repeat some tests, and such repeat testing will be at no cost to the Authority.
5. A list of all field tests to be performed at each location affected by this Contract.
  - a. This list shall include the following items for each field test listed:
    - 1) List issue number
    - 2) Test procedure
    - 3) Current revision number of the test procedure
    - 4) Descriptive title of test
    - 5) Partial acceptance level of test
    - 6) Prerequisite tests and/or installation inspections required
    - 7) Remarks
    - 8) Date on which list was revised and reason.
  - b. This list shall have an Authority and designated Resident Engineer approved distribution list which may contain the names of as many as twenty persons.
  - c. This list shall be reissued following every list revision.
- B. The Contractor shall, within 120 calendar days of Notice to Proceed, submit a Field Installation Inspection Procedure for each of the field installation inspections to be performed. (See Section 18981.1.05-A.2.) These field installation inspection procedures shall include, but not be limited to the following items:
  1. Title sheet
  2. Revision log
  3. Table of Contents
  4. Introduction
  5. Responsibilities
  6. List of applicable documents
  7. List of items to be inspected
  8. Quality assurance flow diagram
  9. Field installation inspection check list
  10. Discrepancy List
  11. Discrepancy Resolution Sheet
  12. Designated spaces for signatures of inspection personnel and Contractor's project manager
  13. Designated space for signature of Authority's witnessing inspector.

- C. The Contractor shall, within 120 calendar days of Notice to Proceed, submit three copies of a basic "Test Report" document (on 8-1/2 inch by 11 inch paper) for every field and factory test required in these Specifications. This document shall include titled lines for the following information where possible:
1. Prerequisite installation inspections and tests, and all other prerequisite installation documents or information necessary
  2. Name and number of test
  3. Date and time of start and conclusion of test
  4. Names of personnel performing test
  5. Name of Test Supervisor
  6. Time Test Supervisor was present during test
  7. Names, model numbers, calibration dates and serial numbers of all instruments used in test
  8. Results of test
  9. List of difficulties or discrepancies encountered in test
  10. Recommendations and authorization for remedial action and retest
  11. Signatures of test personnel and Test Supervisor
  12. Authority approvals
  13. List of circuit pages, drawings, and/or arrangement plans used during test
  14. List of circuit pages, arrangement plans or other documents revised due to corrections or modifications
  15. Miscellaneous comments
  16. Train car numbers and current train validation date.
- D. The Contractor shall endeavor to minimize the amount of paper required for the Test Report forms by providing self explanatory boxes to check, in lieu of long written descriptions made during the test.
- E. The Contractor shall, at least 30 calendar days prior to the commencement of manufacture, submit for approval of the designated Resident Engineer, detailed factory test documents as described herein. These test documents shall conform to the following requirements:
1. The Contractor's factory test documents shall consist of a test procedure and pre-printed data sheets and/or inspection sheets for each test.
  2. When completed by the factory test personnel and checked for accuracy and completeness, the data sheets shall be submitted as the factory test report.
  3. The Contractor shall submit these data sheets to the Engineer and receive formal approval thereof before the equipment thereby tested is shipped.
  4. When factory tests require specific meter or test instrument readings, the pre-printed data sheet shall show the allowable range of values, and each part of the test. The test report shall also contain a checkoff system for each action and a blank space adjacent to the expected range of values in which to record the test readings. When tests include observations of pertinent responses which do not require instrument readings, each response shall have its own checkmark. No single checkmark shall be used for groups of responses.
  5. If, during the factory test, a discrepancy is found, it shall be corrected and any affected portion of the test shall be repeated. No piece of equipment with an uncorrected discrepancy shall be shipped.
  6. If, during the factory test, a discrepancy is found which cannot be corrected, testing shall be discontinued and the Engineer shall be notified and furnished with the test results and all particulars.
  7. Each device requiring factory test shall be given a model number to which the test documents are keyed. Any change in the organization or construction of the device shall result in a new model number or alternatively, the same model number, but a new series number. Each device requiring factory test shall have a serial number which shall be unique for any given model number. These numbers shall appear on the device.

- F. For each field installation inspection the Contractor shall submit, at least two weeks prior to the inspection, a Field Installation Inspection Report which shall include, but not be limited to, the following:
1. Title sheet showing specific equipment inspected
  2. Check list
  3. Discrepancy list
  4. Discrepancy resolution sheet
  5. Signatures of Contractor's inspection personnel and Project Manager
  6. Signature of Authority's witnessing inspector.
- G. For each field test the Contractor shall submit a detailed test procedure, as described herein, at least 60 calendar days prior to the scheduled performance of the test for approval of the designated Resident Engineer. These test procedures shall meet, as a minimum, the following requirements:
1. The Contractor's field test documents shall consist of applicable, approved pre-printed data sheets for recording data for each test. When preprinted data sheets are used for more than one set of conditions, the Contractor shall identify each set of conditions on separate data sheets. For all tests, if a check mark is required to indicate proper performance, the data sheet shall have a box for indicating the nomenclature of the applicable device, and the desired condition, e.g., XXX relay energized (or deenergized), YYY light indication on (or off), or color, etc. When completed by the field test personnel and checked for accuracy and completeness, the sheets shall be submitted to the designated Resident Engineer as the test report.
  2. When field tests require specific meter or test instrument readings, the pre-printed data sheet shall show the allowable range of values, for each part of the test by providing on the data sheet, the maximum and minimum values for each value measured. The test report shall also contain a checkoff system for each action and a blank space adjacent to the expected value in which to record the test readings. When tests include observations of pertinent responses which do not require instrument readings, each response shall have its own checkmark. No single checkmark shall be used for groups of responses.
  3. If, during the field test, a discrepancy is found, it shall be corrected and any affected portion of the test shall be repeated. No piece of equipment or test with an uncorrected discrepancy will be approved.
  4. If, during the field test, a discrepancy is found which cannot be corrected, testing shall be discontinued and the Engineer shall be notified and furnished with the test results and all particulars. Corrective action by the Contractor shall be started immediately.
  5. The field test report shall also contain a final description sheet on which the Contractor shall record discrepancies found and action taken. This documentation shall be furnished to the designated Resident Engineer. All test reports shall be dated and signed by the responsible employee of the Contractor, or subcontractor, on the day the test is performed. Space shall also be provided for the signature of the witnessing inspector.
  6. Each step of the test procedure shall be clearly written in a manner which describes the action to be performed and also the purpose of the step.
  7. Test procedures shall be clearly worded. A Glossary of Technical Terms shall be provided with each group of test procedures submitted. No technical words shall be used which are not in the Glossary. No words may be used in the test procedures which are not either in the Glossary or in common usage as defined by their inclusion in a commonly used "desk" or "college" edition dictionary. Words shall have their common meaning or a meaning in general use in the Signal Industry.
  8. A Glossary of Abbreviations shall be provided with each group of test procedures submitted. No abbreviation may be used in the test procedure which is not included in the Glossary of Abbreviations.

9. Test procedures shall not be written for specific locations, but shall be general, and apply to all locations of the same general type. Where a particular location has a special feature not usually found in locations of the same general type, the Contractor shall add a special section to the general procedure, clearly designated for that special feature. The Contractor shall provide entry spaces in the Data Sheets for the entry of the data which makes the general test procedure specific for specific locations. Examples of such data are:
    - a. Location designations
    - b. Adjacent location designations
    - c. Track circuit numbers
    - d. Signal numbers
    - e. Train numbers
  10. The Contractor shall record the results of each factory or field test as specified herein. The Contractor shall submit properly executed test documents for each prescribed test within not more than two weeks of completion of the individual tests. All test reports shall be checked and approved by the Contractor prior to submittal to the designated Resident Engineer. Partially completed test documents shall not be submitted without permission of the designated Resident Engineer. The test report shall be all-inclusive, that is it shall contain all required data, reference drawings, explanations, and other information necessary to permit evaluation without the necessity of securing this information from other sources by those responsible for evaluating the test report. All superfluous data shall be so marked or eliminated from the test report prior to submittal. The test report shall be legible in its entirety. Test reports which do not meet the requirements as outlined in these paragraphs will be rejected.
- H. The Contractor shall organize each test procedure into the following sections:
1. Title Sheet - containing the test procedure title, number, acceptance level, issue date and revision date. This sheet shall also present a concise, but complete statement of the purpose of the test described. Finally, blanks shall be provided for the signatures (and dates of signatures) of the Contractor's responsible personnel and the designated Resident Engineer.
  2. Table of Contents
  3. List of test and installation inspection prerequisites
  4. List of abbreviations used in test
  5. List of test equipment required
  6. Preliminary information (background information further clarifying the purpose of the test)
  7. Test description
  8. Data sheets for recording results. These sheets shall include maximum and minimum values for expected results and shall include boxes to be checked for each adjustable circuit component to indicate that the adjustment is within the acceptable mid-50 percent range.
- I. Prior to the commencement of any test, the Contractor shall present a copy of the approved test procedure to the inspector who is to witness the test.

## **PART 2 - PRODUCTS**

### **2.01 TEST INSTRUMENTS**

- A. The Contractor shall use only test and inspection instruments which are of the proper type and capacity for the task required.

- B. The Contractor shall use only test and inspection instruments which are properly calibrated and in good working order.
- C. The Contractor shall obtain approval of test and inspection instruments in accordance with the provisions of Sections 16982, 16983, 16984, 16985, 16986 and 16987 of these Specifications.

## **PART 3 - EXECUTION**

### **3.01 FACTORY TESTS AND INSPECTIONS**

- A. The Contractor and/or his subcontractors shall perform all necessary factory tests and inspections of systems, subsystems, assemblies, subassemblies, and components supplies under this Contract to ensure compliance with these Specifications. These tests shall verify design and nameplate ratings, and shall ensure adequate and proper performance, safety and reliability.
- B. All systems, subsystems, and components forming an integral part of a fail-safe circuit and all electronic devices shall be 100 percent inspected and tested. All components, other than those related to fail-safe circuits shall be tested on a sampling basis. An approved number of randomly selected components or units from the manufacturing process shall be tested to ensure the adequacy and acceptability of all components and units produced. Bidders shall indicate in their proposals:
  - 1. The tests to be performed on each type of component or unit, and;
  - 2. The numbers of each type of component or unit to be tested to demonstrate the adequacy of design and quality control.
- C. When test results are not recorded on a test-data plate affixed to the component or unit, the Contractor shall furnish certified test reports for each item at the time of delivery.
- D. Each component and unit shall be inspected at its point of manufacture and evidence of this inspection and acceptability shall be indicated on the item where practicable.
- E. The Authority and the designated Resident Engineer reserve the right to witness any or all tests and inspections in the Contractor's and/or subcontractors' plants. The Contractor shall advise the designated Resident Engineer a minimum of two weeks in advance of each test. When tests are to be conducted continuously as a production-line routine, the Contractor shall advise the designated Resident Engineer two weeks in advance of the start of such tests and shall indicate the duration of the period over which such tests will be conducted.
- F. All test and inspection procedures shall be subject to the approval of the designated Resident Engineer.

### **3.02 FIELD INSTALLATION INSPECTIONS**

- A. The Contractor shall perform in the field all installation inspections necessary to ensure the proper installation of all Train Control equipment installed under this Contract. These inspections shall verify that all equipment to be provided is present, properly installed, tagged and marked according to Section 16977, Tagging and Marking. These inspections shall be performed in the manner described in the Contractor's Field Installation Inspection Procedures as approved by the designated Resident Engineer.
- B. The Contractor shall record the results of each field installation inspection and submit the completed report to the designated Resident Engineer for approval. The designated Resident Engineer will review the installation inspection reports in conjunction with any on-

site inspections he considers necessary, and inform the Contractor as to whether the inspected area is acceptable for field testing. The designated Resident Engineer reserves the right to decide whether installation inspection discrepancies, either noted in the Contractor's reports or noted by the designated Resident Engineer during his on-site inspection, must be corrected prior to commencement of field tests.

- C. It is the intent of these Specifications that the Field Installation Inspections ensure that proper installation of equipment has been accomplished prior to the commencement of field testing. Approval of the installation does not constitute final or partial acceptance of the equipment by the Authority.

### **3.03 FIELD TESTS**

- A. The Contractor shall perform in the field all tests required to ensure the proper and safe operation of all equipment, systems and subsystems and to prove the adequacy and acceptability of the total installation. The tests to be performed shall cause each system and subsystem to be sequenced through its required operations, including the imposition of simulated conditions to prove that the installation complies with all specified fail-safe requirements.
- B. Contractor Responsibility
  1. The Contractor shall develop computerized spread sheets or data bases to track all field tests and test results. Copies of all software used which is not already in use by the designated Resident Engineer shall be delivered to the designated Resident Engineer along with the computerized data sheets prior to commencement of testing.
  2. The Contractor shall provide equipment and apparatus required for the tests and shall disconnect and reconnect any connections necessary in performing the tests.
  3. For each test crew, the Contractor shall loan to the designated Resident Engineer a notebook-style computer capable of running the programs used for test result tracking. These computers will remain in the possession of the designated Resident Engineer until the review of test data is complete.
  4. Wherever practicable, Test Data sheets shall be computer-generated printouts by the Contractor. The Data Sheets will be checked and, if acceptable, signed by the designated Resident Engineer's representative. Copies of the completed test data shall be submitted by the Contractor on magnetic disk along with the signed hard copy.
- C. Only those field tests which are conducted and documented by the Contractor after the designated Resident Engineer has notified the Contractor that the installations are acceptable will be considered valid tests and be accepted for review by the designated Resident Engineer.
- D. The Contractor's field testing shall be divided into six "Levels," (A, B, C, D, E and F) as specified in Sections 16982, 16983, 16984, 16985, 16986 and 16987 respectively. The tests shall be performed in sequence and conducted in compliance with the requirements of Division 1, Article IX, Commencement, Prosecution and Completion of Work, and as specified herein.
- E. There will be a period of time after Level B Test WTP 2.7 and all Level A testing has been completed, which will be reserved for the Authority to certify the system for train operations, energize the wayside (Propulsion Power) system and condition the rails for the remaining Level B testing. The wayside will not be available to the Contractor during this energization period. All Level A testing and Level B test WTP 2.7 must be complete prior to energization. See Section 16995, Appendix L, for this time period.

- F. There will be a period after all Level B, C, D and E testing has been completed which shall be reserved for the Authority to conduct its own testing and evaluation. At the conclusion of this period, the Contractor shall commence the Level F testing if so authorized by the designated Resident Engineer. The Authority will inspect each TCR to determine if the TCR is ready for Level F testing. The Contractor shall endeavor to minimize all installation and testing discrepancies prior to this period. The designated Resident Engineer will not authorize the start of Level F testing if discrepancies are found that constitute a lack of confidence in the Contractor's performance. Discrepancies in circuits, and data sheets containing data that do not meet the Contract requirements are examples of situations which will create such lack of confidence.
- G. After (Propulsion Power) energization, the Contractor's testing activities and access to the energized test areas will be controlled by WMATA Start-Up. Only Authority-authorized Contractor personnel with escort, will be allowed in the track bed in an energized area, and only for tasks in support of the test program which can safely be performed in the energized environment. For other activities, the Contractor will be required to make arrangements in advance with the designated Resident Engineer for removal of power before occupying the track bed. The Contractor shall provide, in writing to the designated Resident Engineer, his planned duration of testing including the holidays he plans to observe during the test period.
- H. The Authority publication "Start-Up Rules for Conducting Test Operations," as amended for the current Contract's track configuration, will be in effect and will govern the movement of trains and the Contractor's access and activities. The latest revision of R-SMNT Red Tag SOP 200-22 and all other applicable Authority RAPs shall be followed by the Contractor. Revenue operating rules and safety procedures will be in effect, and failure to comply with these rules will result in disciplinary action against the Contractor. These documents will be available to the Contractor at the WMATA Systems Maintenance Facility, located at 195 Telegraph Road, Alexandria, Virginia 22314.
- I. After energization the Contractor shall not move any switch points, or operate any switch-and-lock movements, without first requesting (and securing) permission from Start-Up Control.
- J. When it is necessary for the Contractor to utilize one or more trains for conducting tests according to these Specifications, the Authority will furnish the proper number of "valid trains," as long as the total number of trains does not exceed the number of trains specified in Part 1.05-C.16 of this Section. Each train will be available according to the following conditions:
1. A "valid train" will be considered to be a train on which all electrical facilities, controls, motive power equipment and brake gear is in good operating order and a train which responds correctly to the Daily Safety Test at an existing location. In addition to the requirements specified above, a "valid train" for safe braking distance (SBD) purposes shall meet the requirements specified in Section 16905, Part 1.03, Acceleration and Brake Rates.
  2. The necessary number of 2-car "valid trains" will normally be available to the Contractor for not more than two (2) shifts (15 hours) per day and not more than five (5) days per week, subject to the following conditions:
    - a. The Authority will normally furnish up to two (2) 2-car "valid trains" as required, with one (1) operator per valid train. When a particular test requires a 4-car train, the two 2-car trains furnished shall be coupled. When a 6-car or 8-car train is needed, the Authority, after two weeks advance notice, will provide one or two additional married pairs of cars as necessary for the 2 to 3 hours required for the test.

- b. For WTP 2.20, Part III, Control Line Tests, the Authority will provide two (2) two-car "valid trains" with one (1) operator for each "valid train" in addition to the two (2) 2-car trains normally furnished.
    - c. The Contractor shall, as a minimum, have one qualified, experienced technician per test train, and one qualified, experienced test supervisor for dynamic testing, who shall be full time salaried employees of the Contractor.
  - 3. This equipment will be available as long as the Contractor keeps it in current use and does not let it stand idle for more than three consecutive working days.
  - 4. If equipment on the valid train becomes inoperative as a result of an action taken by the Contractor, the Contractor shall bear the cost of restoring the equipment to proper working order.
  - 5. It shall be the responsibility of the Contractor to keep a log of any changes or readjustments made on the "valid train" while it is being used by the Contractor. This log shall be turned over to the Authority with the train at the end of the testing period for which the train is required.
  - 6. No changes, replacements or readjustments shall be made to any connections, wiring or equipment aboard the "valid train" without the knowledge and express consent of the designated Resident Engineer and the Authority. The Authority's Rail Car Maintenance Department (R-CMNT) will make all modifications and equipment changes to the test train as approved by the designated Resident Engineer.
  - 7. Interface testing must be scheduled two weeks in advance of the test start date and shall be conducted only during the hours listed below:
    - a. 1:30 am - 3:30 am Monday through Friday
    - b. 2:30 am - 4:30 am Saturday
    - c. 2:30 am - 5:30 am Sunday
    - d. All preparatory work such as equipment set-up, data sheet preparation and boarding of the train shall have been completed by the Contractor in advance of the hours stated above.
  - 8. Track inspection will be performed by the Authority prior to the start of each working day in non-revenue areas. The trackway will not be available for testing during these inspection periods. The productive test time percentage shall be calculated by multiplying the number of trains available by the number of hours scheduled for each shift which gives the total number of hours available and then dividing the number of test hours recorded, by the total number of hours available. The productive test time applies to all phases of Dynamic Testing including system tests (Level F). The Contractor can expect, on the average, between 35 and 45 percent productive test time during the above working-day and non-revenue periods.
- K. All field tests and procedures will be subject to the approval of the designated Resident Engineer. The designated Resident Engineer will have the right to witness any or all field tests conducted. The Contractor shall notify the designated Resident Engineer in writing at least 48 hours prior to each test.
- L. Following the completion of each field test, the test results, data sheets and other required records shall be furnished to the designated Resident Engineer. Where the installation did not comply with the Specifications, the remedial action taken by the Contractor shall be recorded and included with the test results.
- M. The Contractor shall resolve all field test discrepancies in accordance with applicable sections of the following procedure:
- 1. Upon discovery of each discrepancy, the Contractor shall describe the discrepancy on the data sheet form which he has provided for that purpose.
  - 2. If the discrepancy is due to an error in field wiring and connections which do not agree with the approved circuit plans, the Contractor may correct such errors without prior approval of the designated Resident Engineer.

3. If the test discrepancy is due to an error in the approved circuit, the Contractor shall not make any changes which affect safety of operation of the approved circuits, as designed, without prior approval of the designated Resident Engineer.
  4. The Contractor shall retest the affected portions of each discrepancy he has corrected.
  5. The retest shall be documented by the Contractor in the manner prescribed in Part 1.05.G of this Section.
  6. Whenever a resolution to the discrepancy is not available at the conclusion of the test, the Contractor shall describe the follow-on action required and list responsibility for such action in the initial field test report.
- N. The designated Resident Engineer will make all final determinations as to whether only a part, or the whole test, shall be re-run when any specific field test does not meet the requirements specified for the test.

### **3.04 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. Testing of the wayside ATC System and equipment for each TCR area of control will be divided into the following categories for measurement purposes for partial payments:
1. Factory Test Documentation
  2. Level A Tests
  3. Level B Tests
  4. Level C Tests
  5. Level D Tests
  6. Level E Tests
  7. Level F Tests
    - a. The six test "Levels" (A, B, C, D, E and F) are defined in Sections 16982, 16983, 16984, 16985, 16986, and 16987, respectively, and in SECTION 101, Article IX, Commencement, Prosecution and Completion of Work.
  8. Test Report Discrepancy Correction
  9. Field Wire and Cable (F.W. & C.) Test Documentation
  10. F.W. & C. Test Report Discrepancy Correction
- B. In addition to the items listed above, the following items will be measured for partial payments as part of the testing for the first TCR area of control to be tested:
1. Master List of all ATC Factory Tests required under this Contract, and Factory Test Procedures for all such required tests.
  2. Master List of all ATC Field Tests required under this Contract, and ATC Field Test Procedures for all such required tests.

### **3.05 PAYMENT**

- A. The sum of payments for ATC Testing at each TCR area of control will equal the Lump Sum Price listed in the Unit Price Schedule for the applicable area under:
1. (NAME OF FIRST TCR LOCATION) ATC TESTING
  2. (NAME OF SECOND TCR LOCATION) ATC TESTING (As Applicable)
  3. (NAME OF THIRD TCR LOCATION) ATC TESTING (As Applicable)
  4. (Etc. as Applicable)

**END OF SECTION**

## SECTION 16982

### ATC - PRELIMINARY AND INTERLOCKING TESTS (LEVEL A)

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the criteria for the field tests and inspections which the Contractor shall develop and conduct in order to prove that the ATC system at individual TCR locations is ready for system testing and to verify that interlockings at such locations are acceptable for manual train operation.
- B. The preliminary tests and inspections to be performed throughout the area of control of each Train Control Room shall cover, as a minimum, the following functions:
  - 1. Train Control (TC) Maintenance Telephone System
  - 2. Power distribution and alarms
  - 3. Grounding system
  - 4. Negative propulsion return system
  - 5. Proper wiring, both vital and non-vital
  - 6. Proper insulation for cable, running rails and equipment
  - 7. Track circuit equipment modules, both track-mounted and rack-mounted
  - 8. Track circuit adjustment, both audio frequency and power frequency
  - 9. Traffic and line circuits
- C. At locations where there is no interlocking equipment, Level A acceptance shall, as a minimum, consist of the preliminary tests only. The preliminary tests are:
  - 1. 1.1 Power Racks, Energy Distribution and Failure Alarm Circuits
  - 2. 1.2 Breakdown Test of Vital Circuits and (where applicable) Interlocking Control Circuits
  - 3. 1.3 Breakdown Test of Non-Vital Circuits
  - 4. 1.5 ATP Track Module Test
  - 5. 1.11 Checkout of Impedance Bonds
  - 6. 1.14 Inspection and Test of Cable
  - 7. 1.15 Inspection and Test of Equipment Grounds
  - 8. 1.18 Test of Track Circuit Terminating Receivers (where applicable)
  - 9. 1.21 Test and Inspection of Negative Return Bonding
  - 10. 1.22 Tests of TC Maintenance Telephone System
  - 11. 1.33 Test of Track and Alarm Indication Panels
  - 12. 2.1 Adjustment of ATP Track Modules
  - 13. 2.15 Operating Test of Line Circuits between Consecutive TC Rooms
- D. Where an interlocking is included within the area controlled by a Train Control Room, tests of the following functions shall, as a minimum, be conducted in addition to the tests listed previously:
  - 1. Track switch control and indication
  - 2. Signal control and indication
  - 3. Detector locking
  - 4. Approach and/or time locking
  - 5. Route locking
  - 6. Derail operation (where applicable)
  - 7. Wayside pushbutton box operation (where applicable)
  - 8. Loop operation
  - 9. Entrance-Exit control operation.

10. Slave module operation

- E. At locations where there is an interlocking, Level A acceptance testing shall, as a minimum, include, in addition to the preliminary tests listed above, certain interlocking tests. These interlocking tests are:
1. 1.6 ATP Slave Module Checkout
  2. 1.12 Lamp Circuitry and Signal Performance
  3. 1.13 Wiring and Adjustments to Switch-and-Lock Movements
  4. 1.16 NOT USED (Wiring and Adjustments to Derail Layouts)
  5. 1.19 Checkout of Wayside Pushbutton Layouts (where applicable)
  6. 2.10 Interlocking Plant Vital Circuit Test
  7. 2.12 Inductive Track Loop Tests
  8. 2.13 Interlocking Plant Tests
  9. 2.24 Tests of 60-Hz, Single-Rail, AC Track Circuits
- F. The area covered by these additional interlocking tests shall be the tracks within the interlocking limits and all tracks approaching the interlocking to and including the approach limits for each interlocking signal.

**1.02 RELATED SECTIONS**

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
- |     |                         |  |
|-----|-------------------------|--|
| 1.  | DIVISION 1 (Article IX) | Commencement, Prosecution and Completion of Work       |
| 2.  | Section 16904           | Current Automatic Train Control System                 |
| 3.  | Section 16916           | Basic ATC Circuit Requirements                         |
| 4.  | Section 16917           | Basic Interlocking Requirements                        |
| 5.  | Section 16918           | Special Requirements for Specific Locations            |
| 6.  | Section 16928           | Interlocking Vital Processor System                    |
| 7.  | Section 16940           | ATC Electrical And Electronic Components and Materials |
| 8.  | Section 16977           | Tagging and Marking                                    |
| 9.  | Section 16981           | Basic ATC Test and Inspection Requirements             |
| 10. | Section 16986           | Miscellaneous Tests (Level E)                          |
| 11. | Section 16997           | RTU Scan Sheets  |

**1.03 SUBMITTALS**

- A. The Contractor shall, at least 60 calendar days prior to the scheduled performance of each test described herein, submit a detailed test procedure for that test:
1. Test 1.1 - Power Racks, Energy Distribution and Failure Alarm Circuits
    - a. The purpose of this test is to determine whether energy at all required levels is available in the control room, and properly distributed to equipment requiring it, both in the field and in the control room.
    - b. This test shall be made with all loads connected and shall prove that the voltage supplied to any module, device or appliance is within plus or minus 5 per-cent of its rated voltage when the module, device or appliance is operating at its maximum current and at its minimum current.
    - c. This test shall be made after test 1.15 is completed and according to the Critical Path Testing Schedule.
    - d. This test shall check that no grounds, shorts, open circuits, crosses or misplaced wiring exist in the power distribution system.

- e. All standby or reserve power circuitry and the Automatic Transfer Switch shall be checked both for completeness and specified operation.
  - f. All alarm circuits shall be tested by simulating power or equipment failure.
  - g. This test shall also include the following:
    - 1) Check AC Power sources for correct voltage levels, and, where necessary, for correct phasing.
    - 2) Check DC power supplies for correct voltage levels and correct polarity.
    - 3) Check transformer taps and adjust as necessary.
    - 4) Check and make operational all ground detectors.
  - h. Any malfunctions, lack of power, or blown fuses shall be reported for later correction and retesting.
2. Test 1.2 - Breakdown Test of Vital Circuits and (where applicable) Interlocking Control Circuits
- a. All vital circuits shall be tested in their entirety for the correct operation of, and response to, each contact on each circuit element, such as relays and contractors. Where parallel paths exist, the tests shall validate each path, and circuits shall be opened to ensure the proper test.
  - b. Where parallel paths exist in a relay circuit, the circuit shall be checked to ensure that all such paths are energized from the same fuse.
  - c. Each circuit shall be tested by simulating all operating conditions to ensure that the relay is energized and that the circuit operates in accordance with the requirements of these Specifications and that it is implemented according to an up-to-date and approved copy of the circuit plans. This shall be done by removing contact terminals from plugboards starting at the positive (+) energy bus and henceforth, at each succeeding contact, checking to see that the energized relay drops.
  - d. These tests shall also include the verification of correct current where resistors are used to reduce current.
  - e. These tests shall also include the checking of all tags and markings for their presence, legibility, and accuracy. Any discrepancy shall be tagged with a red tag fastened to the wire or device with string.
  - f. Wires used for temporary connections for these tests shall be of vividly contrasting color to the rack wire, or alternatively, these wires shall be identified by a green paper tag fastened to the wire with string. These wires shall be removed at the end of the tests.
  - g. Both ends of each wire shall be checked during these tests to be certain that their terminations are solidly applied and that they are properly held in their correct place. The corresponding line on an up-to-date set of approved plans shall be marked with green pencil to indicate the presence of continuity in each wire and that each wire is in its proper position and properly terminated.
  - h. This test shall be performed after tests 1.1 and 1.15 have been completed, and in accordance with the Critical Path Testing Schedule.
  - i. All circuit elements shall be checked in the breakdown test. This shall include, but not be limited to, relay test posts, pushbutton contacts, and switch machine control, energization and indication contacts in the Train Control Room. All terminations shall be checked to ensure that no extraneous connections exist.
  - j. A contrasting colored pencil (brown) shall be used to checkmark each circuit element connected by the circuit (on the set of plans included with the test submittal) to indicate that each circuit element has been

checked and that it is correct and in place as shown on the Contract Drawings. All coordinates for identifying apparatus locations shall be checked during this test.

- k. Where applicable, these tests shall include the portions of the Vital Processor circuitry which are external to that unit.
3. Test 1.3 - Breakdown Test of Non-Vital Circuits
- a. When all relay rack connections have been completed and all equipment is in place, the Contractor shall energize and test each non-vital circuit to determine that it meets the requirements of these Specifications and that it is implemented according to an up-to-date and approved copy of the circuit plans. The Blown Fuse Circuit shall be the first circuit to be tested.
  - b. As each circuit is checked for continuity, by first energizing the relay and then opening the circuit, contact by contact, from energy plus to energy minus, the corresponding circuit in the circuit plans shall be delineated with green pencil so that no wire, contact, coil, device or connection is overlooked.
  - c. On relays with exposed contacts, circuits may be checked by placing a thin strip of plastic between the appropriate pair of contacts and checking to see that this break de-energizes the relay of the circuit being checked. These plastic strips shall be configured so that they cannot be inadvertently left in place after the test. These plastic strips can be utilized to separate multiple circuit paths so that each contact in the remaining single circuit path may be checked. As each circuit element is checked out, its corresponding symbol on the plans shall be marked with a brown pencil.
  - d. Where the device being controlled is remote from the equipment being tested, a lamp, buzzer, or voltmeter shall be connected at the final terminal leading to that device. NOTE: If a buzzer or other vibrating contact device is used, its coil shall be properly suppressed to prevent transient damage to the equipment.
  - e. Paragraphs b, e, f and j of Test 1.2 shall also apply to this test.
  - f. This test shall be performed after Tests 1.1 and 1.15 have been successfully completed and in accordance with the Critical Path Testing Schedule.
4. Test 1.5 - ATP Track Module Test(See Section 16953, ATP Track Modules) The Contractor shall test each ATP (Automatic Train Protection) module in accordance with an approved test procedure consistent with the following Specifications:
- a. This test shall be made at a time consistent with the Critical Path Testing Schedule after Tests 1.1, 1.2 and 1.15 have been successfully performed. This test shall be made with all field wiring disconnected, according to an up-to-date set of circuit plans and following an approved step-by-step test procedure.
  - b. The following items shall be checked, and the Contractor shall determine that:
    - 1) Filters of the proper frequency are in place.
    - 2) The unit has a track carrier generator of the proper frequency in place for the location.
    - 3) Code rate generators with the proper coding rate are in place for the location.
    - 4) The module for TWC (Train-To-Wayside Communications) is in place if required at the location.
    - 5) All other components of the module are in place and properly positioned.

- 6) A suitable test fixture is connected to the output.
  - 7) Power is present at the module, device or appliance and it is within plus or minus 5 percent of its nominal voltage rating with all loads connected, during operation.
  - 8) The unit does not overheat when power is applied.
  - 9) The proper current is being drawn from the power supply.
  - 10) The proper carrier frequency is being generated and that it is within the tolerance designated by the manufacturer and approved by the designated Resident Engineer.
  - 11) The proper code rates are being generated and that they are within the tolerance designated by the manufacturer and approved by the designated Resident Engineer.
  - 12) A suitable test fixture is connected to the input and that the receiver gain is properly adjusted.
  - 13) With the module connected to the test fixture, the track relay is energized.
  - 14) With the module connected to the test fixture and track shunting simulated, the relay is de-energized.
5. Test 1.6 ATP Slave Module Checkout (See also also Section 16953, ATP Track Modules).The Contractor shall test each ATP Slave Module in accordance with an approved test procedure consistent with the following Specifications:
- a. This test shall be made at a time consistent with the Critical Path Testing Schedule after tests 1.1, 1.2, 1.5 and 1.15 have been successfully completed.
  - b. The following items shall be checked and the Contractor shall determine that:
    - 1) The module does not overheat.
    - 2) Transmitted output has correct frequency for the location and is within the tolerance designated by the manufacturer and approved by the designated Resident Engineer.
    - 3) Transmitter output responds to changes in code rate supplied from ATP transmitter or test fixture.
    - 4) Receiver input can be adjusted to be within the specified tolerance.
    - 5) Track relay connections are complete, free from shorts and grounds, and the relay responds to simulated shunting of the track.
6. Test 1.11 - Checkout of Impedance Bonds(See also Section 16962, Impedance Bond Layouts).The Contractor shall test all impedance bonds in accordance with a test procedure which he has prepared and which the designated Resident Engineer has approved. Each test shall produce a printed trace from a spectrum analyzer using a signal generator connected to the track terminals in the TCR. The test shall be consistent with the following requirements:
- a. This test shall be made at a time consistent with the Critical Path Testing Schedule and after tests 1.1, 1.2, 1.5, 1.6, 1.14, 1.15 and 1.21 have been successfully completed at that location.
  - b. The following items shall be checked and the Contractor shall determine that:
    - 1) A frequency sweep test verifies that voltage peaks are present for all frequencies assigned to this location and that these peaks are within tolerance according to the manufacturer's approved specifications.
    - 2) The impedance bond is connected to the correct ATP module.

- 3) With untuned bonds, (for which frequency sweep tests cannot be made) amplitude tests prove the correct connections are made and the bond is operable.
7. Test 1.12 - Lamp Circuitry and Signal Performance(See also Section 16965, Signal Layouts).The Contractor shall test all signal layouts in accordance with a test procedure which he has prepared and which the designated Resident Engineer has approved. The test shall be consistent with the following requirements:
- a. This test shall be made at a time consistent with the Critical Path Schedule and after tests 1.1, 1.2, 1.14, 1.15 and 1.22 have been successfully completed at the location involved.
  - b. The following items shall be checked and the Contractor shall determine that:
    - 1) The signal layout is wired according to the approved circuit design plans.
    - 2) The signal is located according to the approved plans.
    - 3) The signal displays the proper aspect for the signal control relay positions and has the correct lamp installed.
    - 4) The signal is energized with the proper voltage, which is 9 volts, and that this voltage does not vary beyond the range of +1 percent and -5 percent during normal power supply and load fluctuations. This voltage shall be recorded on the test data sheet.
    - 5) The signal connections are checked for tightness, clearness and integrity.
    - 6) The signal layout and all its components are tagged and marked according to Section 16977, Tagging and Marking.
    - 7) The TC maintenance telephone line and jack are properly installed and in operating order.
    - 8) The performance of the signal beam is visually checked for intensity, alignment and sufficient beam width, to allow continuous viewing from an approaching train over the required upstream distance.
8. Test 1.13 - Wiring and Adjustments to Switch-and- Lock Movements(See also Section 16954,Switch-and-Lock Movements)The Contractor shall test all Switch-and-Lock Movements in accordance with a test procedure which he has prepared and which has been approved by the designated Resident Engineer. The test shall be consistent with the following requirements:
- a. This test shall be made at a time consistent with the Critical Path Testing Schedule and after tests 1.1, 1.2, 1.3, 1.14, 1.15 and 1.22 have been successfully completed.
  - b. The following items shall be checked and the Contractor shall determine that:
    - 1) The Switch-and-Lock Movement is properly placed, installed, lubricated, free of abnormal mechanical resistance, and wired according to the approved plans.
    - 2) The Switch-and-Lock Movement is energized with the proper voltage, and that the voltage remains within a tolerance of plus or minus 5 percent of its nominal rating during operation of the movement.
    - 3) That all internal and external mechanisms are in adjustment according to the manufacturer's instructions **and meet all requirements of Sections 16954 and 16964.**
    - 4) The movement responds to a blocked point in the manner specified.

- 5) The movement draws the correct current at the voltage supplied as specified by the manufacturer.
  - 6) The movement responds in the correct direction according to the control relays and the appropriate repeater relays are energized.
  - 7) The movement can be hand-cranked to both extreme positions and cannot be operated electrically with the crank in place.
  - 8) The movement heater(s) are in place and are at the correct temperature.
9. Test 1.14 - Inspection and Test of Cable (See also Section 16949, Signal Wire and Cable).The Contractor shall test all cable in accordance with a test procedure he has prepared and which the designated Resident Engineer has approved. The test shall be consistent with the following requirements:
- a. Appropriate tests shall be made before installation and after installation is complete, at times consistent with the Critical Path Test Schedule.
  - b. The following items shall be checked BEFORE INSTALLATION. The Contractor shall determine that, with the cable on the reel:
    - 1) A visual inspection shows exterior of cable to be free from nicks, gouges, or any obvious damage insofar as the cable can be inspected.
    - 2) Insulation resistance between all conductors and all conductors and shield, if any, meet the specified values.
    - 3) The cable is of the type and configuration specified and shown on the plans and drawings.
    - 4) Continuity for each conductor is satisfactory.
  - c. The following items shall be checked AFTER INSTALLATION is complete. The Contractor shall determine that:
    - 1) A visual inspection of the exposed portion of the cable shows the exterior to be free of nicks, gouges or any obvious damage.
    - 2) The cable is properly installed and supported in the correct location, and adequate slack has been provided to prevent strain on the terminations or abrasion to the cable.
    - 3) The cable shows adequate insulation resistance (at least one megohm for 600V-class cable and at least 100 megohms for 1000V-class cable) to ground and between each conductor and all other conductors. (The cables shall be disconnected by opening terminal links, or by other means, for these tests). A megger of the type specified in Section 16931.1.01 F., or approved equal, shall be used to conduct this test.
    - 4) Cable of the proper size, voltage rating and type has been installed. (If substitution was necessary and was authorized and made, the plans shall show these changes.)
    - 5) A proper tag has been installed on both cable wire, and the wires have been properly terminated and landed. (All drawings showing cable terminations shall be verified as to completeness and correctness of the cable terminations, and shall be submitted with the Test Report.)
10. Test 1.15 - Inspection and Test of Equipment Grounds(See also Section 16922, Lightning/Surge Protection and Grounding Systems)The Contractor shall inspect and test all equipment grounds in accordance with a test procedure which he has prepared and which the designated Resident Engineer has approved. The test shall be consistent with the following requirements:
- a. This test shall be made as soon as the grounding system has been established, before testing of electronic equipment is started and according to the Critical Path Testing Schedule.

- b. The following items shall be checked and the Contractor shall determine that:
  - 1) The grounding systems called for in these Specifications or shown on the Contract Drawings are in place and correctly installed.
  - 2) A visual inspection shows all ground connections tight, free of paint and suitably protected from physical damage and corrosion.
  - 3) A visual inspection shows all ground leads to be properly sized (per Specifications), short, direct and free of bend radii less than six inches.
  - 4) The dc resistance from TCR Prime Ground Bus has been tested and recorded by the use of an approved testing device, and it has been determined that the ground resistance between the bus and true ground is less than 15 ohms.
  - 5) The dc resistance from each equipment ground connection to the TCR Prime Ground Bus has been checked and recorded, and it has been determined that the dc resistance is less than 0.01 ohms.
  - 6) One path and only one path exists between the TCR Prime ground bus bar and ground. (Disconnecting the leads from the bar to ground shall show a DC resistance from the bar to ground of over 100,000 ohms.)
  - 7) The dc resistance between racks, cable trays or other pieces of equipment which are required to be insulated from each other and/or insulated from supporting framework is at least 100,000 ohms.
  - 8) All ground wires are properly attached to the TCR Prime Ground Bus and properly labeled as to their origin.
- 11. Test 1.18 - Test of Track Circuit Terminating Receivers (Where applicable)(See also Section 16953, ATP Track Modules)The Contractor shall test all Track Circuit Terminating Receivers which may be included in the ATC system, in accordance with a test procedure which he has prepared and which has been approved by the designated Resident Engineer. The test shall be consistent with the following requirements:
  - a. The test shall be made at a time consistent with the Critical Path Testing Schedule and after tests 1.1, 1.2, 1.5, 1.14 and 1.15 have been successfully completed at that location.
  - b. The following items shall be checked and the Contractor shall determine that:
    - 1) The Terminating Receiver is located and installed according to the approved plans.
    - 2) The associated track module transmitter is operating and adjusted according to test procedure 1.5.
    - 3) The correct bandpass filter for the location is installed.
    - 4) The gain is properly adjusted according to the approved test procedure, utilizing a special test fixture if necessary to obtain adjustment.
    - 5) If the location requires a second parallel connected receiver, the test procedure nevertheless still allows proper gain adjustment of both units.
    - 6) The approved test data sheets, properly filled in, have been submitted. (A separate special data sheet shall be prepared for each module configuration, and it shall show the limits of acceptance performance for each reading.)

- 7) The applicable track relay operates properly according to whether its track is shunted or unshunted, as specified elsewhere in these Specifications.
12. Test 1.19 - Checkout of Wayside Pushbutton Boxes(Where applicable) (See also Section 16966, Wayside Pushbutton Layouts)The Contractor shall test all wayside pushbutton boxes in accordance with a test procedure which he has prepared and which the designated Resident Engineer has approved. The test shall be consistent with the following requirements:
    - a. The test shall be made at a time consistent with the Critical Path Testing Schedule and after tests 1.1, 1.2, 1.3, 1.14 and 1.15 have been successfully completed at that location.
    - b. The following items shall be checked and the Contractor shall determine that:
      - 1) The pushbutton layout is located and installed according to the approved plans.
      - 2) Where indicating lamps are included in the pushbutton box, each lamp lights only when the appropriate circuit is energized in the Train Control Room.
      - 3) Each pushbutton control circuit in the TCR becomes energized (or for some circuits, deenergized) only when its corresponding pushbutton is pushed.
  13. Test 1.21 - Test and Inspection of Negative Return Bonding(See also Section 16968, Track Bonding Layouts).The Contractor shall test each Negative Return Bond (including impedance bond, shunt bar and crossbonding connections) in accordance with test procedures which he has prepared and which the designated Resident Engineer has approved. The tests shall be consistent with the following requirements:
    - a. Before any bonding has been installed, the Contractor shall verify that all insulated joints have been correctly located, correctly installed and that their resistance when tested by the Authority's approved method is above 5000 ohms. If any discrepancy is found in the insulated joint, the Authority shall be notified and the bonding of that section shall be postponed.
    - b. The remaining tests shall be made after all the bonds and negative return equipment have been installed at a particular location, and according to the Critical Path Testing Schedule.
    - c. The following items shall be checked and the Contractor shall determine that:
      - 1) Each bond has been installed in the correct location according to these Specifications and that all bonds necessary to ensure an uninterrupted low resistance path for the negative return current are in place.
      - 2) The cap screw of each negative return cable clamp has been tightened with the proper torque according to the approved procedure.
      - 3) Each bond has been tested by the Null Balance method utilizing a four terminal configuration of a Kelvin Bridge.
      - 4) The resistance of each bond has been measured and does not exceed the maximum acceptable ohmic value (for its configuration and bond length) which has been approved by the designated Resident Engineer.
  14. Test 1.22 - Tests of TC Maintenance Telephone System(See also Section 16923, TC Maintenance Telephone System).The Contractor shall test each train control maintenance telephone, telephone jack and selector switch both at the factory and after installation in the field in accordance with a testing procedure

which he has prepared and which the designated Resident Engineer has approved. The tests shall be consistent with the following requirements:

- a. The tests shall be made at a time consistent with the Critical Path Testing Schedule and after test 1.14 has been successfully completed at that location.
  - b. The field tests shall be made after all interconnecting wiring has been installed, after the test procedure 1.15 has been successfully completed, and in accordance with the Critical Path Testing Schedule.
  - c. The field tests shall be made according to the approved test procedures. The Contractor shall determine that:
    - 1) Each TC Maintenance Telephone is operating properly, and conforms to the manufacturer's specifications. Proper operation will be judged according to the following qualities:
      - a) Clarity of tone (distinctness and freedom from distortion) at all normal working levels.
      - b) Uniform volume level among units at midpoint on the control with a good range of adjustability of the control.
    - 2) Voice communications can be maintained through the extreme ends of TC Maintenance Telephone circuits for this route segment with a signal-to-noise ratio which meets the specified minimum requirements.
    - 3) Each phone jack and selector switch is installed, properly placed, and wired correctly according to these Specifications, and is not a source of hum, noise or static as determined by an actual listening test.
    - 4) The system functions as intended and herein specified.
15. Test 1.33 - Test of Track and Alarm Indication Panels(See also Section 16955, Track and Alarm Indication Panels).The Contractor shall test all Track and Alarm Indication Panels in accordance with a test procedure which he has prepared and which has been approved by the designated Resident Engineer. The test shall be consistent with the following requirements:
- a. This test shall be made only after all of the installation work in the TCR is essentially complete. It shall be made at a time consistent with the Critical Path Testing Schedule and after tests 1.1, 1.2 and 1.3 have been successfully completed.
  - b. The following items shall be checked and the Contractor shall determined that:
    - 1) The programming jumpers are correctly installed.
    - 2) Typed track circuit occupancy and alarm indication designation labels are correct and inserted at the appropriate locations.
    - 3) Each visual Track Occupancy indication is activated by manually dropping the associated track relay.
    - 4) All NORMAL and REVERSE Traffic indications function properly and display the specified indication color.
    - 5) All Blown-Fuse indications function properly for every fuse.
    - 6) All Ground Detector and Transfer Panel indications function properly.
    - 7) All Power Failure and Power Off indications function properly.
    - 8) Where applicable, all Snowmelter Problem and Snowmelter Failure indications function properly.
    - 9) Where applicable, the Non-Vital Interlocking Problem indication(s) function properly.
    - 10) Where applicable, all Vital Processor On-Line indications function properly.

- 11) Where applicable, all Vital Processor Failure indications function properly.
  - 12) All spare and unused alarm indication inputs are capable of correct operation.
  - 13) The audible alarm functions as specified for each alarm tested.
  - 14) An output for the pen recorder functions for each alarm indication and "test" position of the alarm control switch.
  - 15) If two or more alarm panels are installed in the same room, their fifteen interpanel input plug coupler pins have continuity between panels.
16. Test 2.1 - Adjustment of ATP Track Modules(See also Section 16953, ATP Track Modules).The Contractor shall test and adjust each ATP track module, both at the factory and after installation in the field, in accordance with a testing procedure which he has prepared and which the designated Resident Engineer has approved. The tests shall be consistent with the following requirements:
- a. The field tests shall be made after all the necessary equipment has been correctly installed; after the successful completion of test 1.11 and, if applicable, test 1.18, and all of their prerequisite tests, and; in accordance with the Critical Path Testing Schedule.
  - b. The field tests shall be made according to the approved test procedures and shall determine that:
    - 1) The track module is complete and properly installed according to the Specifications.
    - 2) The track module is drawing the correct current from the power supply. This current shall be read and recorded during track and train transmission, after track and train power levels have been set.
    - 3) The output power level is properly adjusted according to the manufacturer's approved instructions.
    - 4) The proper output to the track relay is present and the relay is picked up on the correct current and polarity.
    - 5) When an 0.06 ohm shunt is placed across the track **at the middle of the track circuit** the corresponding track relay drops. The track relay also drops **when an 0.06 ohm shunt is placed across** the track transmitting bond or Mini-Loop and when an 0.06 ohm shunt is placed across the receiving bond of the track circuit being tested. At interlockings, verification of the appropriate track relay dropping with an 0.06 ohm shunt placed across the switch points is also required.
    - 6) The input sensitivity of the receiver amplifier is correctly adjusted according to the manufacturer's approved procedure for the configuration of the track installation being tested. (A separate set of instructions shall be available for every configuration.)
    - 7) Each receiver filter shall be checked during field testing to determine that the ringing (fill-in), during the "off time" of the track frequency cycle is less than the maximum level established during the type acceptance testing. Filters which do not meet this requirement shall be rejected and shall not be furnished or installed under this Contract.
    - 8) The train frequency is correct and its voltage is adjusted according to the manufacturer's approved procedure.
    - 9) The coupling transformer or series resistor (if any) is properly adjusted according to the manufacturer's procedure.

- 10) The signal-to-noise ratio on any pair of leads is not less than 10:1.
  - 11) Data taken in this test has been recorded as part of a permanent log located in each Train Control Room. (This log shall be kept for use by the Authority for ongoing maintenance.)
  - 12) The cross-talk on any pair of leads is below a level corresponding to a signal-to-noise ratio of 10:1. (This test shall be made with all transmitters in operation except the one under test.)
17. Test 2.10 - Interlocking Plant Vital Circuit Test(See also Sections 16928, 16943, 16953, 16954, 16961, 16963, and 16965).The Contractor shall perform a dynamic test of each of the vital interlocking circuits at each location. This test shall prove by actual visual observation of all interlocking relays, switches, and signals, that the vital circuits enforce the rules of safe interlocking of signals, track switches, and track occupancy.
- a. The Contractor shall delineate in his test procedure the intended purpose of each circuit contact break or program routine as it is listed. This test procedure shall be prepared by the Contractor and approved by the Engineer before testing may begin.
  - b. The test shall be conducted in conformance with the approved test procedure and shall check that each and every circuit contact break or program routine performs the function intended, and does not perform or allow any function which could result in an unsafe situation.
  - c. This test shall be made only after all of the vital equipment at a location has been installed, after tests 1.6, 1.12, 1.13, 1.18, 1.21 and 2.24 have been successfully completed, and in accordance with the Critical Path Testing Schedule.
  - d. The vital circuit test procedure shall be complete and shall be consistent with all of the following considerations. The Contractor shall determine for every possible route in the interlocking, that:
    - 1) When a signal is cleared for a given route, all track switches along that route and all potentially conflicting routes are properly positioned and locked, and no signals governing conflicting routes can be cleared.
    - 2) When any track circuit within the interlocking is occupied, all switches previously locked by a cleared signal remain locked, and no signal can be cleared over that or conflicting routes.
    - 3) No switch can be operated if its track circuit is occupied.
    - 4) With a train occupying the approach to a given signal, once that signal is cleared, no other signal can be cleared over a conflicting route until the first signal is put to stop and a suitable time period expires.
    - 5) With a train occupying the approach to a given signal, once that signal is cleared, no switch along that or conflicting routes can be moved until the signal is put to stop and a suitable time period expires.
    - 6) No signal can be cleared over a locked route, a route conflicting with a locked route, a route with an occupied track circuit or a route with an unexpired time period.
    - 7) No subsequent call for a signal or switch movement over any part of a locked route can be stored so long as the route remains locked.
  - e. **WARNING:** The Contractor shall take every precaution to see that no vital interlocking circuit is compromised as a result of these tests. All temporary test jumpers, programs or devices of any kind shall be

removed at the conclusion of the testing and all wiring, programs and equipment shall be restored to their proper operating condition. The use of high visibility tagging on any such wire or device, or where any wire is removed, is mandatory.

18. Test 2.12 - Inductive Track Loop Tests(See also Section 16961, Audio Frequency Track and Loop Circuit Layouts)The Contractor shall test all Inductive Track Loops in accordance with a test procedure which he has prepared and which the Engineer has approved. The test shall be consistent with the following requirements:
- a. This test shall be made after all the loops, bridging receivers, shunt bars and impedance bonds at a given location are in place according to the plans, and the installation, insofar as the loops may be affected, is complete. It shall also be made at a time consistent with the Critical Path Testing Schedule, and after test 2.1 and all its prerequisite tests have been successfully completed.
  - b. The following items shall be checked and the Contractor shall determine that:
    - 1) The transmitter power level adjustments for all the loop and track transmitters at the location under test (made in the 2.1 test procedure) are still correct.
    - 2) For progressive placements of a shorted shunt strap, the track and loop currents of the route selected are present and within tolerance. (The Contractor shall describe in the test procedure the correct locations for shunt strap and current measurements for all track circuits and loops along every legitimate route.)
    - 3) When tests are made with shorted shunt straps, correct sequencing of the strap application and removal is observed.
    - 4) For any given strap placement, only the correct loops are active and the remainder are de-energized. The values of the measured current in both the energized (active) and the nominally de-energized track circuits shall be recorded on the test data sheet where the acceptable range of values is shown.
19. Test 2.13 - Interlocking Plant Tests(See also Section 16961, Audio Frequency Track and Loop Circuit Layouts)The Contractor shall test the interlocking plant equipment in accordance with a procedure which he has prepared and the designated Resident Engineer has approved. The procedure shall cover field testing and final operating tests. The test procedure shall be consistent with the following requirements:
- a. The field test shall be made after all the associated equipment at the location of the test is completely installed and in apparent working order. It shall be made at a time consistent with the Critical Path Testing Schedule and after tests 1.19, 2.10, 2.12, 2.24 and all their prerequisite tests have been successfully completed. Note that for certain locations where approach locking extends beyond the limits of the room under test, the portion of test procedure 2.15 dealing with these approach locking circuits shall also be considered a prerequisite.
  - b. The test procedures shall be designed to prove safe and proper operation of the interlockings. The test sequence shall be designed to test each function for correct performance in accordance with the Contract Specifications. Furthermore, the test sequence shall include simulated unusual conditions to determine that the interlocking circuits will respond to these in a safe and desirable way. The functions to be tested shall include, but not be limited to, the following:
    - 1) Signal indication locking
    - 2) Approach locking

- 3) Traffic locking
- 4) Route locking
- 5) Time locking
- 6) Switch indications
- 7) Signal indications
- 8) Locking indications
- 9) Occupancy indications
- 10) Route indications

c. The operational test shall be designed to offer PROOF that the system will perform as specified to provide fail-safe operation of trains. During this test, each and every possible route shall be tested to determine that, at the appropriate time in the interlocking operation sequence:

- 1) The route is effectively secured.
- 2) Control panel indicators are correct and present a true picture of locking, switch position, signal aspect and track occupancy conditions at the interlocking.
- 3) All switches are locked in position and cannot be moved electrically by any controls.
- 4) All conflicting signals are locked in their stop aspect and cannot be cleared by any controls.
- 5) The route is released correctly, and sectionally where required, by occupancy (followed by unoccupancy in some cases) of the specified track circuits, and no conflicting switch movement or signal clearing is possible until passage of the train.
- 6) "Preconditioning" can not be set up by any panel manipulation, train movement or combination thereof. "Preconditioning" shall be understood to be the storage of a control or panel manipulation which will cause the clearing of a route or movement of a switch at some later time as the result of a timer operation or train movement.
- 7) Time locking is operating properly and timers are set to correct times.
- 8) Coded speed commands are correct.
- 9) All coded speed commands from the interlocking are cut off in the event a train passes a stop aspect signal, and any cleared signal at that interlocking is put to stop.
- 10) That wayside pushbuttons and associated indications (at locations so equipped) work properly and conflicting or erroneous routes cannot be set up.
- 11) That Fleeting and Automatic Route Selection (at locations so equipped) operate safely and according to the Specifications.

20. Test 2.15 - Operating Test of Line Circuits between Successive Train Control Rooms. The Contractor shall make an operating test of the line circuits between all consecutive Train Control Rooms, and between Train Control Rooms for consecutive interlocking locations. This test shall be performed in accordance with a test procedure which he has prepared and which has been approved by the Engineer. The test shall be consistent with the following requirements:

- a. This test shall be made: after all equipment installations at the applicable consecutive interlockings have been completed; after test 2.13 and all its prerequisite tests have been successfully completed at both interlocking locations; after all preliminary tests have been successfully completed at all intermediate locations, and; in accordance with the Critical Path Testing Schedule.
- b. The following items shall be checked and the Contractor shall determine that, for the successive interlocking involved:

- 1) A route can be established on each track between successive interlocking locations, but for only one direction at a time, not both directions simultaneously.
  - 2) When a route is established on a track between two successive interlockings: the correct indications at both interlocking locations are energized; the correct relays, properly tagged, are energized; no conflicting route from either location can be established, and; no opposing signals can be cleared.
  - 3) Attempts to clear all opposing signals have no effect on a previously cleared signal.
  - 4) Route locking for each route releases in the manner specified after canceling a cleared signal or acceptance of the route.
  - 5) All track circuits between the interlockings are effective in their operation on the traffic circuitry.
  - 6) When intermediate locations exist on the track section between interlockings, the traffic circuitry is properly selected and affected by the track circuits at these locations.
  - 7) Loss-of-shunt timers (where required) are adjusted to correct time settings, and are operating properly.
  - 8) The control of "AR" relays has not been selected over traffic relay contacts which would cause unnecessary timer operations.
21. Test 2.24 - Testing 60 Hz, Single Rail, AC Track Circuits(See also Section 16963, Power Frequency Track Circuit Layouts).The Contractor shall test each 60 Hz Single Rail AC Track Circuit in accordance with a test procedure which he has prepared and which the designated Resident Engineer has approved. The test shall be consistent with the following requirements:
- a. This test shall be made after the installation is complete, after tests 1.1, 1.2, 1.14, 1.15 and 1.21 have been successfully completed, and in accordance with the Critical Path Testing Schedule.
  - b. The following items shall be checked and the Contractor shall determine that:
    - 1) The feed-end resistor has been adjusted to its correct value.
    - 2) The track voltage has been adjusted to the proper level according to the track circuit length.
    - 3) The relay-end resistor has been adjusted to its correct value.
    - 4) When a .06 ohm shunt is placed across the track, the corresponding relay drops.
    - 5) The relay drops whether the .06 ohm shunt is placed at feed end, relay end, or, in turnouts, across insulated joints.

PART 2 - NOT USED

PART 3 - NOT USED

**END OF SECTION**

## SECTION 16983

### ATC - TRAIN SEPARATION TESTS (LEVEL B)

#### PART 1 GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the criteria for the field tests and inspections which the Contractor shall develop and conduct in order to prove that the wayside ATC system is capable of providing safe automatic train operation within the areas controlled by TCRs included under this Contract.
- B. The basic functions which shall be tested include:
  - 1. Speed command logic
  - 2. Wayside/car detection, protection and speed commands
  - 3. Track shunting
  - 4. Block design control line verification
  - 5. Safe braking distances enforcement
  - 6. Programmed stop and platform edgelight control
- C. Level B acceptance shall, as a minimum, consist of the following train separation tests:
  - 1. Test 1.23 - Verification of Speed Command Logic
  - 2. Test 2.4 - Testing of Program Stop and Platform Edgelight Control
  - 3. Test 2.17 - Wayside/Car Interface Checkout (Level B)
  - 4. Test 2.20 - Wayside Train Detection and Protection Tests
  - 5. Test 2.21 - Safe Braking Distance Tests
- D. The Contractor shall provide sufficient test equipment to perform simultaneous testing on at least two trains for the time consuming test procedures: WTP 2.20 (Part I), WTP 2.21 and 2.18 (in Level C).
- E. The area covered by these tests shall be all tracks within the control limits of each TCR included under this Contract.

##### 1.02 RELATED SECTIONS:

- A. Related work specified elsewhere shall include, but not be limited to. The following Sections:
  - 1. Division 1 General Requirements
  - 2. (Article IX) Commencement, Prosecution and Completion of Work
  - 3. Section 16904 Current Automatic Train Control System
  - 4. Section 16928 Interlocking Vital Processor Systems
  - 5. Section 16940 ATC Electrical and Electronic Components and Materials
  - 6. Section 16960 Train Control Equipment Layouts
  - 7. Section 16981 Basic ATC Test and Inspection Requirements
  - 8. Section 16982 Preliminary and Interlocking Tests(Level A)
  - 9. Section 16984 ATO and Local ATS Tests (Level C)

##### 1.03 SUBMITTALS

- A. The Contractor shall, at least 60 calendar days prior to the scheduled performance of each test described herein, submit a detailed test procedure for that test:
  - 1. Test 1.23 - Verification of Speed Command LogicThe Contractor shall test the speed command logic circuits in accordance with a test procedure which he has prepared

and which has been approved by the designated Resident Engineer. The test shall be consistent with the following requirements:

- a. This test shall be made at a time consistent with the Critical Path Test Schedule and after Level A Preliminary Test 2.1, 2.24 (when applicable), 1.18 (when applicable) and all of their prerequisite tests have been successfully completed.
  - b. The following items shall be checked and the Contractor shall determine that:
    - 1) With test equipment (fixtures) set up, all possible routes exhibit the proper speed commands for all possible occupancies (or combinations of occupancies).
    - 2) Track frequencies and code rates correspond to the values shown on the Contract Drawings and the values are duly recorded on the test data sheets or checked off on the control line diagram in the Contract Drawings.
    - 3) Each of the above measured values is within tolerance as compared to maximum and minimum values given in the test procedure.
    - 4) The speed commands are affected properly as the temporary speed restriction plug couplers are manipulated to all of their positions for each module.
    - 5) The presence of the temporary speed restriction plug couplers in the ATP modules is properly expressed in the RTU unit and has been checked and duly recorded on the test documents.
    - 6) Relay contacts have been wired in accordance with WMATA relay contact assignment rules wherever such rules are applicable.
2. Test 2.4 - Testing of Program Stop and Edgelight Control .The Contractor shall test the Program Stop and Platform Edgelight Control logic and circuitry in accordance with a test procedure which he has prepared and which has been approved by the designated Resident Engineer. The test shall be consistent with the following requirements:
- a. This test shall be made at a time consistent with the Critical Path Test Schedule and after Tests 1.4 and 1.7, and all their prerequisite tests have been successfully completed.
  - b. The following items shall be checked and the Contractor shall determine that:
    - 1) Utilizing the proper test equipment connected to the RTU rack, the SKSS, NSKS, PTP, PTPS relays can be manually sequenced to verify these circuits.
    - 2) Utilizing the test fixture, the correct relays operate for the various train lengths.
    - 3) All wiring for the possible future control of stop location from the Kiosk operates correctly.
    - 4) The controls to the variable markers are operating correctly.
    - 5) The edgelight relays and circuitry extending to the interface point are operating correctly.
3. Test 2.17 - Wayside/Car Interface Checkout.The Contractor shall verify the proper operation of the Wayside/Car Interface with a dynamic train test which is in accordance with a test procedure which he has prepared and which has been approved by the designated Resident Engineer. Radio communication links between the train and wayside shall be operational for this test. The test shall verify the communication links and the operation of the ATP and TWC systems. The test shall be consistent with the following requirements:
- a. This test shall be made at a time consistent with the Critical Path Test Schedule and after Level B Tests 2.4 and 1.23, and all their prerequisite

tests have been successfully completed, but before Test 2.20 has been performed. The transit cars used in this test must constitute a Contractually "Valid" train with all carborne ATC systems operating properly.

- b. The following items shall be checked and the Contractor shall verify that:
  - 1) For every possible route, in both normal and reverse running directions, the speed command information is received aboard the train from every track circuit and loop with no dropouts.
  - 2) The TWC system is operating correctly and according to the requirements of these Specifications.
  - 3) For every possible route, in both normal and reverse running directions, valid communication occurs with respect to each applicable Flyby Receiver and Flyby Transmitter.
  - 4) As the above specified information is verified, the data sheets are properly filled out.
- 4. Test 2.20 - Wayside Train Detection and Protection Tests. The Contractor shall verify the performance of the equipment tested under the four parts of this test procedure. These four parts are; Part I - ATP Signal Level Test ; Part II - Post-Shunt and Pre-Shunt Tests; Part III - Control Line Verification Tests and Part IV - Signal Sighting, Slotting and Clearing Tests .The test of these four parts shall be consistent with the following requirements:
  - a. The test of each part shall be made at a time consistent with the Critical Path Test Schedule and after Tests 1.23 and 2.15, and all their prerequisite tests have been successfully completed. The transit cars used in this test must constitute a Contractually "Valid" train with all carborne ATC systems operating properly.
  - b. The following items shall be checked and the Contractor shall determine that for every track circuit in both directions:
    - 1) In Part I: (Utilizing one train)
      - a) The level of both carriers of the ATP signal received aboard the car is measured and recorded, and is within the maximum and minimum tolerance values shown on the data sheet
      - b) A recording of both carrier levels (where existent) is made for each ATP circuit.
    - 2) In Part II - (Utilizing one train)
      - a) The distance of the front wheels of the train from each track circuit boundary which the train is approaching at the time the track relay drops, has been measured and recorded on the data sheet under "pre-shunt" and that distance is within the specified tolerance zone of 20 to 40 feet. (50 to 70 feet when transmitter and receiver are in different TCRs.)
      - b) The distance of the rear wheels of the train from each track circuit boundary which the train is leaving at the time the track relay picks up, is measured and recorded on the test data sheet under "post-shunt," and that distance is within the specified tolerance zone of 20 to 40 feet. (50 to 70 feet when transmitter and receiver are in different TCRs.)
    - 3) In Part III: (Utilizing two trains) With train A stationary and "keyed up" facing train B, and with train B moving in the appropriate direction of traffic in approach to train A:
      - a) No speed commands are received by train A, as observed and noted based upon continuous observation of the display readout on train A.
      - b) Successive speed commands (for each track circuit occupied) are checked and noted based upon continuous



distance (determined from the block design), then removes power and brakes to a stop with a minimum of 10 feet remaining to the overrun bond at the end of the test section. (The test shall include a remaining distance allowance to accommodate 8 car trains if they require more stopping distance as determined by the block design.) If the train is unable to reach the desired test speed, three runs shall be made and the data sheet so marked.

- 2) The distance from the actual stopping point (front end of train) to the end of block (overrun bond) has been measured and recorded on the data sheet and is within limits.
- 3) The test has been conducted in the required direction for every target bond within the area under test.
- 4) The data sheet shows the maximum speed within the block, the stopping distance and time, and the distance to the overrun bond for every test.
- 5) The data sheet shows that each run complies with (or does not comply with) the block design for distance readings, overrun distance, speed and brake rate.

- B. The Contractor shall submit Safe Braking Distance (Test 2.21) data as per Drawing G-026, on 3-1/2 inch floppy disk in "EXCEL" format. The Contractor shall also submit a printed copy of the Test form as a pre-printed data sheet, for each route track segment to be tested.

**PART 2**  
NOT USED

**PART 3**  
NOT USED

**END OF SECTION**

## SECTION 16984

### ATC - ATO AND LOCAL ATS TESTS (LEVEL C)

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the criteria for the types of field tests which the Contractor shall develop and conduct in order to ensure that the wayside ATC system is performing the following functions properly over the area controlled from a given Train Control Room:
1. Programmed station stopping
  2. Train-to-wayside communications (TWC)
  3. Door, dwell and destination control
  4. Automatic route initiation (where applicable)
  5. Marker coil installation
  6. Station stopping distance data transmission
  7. Interlocking Control Panel operation (where applicable)
  8. NEXT TRAIN Sign energy control (where applicable)
- B. Level C acceptance shall, as a minimum, consist of the following ATO and local ATS tests: 1.7, 1.8, 1.9, 1.10, 1.24, 1.26, 2.2, 2.3, 2.7, 2.18, 2.19, 2.31, and 2.32, as applicable.

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
- |    |               |  |
|----|---------------|--|
| 1. | Division 1    | Contract Record Drawings                               |
| 2. | Section 16904 | Current Automatic Train Control System                 |
| 3. | Section 16918 | Special Requirements for Specific Locations            |
| 4. | Section 16924 | Non-Vital ATO & ATS Processor Systems                  |
| 5. | Section 16940 | ATC Electrical and Electronic Components and Materials |
| 6. | Section 16960 | Train Control Equipment Layouts                        |
| 7. | Section 16981 | Basic ATC Test and Inspection Requirements             |
| 8. | Section 16982 | Preliminary and Interlocking Tests (Level A)           |

##### 1.03 SUBMITTALS

- A. The Contractor shall, at least 60 days prior to the scheduled performance of each test described herein, submit a detailed test procedure for that test:
1. Test 1.7 - TWC Receiver Test  
The Contractor shall perform a test to verify the correct operation of all TWC Station and Dispatch receivers in accordance with a test procedure which he has prepared and which has been approved by the designated Resident Engineer. The test shall be consistent with the following requirements:
    - a. The test shall be made at a time consistent with the Critical Path Test Schedule and after Tests 1.1, 1.2, 1.3, 1.14 and 1.15 have been successfully completed.
    - b. The following items shall be checked and the Contractor shall determine that:
      - 1) With the receiver properly connected to a test fixture, all receiver adjustments have been properly made, are correct and have been recorded on the data sheet.
      - 2) The connections to the RTU are correct and that the information flow through them corresponds to the makeup of the pulse train.

2. Test 1.8 - TWC Transmitter Test  
The Contractor shall perform a test to verify the correct operation of all TWC transmitters in accordance with a test procedure which he has prepared and which has been approved by the designated Resident Engineer. The test shall be consistent with the following requirements:
  - a. The test shall be made at a time consistent with the Critical Path Test Schedule and after Tests 1.1, 1.2, 1.3, 1.14 and 1.15 have been successfully completed. The following items shall be checked and the Contractor shall determine that:
    - 1) With the transmitter properly connected to a test fixture, all transmitter adjustments have been properly made, are correct and have been recorded on the data sheet.
    - 2) The connections to the RTU are correct and that the information flow through them corresponds to the makeup of the pulse train.
3. Test 1.9 - TWC Flyby Receiver Test  
The Contractor shall test all Flyby Receiver equipment, circuitry and logic in accordance with a test procedure which he has prepared and which has been approved by the designated Resident Engineer. The test shall be consistent with the following requirements:
  - a. The test shall be made at a time consistent with the Critical Path Test Schedule and after Tests 1.1, 1.2, 1.3, 1.14 and 1.15 have been successfully completed.
  - b. The following items shall be checked and the Contractor shall determine that:
    - 1) With the receiver properly connected to a suitable test fixture, all input and/or output frequency and amplitude adjustments for Carrier, Mark and Space have been properly made, are correct and have been recorded on the data sheet. (Maximum and minimum values, approved by the designated Resident Engineer, shall also appear on the data sheet.)
    - 2) The Flyby Receiver has a valid message with correct parity as specified in Section 16924, Non-Vital ATO & ATS Processor Systems.
    - 3) Bit control connections are properly made and function as specified elsewhere in these Specifications.
4. Test 1.10 - TWC Flyby Transmitter Test  
The Contractor shall test all Flyby Transmitter equipment, circuitry and logic in accordance with a test procedure which he has prepared and which has been approved by the designated Resident Engineer. The test shall be consistent with the following requirements:
  - a. This test shall be made at a time consistent with the Critical Path Test Schedule and after Tests 1.1, 1.2, 1.3, 1.14 and 1.15 have been successfully completed.
  - b. The following items shall be checked and the Contractor shall determine that:
    - 1) With the transmitter properly connected to a suitable test fixture, all input and/or output frequency and amplitude adjustments for Carrier, Mark and Space have been properly made, are correct and have been recorded on the data sheet. (Maximum and minimum values, approved by the designated Resident Engineer, shall also appear on the data sheet.)
    - 2) The Flyby Transmitter has a valid message with correct parity as specified in another section of these Specifications.
    - 3) Bit control connections are properly made and function as specified elsewhere in these Specifications.
5. Test 1.24 - Route Decoder Test (where applicable)  
The Contractor shall test all Route Decoder equipment, circuitry and logic in accordance with a test procedure which he has prepared and which has been approved by the designated Resident Engineer. The test shall be consistent with the following requirements:

- a. This test shall be made at a time consistent with the Critical Path Test Schedule and after Test 1.9 and all its prerequisite tests have been successfully completed.
  - b. The following items shall be checked and the Contractor shall determine that:
    - 1) All programming jumpers and printed circuit boards are installed in the correct position for the location in which the unit is installed.
    - 2) With a suitable test fixture in place, the unit properly decodes the train destination when presented with applicable train identity information per the plans for that location.
    - 3) The various associated track repeater relays initiate the results indicated in these Specifications.
    - 4) An incorrect train identity decodes only as an "unidentified route."
    - 5) All connections to the flyby equipment are installed and in working order.
6. Test 1.26 - Destination Storage Register Test (where applicable).The Contractor shall test all destination storage register equipment, circuitry and logic in accordance with a test procedure which he has prepared and which has been approved by the designated Resident Engineer. The test shall be consistent with the following requirements:
- a. This test shall be made at a time consistent with the Critical Path Test Schedule and after Tests 1.1, 1.2, 1.3, 1.14 and 1.15 have been successfully completed.
  - b. The following items shall be checked and the Contractor shall determine that:
    - 1) All printed circuit boards are installed in the correct positions.
    - 2) With a suitable test fixture in place, the unit properly responds when presented with applicable storage information derived from manipulation of the test fixture.
    - 3) The unit responds properly to applicable controls from the local control panel.
7. Test 2.2 - Door and Dwell Control Subsystem TestThe Contractor shall test the Door and Dwell Control subsystem in accordance with a test procedure which he has prepared and which has been approved by the designated Resident Engineer. The test shall be consistent with the following requirements:
- a. This test shall be made at a time consistent with the Critical Path Test Schedule and after Tests 1.4, 1.7, 2.1 and all their prerequisite tests have been successfully completed.
  - b. The following items shall be checked and the Contractor shall determine that:
    - 1) With TWC receiver test fixture connected, the "train berthed" relays operate according to specification when the "train berthed" signal is turned on and off at the test fixture.
    - 2) The dwell timers operate correctly and within  $\pm$  one second of their assigned times.
    - 3) Code rate and train frequency are correct and platform speed command relays operate properly during all applicable dwell-timer time out periods.
    - 4) The door control equipment responds properly to manual control from Central as tested utilizing the local RTU and its portable analyzer.
8. Test 2.3 - Destination Decoder Subsystem Test.The Contractor shall test all destination decoder modules in accordance with a test procedure which he has prepared and which has been approved by the designated Resident Engineer. The test shall be consistent with the following requirements:

- a. This test shall be made at a time consistent with the Critical Path Test Schedule and after Tests 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10 and all their prerequisite tests have been successfully completed.
  - b. The following items shall be checked and the Contractor shall determine that:
    - 1) With a suitable test fixture in place, verify that valid destination codes for the location under test are received by the decoder when simulated codes are transmitted by the test unit and when track occupancy and train berthed signals are simulated.
    - 2) With a suitable test fixture in place, verify that valid destination codes for the location under test are received by the decoder via the RTU when the signals from central are simulated by the test fixture.
9. Test 2.7 - Station Stopping Distance Markers - Installation Checkout. The Contractor shall test the Station Stopping Distance Markers in accordance with a test procedure which he has prepared and which the designated Resident Engineer has approved. The test shall be consistent with the following requirements:
- a. The test shall be made at a time consistent with the Critical Path Test Schedule and after Test 1.14 and Test 2.4 and all their prerequisite tests have been successfully completed.
  - b. The following items shall be checked and the Contractor shall determine that:
    - 1) The fixed frequency units are properly tuned to provide frequencies to the trains which are within the specified tolerance ranges.
    - 2) The variable frequency tuning units are properly tuned to provide frequencies to the trains which are within the specified tolerance ranges, and which are properly controlled by the frequency selector circuit in the TCR.
    - 3) All marker coils on both tracks of the location under test have been checked.
10. Test 2.18 - Marker Coil Validation Test. The Contractor shall verify the performance of the Station Stopping Distance Markers in accordance with a test procedure which he has prepared and which the designated Resident Engineer has approved. Proper implementation of the approved procedure shall fully test the dynamic wayside-to-car interface and be consistent with the following requirements:
- a. The test shall be made at a time consistent with the Critical Path Test Schedule and after Test 2.7 and all its prerequisite tests have been successfully completed.
  - b. The test shall measure the carborne marker receiver coil output produced as the receiver aboard the moving train passes over the track-mounted marker layout, utilizing a test fixture (Marker Coil Validation Test Fixture) consisting of a digital computer and the necessary signal acquisition equipment.
  - c. The test shall measure, and compare to a standard, the following aspects of the received signal:
    - 1) Duration of received signal-This is the time in milliseconds during which the received signal is above an adjustable, preselected signal threshold which is nominally 10 percent higher than the background noise signal.
    - 2) Frequency of received signal-This is the frequency of the waveform received from the marker coil during the time that the amplitude is higher than the signal threshold described in the previous paragraph.
    - 3) Frequency classification of the received signal.-This is the nominal marker coil classification of the received marker signal as perceived by either the normal train carried equipment or by test equipment

- based on the identical circuitry. (Frequencies 1 through 4 and 6 through 9 as defined in Section 16967, Marker Coil Layouts.)
- 4) Amplitude of the received signal-This is the maximum amplitude observed as the train crosses the marker coil. In correctly operating markers, this signal should be well above the signal threshold mentioned in the preceding paragraphs.
- d. The information derived from the received signal shall be recorded by the test equipment on a paper printout. In addition to recording the values of the four received signal characteristics, the test equipment shall also record for every marker, the following:
- 1) Speed of train-This is the speed of the train in miles per hour at the instant it passes over the marker. This speed shall be derived from the signal of the wheel tachometer.
  - 2) The distance to the marker-This is the distance in feet which the train has traveled from its starting point. This distance shall be derived from the wheel tachometer.
  - 3) The distance from the previous marker-This is the difference in feet obtained by subtracting from the value of the current marker distance, the value of the preceding marker distance. This is useful in obtaining correspondence between the test data and the track plans in case of a missed marker.
  - 4) The observed frequency-This is the resonant frequency of the marker coil which was observed aboard the train.
  - 5) The observed frequency error-This is the error expressed in percent between the observed frequency and the nominal center frequency of the marker coil which was classified by the train or test equipment. Negative errors shall be indicated with a minus sign. This frequency of the marker coil will be acceptable if it is within 2 kilohertz of the nominal center frequency and readings in excess of this limit shall be flagged on the printout.
- e. In order to make the test data complete and unambiguous, certain additional data shall be recorded on the printout by entering it into the computer before the start of the run. This data is:
- 1) Date of test
  - 2) Time of test
  - 3) Name of nearest TCR
  - 4) Train number
  - 5) Track number
  - 6) Train direction
  - 7) Chaining of start location
  - 8) Number of markers anticipated
  - 9) Run number
  - 10) Value of the signal threshold level.
- f. Date which shall appear on the printout as a result of the data recorded during the run shall be:
- 1) Number of signals received from the pick-up coil which were classified as markers.
  - 2) Chaining of the stop location (obtained by adding or subtracting the total distance traveled to or from the chaining of the start location).
- g. The test shall consist of a minimum of two successful runs in each direction on each track, wherein every marker coil is received and classified properly. Where an interlocking is located in the test section, two additional short runs shall be made in each direction over each crossover or other interlocked track, to test any markers located therein. These crossover runs shall then be repeated after the train has been turned end-for-end. One of the two runs shall be made at a maximum speed of 15 miles per hour and the other

at the maximum control-line speeds (in automatic operation). The readings for every marker shall be within the standard limits listed in the test procedure prepared by the Contractor and approved by the Engineer. All markers shall be successfully recorded. No extraneous "markers" shall be recorded. Discrepancy sheets shall be filled out for any variation from these standards.

- h. The Contractor shall connect the test equipment with properly grounded twisted-pair, shielded cable, organized without ground loops so as to minimize noise pickup from the car-carried equipment and the propulsion power.
  - i. The Contractor shall evaluate the data printouts at the end of each run and, as proof that the requirements for marker coils, delineated in these Specifications, have been met, submit to the designated Resident Engineer evidence of successful marker validations signed by his representative and the designated Resident Engineer's inspector.
11. Test 2.19 - Station Control Tests The Contractor shall test all station control equipment, circuitry and logic in accordance with a test procedure which he has prepared and which has been approved by the designated Resident Engineer. The transit cars used in this test must constitute a contractually "valid" train, with all carborne ATC systems operating properly. The test shall be consistent with the following requirements:
- a. This test shall be made at a time consistent with the Critical Path Test Schedule and after Tests 1.23, 2.2, 2.3, and 2.18 and all their prerequisite tests have been successfully completed.
  - b. The following items shall be checked and the Contractor shall determine that:
    - 1) With the train stationary at the station, and with suitable test equipment (CAU) connected to the RTU, the proper information (bits-carrier) is received for each of the following functions when the train key is in the OFF as well as the ON positions:
      - a) Train Destination
      - b) Train Number
      - c) Manual Pushbutton Right
      - d) Manual Pushbutton Left
      - e) Doors Closed Right
      - f) Doors Closed Left
      - g) PSS Active
      - h) ATP in Effect
      - i) Train in ATO
      - j) Passenger Station Check
      - k) Train Ready
      - l) All Doors Closed
      - m) Train Berthed
      - n) Train Motion
      - o) Train Length
    - 2) With the train standing in the station, and the various functions simulated aboard the train (pushing buttons or relays) that the RTU receives the proper information for the following functions:
      - a) traction power status
      - b) train length description
      - c) "door mode" selector
      - d) "train ready" (ATO start pushbutton)
      - e) "train berthed" pushbutton
    - 3) With the train standing in the station, and entering codes on the CAU, that the following train equipment is operable:
      - a) dwell termination

- b) "limiting speed" display
  - c) door and dwell operation
  - d) destination sign
  - e) train identification display
  - f) door close warning
- 4) With the train positioned outside the first station marker (2700-ft. or 1200-ft.) and the controls properly set, the "Limiting Speed" display indicates the maximum authorized speed for that block. Where an interlocking is involved, more than one speed may have to be checked.
  - 5) With train positioned as in 4), the "ATO Start" button is capable of causing the train to move to a correct stop in the station, indicators operate properly, and the doors open.
  - 6) Test made in 5) operates for all station stopping points (short, center and long stop) in both directions.
  - 7) Skip Stop feature operates in both directions.
  - 8) Tests described in 4), 5), 6), & 7) shall be performed with both two-car and eight-car trains.
  - 9) At locations equipped for automatic route selection, the operation of the following items is as specified:
    - a) The proper route is cleared for the destination code transmitted by the train.
    - b) All valid routes can be cleared.
  - 10) At locations equipped with TWC flyby transmitters, the operation is as specified.
  - 11) At locations equipped with dispatch receivers, the operation is as specified.
12. Test 2.31 - Interlocking Control Panel Operation - Local Train Control Room and/or Dispatcher's Room  
The Contractor shall test the complete operation of every control and indication device on the I.C.P. in accordance with a test procedure which he has prepared and which the designated Resident Engineer has approved. The test shall be consistent with the following requirements:
- a. The test shall be made at a time consistent with the Critical Path Test Schedule and after all applicable track circuits, signal layouts, traffic circuits, switch-and-lock movement layouts, interlocking circuits, and, where applicable, snowmelter layouts, terminal mode selection circuits, and/or automatic routing circuits, have been installed and connected.
  - b. The following items shall be checked:
    - 1) Master Lever Key Switch(es)
    - 2) PANEL LIGHTS pushbutton(s)
    - 3) INDICATION TEST pushbutton (and illumination of all panel indicators)
    - 4) SWITCH POSITION pushbutton(s) and appropriate indicators
    - 5) AUXILIARY SWITCH OPERATION pushbuttons and indicators
    - 6) Route Entrance, Exit, and Turnback Signal Pushbuttons and associated indicators
    - 7) Track Indicators (all route locking and track occupancy)
    - 8) All traffic and switch lock indicators
    - 9) AUTO SIGNAL OPERATION pushbuttons and indicators
    - 10) All control transfer pushbuttons and indicators
    - 11) EMERGENCY RELEASE pushbutton(s)
    - 12) SNOWMELTER control pushbuttons and indicators
    - 13) Terminal MODE SELECTION pushbuttons and indicators
    - 14) NEXT TRAIN Sign rotary switch and indicators
13. Test 2.32 - NEXT TRAIN Sign Energy Control Test (where applicable).  
The Contractor shall test the operation of the control circuitry and relays provided by the

Contractor to control illuminating energy (furnished by others) for NEXT TRAIN signs (furnished by others) at Terminal Stations, in accordance with a test procedure which he has prepared and which the designated Resident Engineer has approved. The test shall be consistent with the following requirements:

- a. This test shall be made at a time consistent with the Critical Path Test Schedule and after Tests 1.23, 2.2, 2.3, 2.18, and 2.19 and all their prerequisite tests have been successfully completed.
- b. The following items shall be checked and the Contractor shall determine that:
  - 1) With the NEXT TRAIN sign control set for TRACK 1 (Manual Override), the appropriate sign control relay in the AC Service Room is energized, and the other sign control relay is deenergized.
  - 2) With the NEXT TRAIN sign control set for TRACK 2 (Manual Override), the appropriate sign control relay in the AC Service Room is energized, and the other sign control relay is deenergized.
  - 3) With the NEXT TRAIN sign control set for the Automatic Mode, the two sign energy control relays in the AC Service Room function in the specified manner, i.e., they close their respective contacts to reflect a "First-In, First-Out" sequence of Next Trains, regardless of which platform tracks become occupied from either end.

**PART 2**  
NOT USED

**PART 3**  
NOT USED

**END OF SECTION**

## SECTION 16985

### ATC - DTS INTERFACE TESTS (LEVEL D)

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the criteria for the types of tests which the Contractor shall develop and conduct in order to ensure that the Data Transmission System (DTS) provided under this Contract is functioning properly.
- B. The basic functions which shall be tested include:
  - 1. The internal functioning of the Remote Terminal Units (RTUs)
  - 2. The interface between the RTUs and wayside ATC and ancillary equipment
  - 3. The interface between Central Control and wayside ATC and ancillary equipment via the RTU and the DTS.

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16904 Current Automatic Train Control System
  - 2. Section 16925 Data Transmission System (DTS)
  - 3. Section 16981 Basic ATC Test and Inspection Requirements
  - 4. Section 16982 Preliminary and Interlocking Tests (Level A)

##### 1.03 SUBMITTALS

- A. The Contractor shall, at least 60 calendar days prior to the scheduled performance of each test described herein, submit a detailed test procedure for that test:
  - 1. Test 1.4 - RTU Local Test. The Contractor shall verify the proper operation of the DTS Interface in accordance with a test procedure which he has prepared and which has been approved by the designated Resident Engineer. The test shall be consistent with the following requirements:
    - a. This test shall be made at a time consistent with the Critical Path Test Schedule and after Tests 1.1, 1.2 and 1.3 have been successfully completed. With a Contractor-supplied analyzer connected to the unit, the Contractor shall determine that:
      - 1) The input pulse train, when constructed according to the approved scan sheet, results in an output at the correct output connection where application relays are connected, or will be connected.
      - 2) The RTU rejects all incorrect addresses and responds to the address of the location where it is installed.
      - 3) All tests specified by the manufacturer of the unit have been successfully completed.
  - 2. Test 2.14 - RTU to Wayside Interface. The Contractor shall test the RTU to wayside interface connections in accordance with a test procedure which he has prepared and which has been approved by the designated Resident Engineer. The test shall be consistent with the following requirements:
    - a. This test shall be made at a time consistent with the Critical Path Test Schedule and after Tests 1.4 and 1.22, and all of their prerequisite tests have been successfully completed.
    - b. The following items shall be checked and the Contractor shall determine that:

- c. All connections between the RTU and its controlled or monitored device connection have been made and are in working order. The test shall be made as follows:
  - 1) When contact closures are simulated at the terminals in each DTS and TC/COMM interface cabinet, the proper indication is received at the CAU and agrees with the approved bit assignment.
  - 2) When each control is transmitted from Central, the proper control voltage can be measured on the proper terminal in the proper DTS or TC/COMM interface cabinet, and is not measurable on the two adjacent terminals. This shall be in accordance with the approved bit assignment.
  - 3) All spare bits (commands or status) are operable at the terminal terminating their connections.
  - 4) Where used, all 4 to 20 milliamp current loop inputs shall be tested for proper operation of the multiplex input, digital conversion accuracy, and appropriate frame/word assignment.
- 3. Test 6.0 - Central to Wayside Interface. The Contractor shall test the Control to Wayside Interface in accordance with a test procedure which he has prepared and which has been approved by the designated Resident Engineer. Wherever possible, wayside equipment shall be used to verify RTU commands. If it is impossible to use the wayside equipment, a simulator shall be connected to the most distant point in the circuit from the RTU in the TCR. The local Interlocking Control Panel (at TCRs so equipped) shall not be used for obtaining data unless that panel is the most distant point on the circuit from the RTU. The test shall be consistent with the following requirements:
  - a. This test shall be made separately at each TCR at a time consistent with the Critical Path Test Schedule, and;
    - 1) after all A, B and C Level tests (except train tests), and D Level Tests 1.4 and 2.14 have been successfully completed,
    - 2) after the Authority has made the necessary changes at central control to accept the new line locations,
    - 3) after the RTU has been on line with central continuously for at least one week, and,
    - 4) after the modem supplied with the RTU system has been tested.
  - b. The following items shall be checked and the Contractor shall determine that:
    - 1) Utilizing suitable test fixtures and temporary expedients (such as deenergizing relays by hand) every control (listed in the "Control Data Sheet" or required by these Specifications) from the Central Console, results in the appropriate operation at the wayside or on the train (simulated).
    - 2) As in (1), every operation of the train and wayside equipment (listed on the "Status Data Sheet" or required by these Specifications) results in the appropriate indication at the Central Console.
    - 3) Proper "Strobe Pulse" operation is verified.
    - 4) Proper "Read Status Signal" operation is verified.

**PART 2**  
NOT USED

**PART 3**  
NOT USED

**END OF SECTION**

## SECTION 16986

### ATC - MISCELLANEOUS TESTS (LEVEL E)

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the criteria for the field tests and inspections which the Contractor shall develop and conduct in order to prove that the devices listed in this category are capable of safe and proper operation as required by these Specifications.
- B. The basic functions and devices which shall be tested include:
  - 1. Fuse Sizing, Circuit Breaker Sizing, Load Sharing and Load Transfer Sensing and Timing
  - 2. Ground Detectors
  - 3. Snowmelter Layouts (Where Applicable)
  - 4. Wayside Coding System (Where Applicable)
- C. The facilities covered by these tests shall be all of the special ATC equipment, systems and configurations within the control limits of each TCR included under this Contract which are not covered by other Levels of ATC testing specified in this Contract.

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Division 1 General Requirements
  - 2. (Article IX) Commencement, Prosecution, and Completion of Work
  - 3. Section 16904 Current Automatic Train Control System
  - 4. Section 16918 Special ATC Requirements for Specific Locations
  - 5. Section 16921 ATC Power Distribution Systems
  - 6. Section 16941 Basic ATC Electrical and Electronic Component Requirements
  - 7. Section 16947 Ground Detectors
  - 8. Section 16951 Transfer and Bypass Equipment
  - 9. Section 16969 Snowmelter Layouts
  - 10. Section 16981 Basic ATC Test and Inspection Requirements
  - 11. Section 16982 Preliminary & Interlocking Tests (Level A)
  - 12. Section 16983 Train Separation Tests (Level B)
  - 13. Section 16985 DTS Interface Tests (Level D)

##### 1.03 SUBMITTALS

- A. The Contractor shall, at least 60 calendar days prior to the scheduled performance of each of the following tests, submit a detailed test procedure for that test:
  - 1. Test 2.28 - Fuse Size and Load Sharing
  - 2. Test 2.29 - Ground Detector Functional Tests
  - 3. Test 1.20 - Snowmelter Layouts and Controls
  - 4. Test 2.25 - Snowmelter Control Units
  - 5. Test 2.6 - Wayside Coding System (Where Applicable)
- B. These test procedures shall prescribe tests which meet the following criteria:
  - 1. Test 2.28 - Fuse Size, Circuit Breaker Size, Load Sharing, and Automatic Transfer Switch This test shall be conducted to determine whether fuses and circuit breakers are properly sized with respect to measured maximum load (as

specified in Sections 16911, Scope of ATC Work, and 16941, Basic Electrical and Electronic Components), to determine whether TCR power supplies are sharing the electrical load equally (as specified in Section 16911); to determine whether the total AC power load is within the capability of the services, and; to determine whether the Automatic Transfer Switch is functioning properly (as specified in Section 16951). The test shall be conducted in accordance with a test procedure previously prepared by the Contractor and approved by the designated Resident Engineer. The test shall be consistent with the following requirements:

- a. The test shall be conducted after all ATC power-consuming equipment has been installed in the TCR and its area of control; after all Level A, B, C and D tests have been successfully completed, and; at a time consistent with the Critical Path Testing Schedule.
- b. Any fuse wire used temporarily shall be removed and replaced with appropriately sized fuses at this time. The nominal as well as temperature derated ratings of all power distribution fuses shall be recorded.
- c. The Contractor shall simulate train occupancy, train movements and, where applicable, set routes and operate such other equipment as required to cause maximum operating load to be drawn from the fuses, circuit breakers and power supplies being examined for proper sizing and load sharing. These maximum operating current values and the total bus load current(s) shall be recorded on pen recorders and the peak values shall be transferred to the test data sheets along with columns for the ratings of the applicable fuses, derated for an operating temperature of 120 degrees F. The derated value must be at least 125 percent of the measured maximum load. A load equal to 125 percent of the measured maximum load on the power supplies shall be within their rating, as required in Section 16921.1.03.
- d. In a similar manner, the load on the two AC power services shall be measured and the results shall be recorded on a data sheet and forwarded to the designated Resident Engineer. This test shall be made twice; once with the "normal" service disconnected and once with the "reserve" service disconnected.
- e. For buses which are normally fed by both NORMAL service power supplies and RESERVE service power supplies, load sharing shall be tested under three conditions as follows:
  - 1) With the bus fed from the NORMAL service power supplies only,
  - 2) With the bus fed from the RESERVE service power supplies only,
  - 3) With the bus fed in the usual manner from both the NORMAL and the RESERVE power supplies.
- f. The Contractor shall measure the load current and check that the fuses and breakers installed are of the proper size, relative to the maximum current measured.
- g. The Contractor shall calculate the expected load current and check that each applicable power supply module is contributing to the total bus load equally within the prescribed tolerances.
- h. The Contractor shall temporarily install any additional control and monitoring equipment on the Normal and Reserve power sources, and on the Transfer Panel, necessary to determine whether the Transfer and Bypass equipment is:
  - 1) Sensing low voltage in each source properly;
  - 2) Sensing return to acceptable voltage levels in each source properly;

- 3) Transferring the load properly (in each direction) without causing vital relays to drop or causing loss or malfunction of the ATC system in any other way.
2. Test 2.29 - Ground Detector Functional Tests This test shall be conducted to determine whether the ground detectors remain functional after the completion of all the tests specified in Levels A, B, C, and D. The test shall be conducted in accordance with a test procedure prepared by the Contractor and approved by the designated Resident Engineer. The cause of any abnormal response shall be determined, documented, and repaired by the Contractor, and the affected function retested as specified in Section 16981. The test shall be consistent with the following requirements:
    - a. The test shall be conducted after all ATC equipment has been installed in the TCR and its area of control; after all Level A, B, C, and D tests have been successfully completed, and; at a time consistent with the Critical Path Testing Schedule.
    - b. The Contractor has ascertained, during the Level A, B, C, and D testing, that any ground, either intermittent or continuous, which may have appeared on any of the ungrounded energy buses being monitored by the ground detectors, has been cleared. Any ground still remaining shall be cleared at this time.
    - c. The three-position manual test switch shall be operated to each of its test positions and the indicators shall be monitored to ensure that the ground detector response is correct when each of the momentary leakage paths from ground to the buses being tested has been made.
    - d. After each operation of the three-position test switch, the reset button shall be operated to check that the manual reset functions and that the indicators display the proper response.
  3. Test 1.20 - Snowmelter Layouts and Controls - Checkout This test shall verify that the Snowmelter Layouts and their Controls and Indications are wired and operate properly. The test shall be made with no electrical connection to the third rail and shall be consistent with the following requirements:
    - a. The test shall be made at a time consistent with the Critical Path Testing Schedule and after tests 1.1, 1.2, 1.3, and 1.14 have been successfully completed.
    - b. The following items shall be checked and the Contractor shall determine that:
      - 1) With all the fuses removed, verification is made of the fact that all Snowmelter Layout wiring is installed and terminated properly.
      - 2) Continuity is made through contacts to fuse receptacles of snowmelter loads.
      - 3) Contactor coil circuits are wired and operate correctly.
      - 4) Door interlock circuits are wired and operate correctly.
      - 5) Control pushbuttons and indications in the TCR are wired and operate properly.
      - 6) When this test has been completed, the Contractor shall check to be sure that there are no tools, test jumpers or foreign materials of any kind in the Snowmelter Control case, and that the high voltage (propulsion power voltage) cables are obviously physically separated from all other case wiring.
  4. Test 2.25 - Snowmelter Control Units - High Voltage This test shall verify that the Snowmelter Control Units operate properly. The test shall be made under strict supervision as third rail propulsion voltages are involved. The test shall be consistent with the following requirements:

- a. The test shall be made at a time consistent with the Critical Path Testing Schedule and after Tests 1.20, 6.0 and all of their prerequisite tests have been successfully completed.
- b. The following items shall be checked and the Contractor shall determine that:
  - 1) With all the fuses removed, verification has been made of the fact that all Snowmelter Layout wiring has been terminated properly.
  - 2) With the applicable Interlocking Control Panel in the local control mode, power applied to the snowmelter control circuit, and the contactor fuses in the Snowmelter Control Unit in place, the Snowmelter Contactor(s) (both) pick up when the "SNOWMELTERS ON" pushbutton is pushed, and drop when the "SNOWMELTERS OFF" button is pushed.
  - 3) With the Snowmelter Control Contactor(s) de-energized, the fuses for all the individual snowmelter heater elements and switch rod heater units in place, the third rail power on, and the 1000 volt fuse in the contact rail fuse box in place, none of the snowmelter heater elements or switch rod heater units is energized.
  - 4) With a SNOWMELTERS ON command in effect (SMZ and SMZP up) and the Snowmelter Contactor(s) energized, the following items are correct:
    - a) Each snowmelter heating element and switch rod heater unit is energized from the proper fuse and is drawing a proper amount of current, as indicated by the energization of its current-sensing (K) relay.
    - b) Each Snowmelter Indication Relay (SMK) is energized and indicating the proper heating elements.
    - c) The "SNOWMELTERS ON" indication light on the Local Manual Control Panel in the Train Control Room is on and remains on only when all of the snowmelters at the interlocking are actually energized. (SMYPK energized). Under these conditions, a SNOWMELTER ON indication shall be transmitted to Central.
    - d) When one or more of the individual series current sensing relays (K1, K2, K3, K4) is down, its associated SMK relay shall drop, causing its associated Snowmelter Failure (SMF) indicator on the I.C.P. to illuminate, and the SNOWMELTER ON indicator to flash. This situation shall also cause the "SNOWMELTER PROBLEM" indication to be transmitted to Central.
  - 5) With the Snowmelter Control Contactor(s) deenergized in combination with a SNOWMELTERS OFF command, the following items are correct:
    - a) All snowmelter heating elements and switch rod heater units are deenergized.
    - b) The "SNOWMELTERS ON" indication light on the local Interlocking Control Panel is extinguished.
  - 6) With control remaining in the Local control mode, the following items are correct:
    - a) Central Control cannot turn the snowmelters on or off. Central Control receives the correct indication of the snowmelters being on or off.
  - 7) With control in the Central Control mode, the following items are correct:

- a) Central Control can turn the snowmelters on and off.
  - b) The snowmelters cannot be turned on or off from the local Interlocking Control Panel.
  - c) The correct indication for the snowmelters is received by both Central Control and the local Interlocking Control Panel.
  - d) Interruption of the DTS communication causes no change in the status of the snowmelters.
- 8) With the snowmelter control relay (SMZ) up and the snowmelter indication relay (SMK) down, the "SNOWMELTERS ON" light on the Interlocking Control Panel displays a flashing red indication.
  - 9) With the fuse for the case heaters in the Snowmelter Control Housing in place, the case heaters and their controlling breaker-switch work properly.
5. Test 2.6 - Wayside Coding System Test (Fiber Optic Interface System Test) This test shall be conducted (where applicable) to determine whether the Fiber Optic Interface System (FOIS) modems and their interconnecting fiber optic cable and local interfacing wiring are functioning properly. The test shall be conducted in accordance with a test procedure prepared by the Contractor and approved by the designated Resident Engineer. The Contractor shall pattern this test procedure according to the requirements of Section 16981. The test shall be consistent with the following requirements:
- a. The test shall be conducted at a time consistent with the Critical Path Testing Schedule, and after the required equipment and wiring have been completely installed in the applicable Train Control Rooms.
  - b. The test shall determine whether all energy levels, frequencies and timing functions in the FOIS modems are correct and performing properly.
  - c. The test shall determine whether the messages generated by the FOIS modems are properly formatted and accurately represent the input information.
  - d. The test shall determine whether the external information presented to the FOIS modems is properly translated into appropriate internal messages of the type and format specified.
  - e. The test shall determine whether the internal FSK messages are properly interpreted and transferred by the FOIS interfacing logic and cable.
  - f. The test shall determine whether the FOIS modem LED maintenance indications are functioning properly.

**PART 2**  
NOT USED

**PART 3**  
NOT USED

**END OF SECTION**

## SECTION 16987

### ATC - SYSTEM LEVEL TESTS (LEVEL F)

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the criteria for the types of tests which the Contractor shall develop and perform in order to ensure that the entire ATC system furnished under this Contract is functioning properly, and can be controlled from Central by both the operator and the computer as required in these Specifications.
- B. The basic functions to be tested shall include, but not be limited to:
  - 1. Interlocking Functions
  - 2. Passenger Station Functions
  - 3. TWC Functions
  - 4. Central Display Equipment Functions
  - 5. Central Computer Operation Functions
  - 6. DTS Functions
  - 7. Miscellaneous Functions

##### 1.02 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Section 16904 Current Automatic Train Control System
  - 2. Section 16912 ATC Submittal Requirements
  - 3. Section 16913 ATC Block Design
  - 4. Section 16917 Basic Interlocking Requirements
  - 5. Section 16918 Special ATC Requirements for Specific Locations
  - 6. Section 16924 Non-Vital ATO & ATS Processor Systems
  - 7. Section 16925 Data Transmission System (DTS)
  - 8. Section 16926 Microprocessor Systems for Non-Vital Interlocking Functions
  - 9. Section 16928 Interlocking Vital Processor Systems
  - 10. Section 16956 Interlocking Control Panels
  - 11. Section 16969 Snowmelter Layouts
  - 12. Section 16981 Basic ATC Test and Inspection Requirements
  - 13. Section 16982 Preliminary and Interlocking Tests (Level A)
  - 14. Section 16983 Train Separation Tests (Level B)
  - 15. Section 16984 ATO and Local ATS Tests (Level C)
  - 16. Section 16985 DTS Interface Tests (Level D)
  - 17. Section 16986 Miscellaneous Tests (Level E)

##### 1.03 SPECIAL REQUIREMENTS FOR LEVEL F TESTING

- A. The Contractor shall conduct the Level F testing in conformance with the Critical Path Test Schedule described in Section 16981.
- B. The Contractor shall not perform any Level F testing until the Authority has performed all of the following:

1. Taken use and possession of the Train Control equipment following approval of all Level A, B, C, D and E testing.
  2. Performed to their satisfaction, all tests which they deem as necessary, prior to permitting the Contractor to perform his Level F tests.
  3. Granted, through the designated Resident Engineer, permission for the Contractor to proceed with the Level F testing.
- C. Other tests, to be developed by the Contractor and assigned numbers higher than 20.6, may be necessary to meet the requirements of these Specifications in proving that all Central Control functions have been implemented. Some of these tests may be performed in conjunction with each other if approved by the designated Resident Engineer.
- D. Train requirements and usage as defined in Section 16981.3.03, Field Tests, apply to System Level Tests (Level F).
- E. Access to the Central console is subject to the same productive time efficiencies as the trains and is further limited by permitting access only at non-revenue times, unless otherwise authorized by the Authority.

#### **1.04 SUBMITTALS**

- A. Submit to the designated Resident Engineer for approval a list of all the test equipment required for each of the tests in Level F. If special test fixtures are required, sufficient documentation shall be submitted with the list to enable the designated Resident Engineer to make a judgment regarding its suitability.
- B. The Contractor shall, at least 60 calendar days prior to the scheduled performance of the tests, submit detailed test procedures for the following tests:
1. Test 20.1 - CONSOLE/STATION/INTERLOCKING TESTThe Contractor shall perform a system test without a train to verify the correct operation of all interlocking functions when under control from Central. This test shall be conducted in conformance with a procedure which the Contractor has prepared and which has been approved by the designated Resident Engineer. The test shall be consistent with the following requirements:
    - a. The test shall be made at a time consistent with the Critical Path Test Schedule and after all Level A, B, C, D and E tests have been completed.
    - b. The Contractor shall determine that the following preparatory steps have been accomplished, and each item checked off on the data sheet.
      - 1) Central Control and wayside systems are all operational.
      - 2) The test is scheduled for non-revenue service hours, unless otherwise authorized by the Authority.
      - 3) All necessary test personnel, test equipment, plans, procedures and documentation are available and on-site.
      - 4) The Contractor's test conductor, the designated Resident Engineer's representa-tives, and the Authority's designated representative for the test are available at Central Control.
      - 5) The Central Control computer is on-line in the test area and the console display is correct for the conditions at the wayside.
      - 6) Alarm status has been verified and recorded before conducting the test. (To be included in the test documentation.)

- c. The Contractor's test procedure shall, as a minimum, contain a step for each of the following items. Each item shall be checked and the results entered at the assigned location on the data sheet. Verify that:
- 1) The third rail can be "electrified" in the test area and the console display properly responds to this process.
  - 2) An alarm print-out has been made and preserved as a test document following the "electrification" and a record made of all alarms displayed on the console.
  - 3) It is possible to institute and verify that Central Control is actually in control and verify removal of control from the interlocking under test. These requirements shall also apply to the two adjacent interlockings.
  - 4) It is possible to transmit the "Cancel All Routes" command to the test interlockings and verify that all signals are at "STOP" within 5 seconds, and no "traffic" arrows are displayed at Central.
  - 5) All required routes can be established, their signals "cleared," route canceled, the signals observed at "STOP" and that conflicting routes cannot be established, while required non-conflicting routes can.
  - 6) All required fleeting routes, including turnbacks, can be established, signals "cleared" and routes canceled.
  - 7) Traffic arrows on the display are correct during route clearings.
  - 8) Automatic routing at automatic signal locations can be established, properly displayed, and canceled.
  - 9) Auxiliary switch commands can be transmitted to operate the switches "NORMAL" and "REVERSE" and that this action is properly displayed.
  - 10) Where applicable, Snowmelter commands and indications function properly.
  - 11) Where applicable, Third Rail Heater commands and indications function properly.
  - 12) Where applicable, Intrusion Detection Warning (IDW) commands and indications function properly.
2. Test 20.2 - CONSOLE/STATION/TRAIN TEST. The Contractor shall perform a system test with a train to verify the correct interaction of a train with all station control functions when under control from Central. This test shall be conducted in conformance with a procedure which the Contractor has prepared and which has been approved by the designated Resident Engineer. The test shall be consistent with the following requirements:
- a. The test shall be made at a time consistent with the Critical Path Test Schedule and after all Level A, B, C, D and E tests and Test 20.1 have been completed, and all outstanding discrepancies resolved.
  - b. The Contractor shall determine that the following preparatory steps have been accomplished, and each item checked off on the data sheet:
    - 1) Central Control and wayside systems are all operational.
    - 2) The test is scheduled for non-revenue service hours, unless otherwise authorized by the Authority.
    - 3) All necessary test personnel, test equipment, plans, procedures and documentation are available and on-site.
    - 4) The Contractor's test conductor, the designated Resident Engineer's representatives, and the Authority's designated representative for the test are available at Central.

- 5) The computer is on-line in the test area and the console display is correct for the conditions at the wayside.
  - 6) Alarm status has been verified and recorded before conducting the test. (To be included in the test documentation.)
- c. The Contractor's test procedure shall, as a minimum, contain a step for each of the following items. Each item shall be checked and the results entered at the assigned location on the data sheet. Verify that:
- 1) The third rail can be "electrified" in the test area and the console display properly responds to this process.
  - 2) An alarm print-out has been made and preserved as a test document following the "electrification" and a record has been made of any alarm displayed on the console.
  - 3) It is possible to institute and verify that Central Control is actually in control and verify removal of control from the interlockings under test. These requirements shall also apply to the two adjacent interlockings.
  - 4) It is possible to transmit the "Cancel All Routes" command to the associated interlockings and verify that all signals are at "STOP" within 5 seconds, and no "traffic" arrows are displayed at Central.
  - 5) When the test train is moved into the test area, the proper display is observed at Central Control and this fact is recorded in the test documents.
  - 6) With the train's identity set upstream from the test location platform, and where the track layout allows, the symbols on the display change from unidentified to identified when the train arrives at the test location platform.
  - 7) The following commands operate and are displayed properly:
    - a) "PLATFORM ID"
    - b) "HOLD WITH DOORS OPEN"
    - c) "DISPLAY TRAIN NUMBER"
    - d) "HOLD WITH DOORS CLOSED"
    - e) "TERMINATE DWELL" (with subsequent departure of train from test location)
  - 8) These commands function properly for all station tracks, during both Normal and Reverse Running.
  - 9) All the ATS Performance/Acceleration commands are received and properly decoded aboard the test train standing at each station platform and that the command most recently given is retained by the train as it leaves each platform.
  - 10) All the ATO commands function as intended, including SKIP STOP for each station platform track in each direction, and TRAIN READY for each put-in location.
  - 11) All flyby transmitters function properly, and that changed performance levels are received and retained aboard the train as it traverses each flyby location.
  - 12) Where provisions have been made for "short turn" operation, (i.e., the pocket-track turn-back of certain revenue-service trains at an intermediate terminal station) the equipment functions properly, allowing the train to return in the direction from which it came, in the specified manner of automatic operation, with the correct stopping point, and that the proper indications of this move are observable at Central.

3. Test 20.3 - CONSOLE/TERMINAL INTERLOCKING TEST (Terminal Modes 1, 2, 3) The Contractor shall perform a system test with three trains to verify the correct interaction of the trains with Central Control, and with all interlocking functions at a terminal, including the Interlocking Control Panel and the Dispatcher's Control Panel, when not under control from Central Control. This test shall be conducted in conformance with a procedure which the Contractor has prepared and which has been approved by the designated Resident Engineer. The test procedure shall be modified as necessary to provide a distinctive test document for each of the various terminal and track configurations at automatic terminal interlockings. The terminal configurations include "normal" terminals (located at the outbound end of the route segment) and "reverse" terminals (located at the inbound end of the route segment). The track configurations at automatic terminal interlockings include, but are not limited to, such layouts as: Interlocking on the inbound end of the station; interlocking on the outbound end of the station, with or without a pocket track, and; interlockings at both ends of the station platform. The test shall be consistent with the following requirements:
- a. The test shall be made at a time consistent with the Critical Path Test Schedule and after all Level A, B, C, D and E tests and System Test 20.1 have been completed, and all outstanding discrepancies resolved.
  - b. The Contractor shall determine that the following preparatory steps have been accomplished and each item checked off on the data sheet.
    - 1) Central Control and wayside systems are all operational.
    - 2) The tests are scheduled for non-revenue service hours, unless otherwise authorized by the Authority.
    - 3) All necessary test personnel, test equipment, plans, procedures and documentation are available and on-site.
    - 4) The Contractor's test conductor, the designated Resident Engineer's representative and the Authority's designated representatives for the test are available at Central.
    - 5) The computer is on-line in the test area and the console display is correct for the conditions at the wayside.
    - 6) Alarm status has been verified and recorded before conducting the test. (To be included in test documentation)
  - c. The Contractor's test procedure shall, as a minimum, contain a step for each of the following items. Each item shall be checked and the results entered at the assigned location on the data sheet. The Contractor shall verify that:
    - 1) The third rail can be "electrified" in the test area and the console display properly responds to this process.
    - 2) An alarm print-out has been made and preserved as a test document following the "electrification" and a record made of any alarms displayed on the console.
    - 3) It is possible to institute and verify "Operation by Central Control" and removal of "local control" at the interlocking under test, and at the adjacent interlocking(s).
    - 4) It is possible to transmit the "Cancel All Routes" command to the test interlocking and verify that all signals are at "STOP" within 5 seconds, and no "traffic" arrows are displayed at Central Control.
    - 5) When the test trains are moved into the test area, the proper display is observed and recorded in the test documents.
    - 6) The operation of each and every specified operation of the interlocking is possible.

- 7) No operation other than those specified or approved by the Engineer is possible.
  - 8) When each of the operations described in these Specifications occurs:
    - a) no conflicting or opposing routes are, or can be, established;
    - b) all conflicting signals are checked at "STOP";
    - c) proper spacing is provided, and;
    - d) proper indications for these operations are observable at Central Control.
4. Test 20.4 - OPERATION OF MAINLINE INTERLOCKINGS BY CENTRAL COMPUTER WITH ONE OR MORE TRAINS
- a. The Contractor shall prepare and submit for approval a test procedure for use with one or more test trains, as necessary, to verify the correct operation of each interlocking when under supervision by the Central Computer. The test shall address each aspect of Central Computer supervision of the interlockings, and shall ascertain whether the test train(s) interact properly with Central Control, and whether the mainline interlocking operates as required by other Sections of these Specifications. The test procedure shall contain easily identified special sections for the testing of the different types of interlockings (Junctions, Emergency Crossovers, Terminals, Turnback Pocket Tracks or Special Combinations, as applicable) which are included in this Contract.
  - b. The test procedure shall include the following preparatory steps:
    - 1) Central Control and wayside systems are all operational;
    - 2) The tests are scheduled for non-revenue service hours, unless otherwise authorized by The Authority;
    - 3) All necessary test personnel, test equipment, plans, procedures, and documentation are available and on-site;
    - 4) The Contractor's test conductor, the designated Resident Engineer's representative and the Authority's designated representatives for the test are available at Central Control;
    - 5) The computer is on-line in the test area and the console display properly responds to the process;
    - 6) The third rail can be "electrified" in the test area and the console display properly responds to the process;
    - 7) Alarm status has been verified following the "electrification" and a record made of any alarms displayed on the console (to be included in test documentation);
    - 8) It is possible to institute and verify operation by Central Control and removal of local control at the interlocking under test, and at the adjacent interlocking(s);
    - 9) It is possible to transmit the "Cancel All Routes" command to the test interlocking and verify that all signals are at "STOP" within 5 seconds, and no traffic arrows are displayed at Central Control;
    - 10) It is possible to reinstitute and verify operation by local control and removal of operation by Central Control, at the interlocking under test and at the adjacent interlockings.
  - c. The test procedure shall include, but not be limited to, sections to test all significant aspects of the following characteristics which are applicable:
    - 1) Train identity
    - 2) Unidentified Train Alarms

- 3) Automatic Routing
  - 4) Train Direction and Location Reporting and Alarms
  - 5) Train Destination
  - 6) Train Ready
  - 7) Platform Information
  - 8) Central Console
  - 9) Data Logger
  - 10) Train Separation
  - 11) ATS Speed Control
  - 12) Intrusion Detection Warning
- d. The Contractor shall pattern this test procedure according to the requirements of Section 16981. Provision shall be made for testing the equipment for any operation which is unique to a given location by providing specific sections of this test which relate to the unique feature. The test procedure shall include checks of the operations which are desired as well as checks of the prevention of operations which need to be precluded, or which interfere in any way with the safe or normal operation of the interlocking.
- e. Features of any applicable automatic-route interlockings to be tested shall include, but not be limited to, those listed below:
- 1) Route Decoder
  - 2) Train Identification
  - 3) Automatic Signal Clearing
  - 4) Proper Interaction between Central and the Wayside Interlocking Control Panel
  - 5) Central Route Initiation
- f. The Contractor shall perform the applicable tests of the centrally supervised interlockings in conformance with the approved test procedure at a time consistent with the Critical Path Test Schedule after all Level A, B, C, D and E Tests, and Test 20.1 have been satisfactorily completed.
- g. When making this test, any associated passenger station areas shall be set for the "Skip Stop" mode of operation.

**PART 2**  
NOT USED

**PART 3**  
NOT USED

**END OF SECTION**

## SECTION 16988

### ATC QUALITY ASSURANCE

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section includes specifications for the design, implementation and maintenance by the Contractor, of a Quality Assurance Program, a Quality Assurance Plan, and an Inspection Plan covering the ATC equipment, systems, and services required by this Contract.
- B. The ATC Quality Assurance Program, Quality Assurance Plan, and Inspection Plan, including related directives, procedures, processes, instructions, and schedules, shall be submitted to the Authority for approval. Basis for approval will be a description of how the ATC Quality Assurance Program Requirements set forth in Part 1.04 of this Section shall be met. The approved program and plans will be used by the Authority in the performance of any inspection in determining the acceptability of the ATC equipment, systems and services being furnished. If the program/plan is returned as unacceptable, the Contractor shall revise and resubmit the Quality Assurance Program or plans to the designated Resident Engineer within 30 calendar days.

##### 1.02 DEFINITION OF QA TERMS

- A. Audit: An examination of the conduct of the (ATC) Quality Assurance Program for the purpose of determining compliance with and conformance to the (ATC) Quality Assurance Plan.
- B. Corrective Action Report : A part of the corrective action process which documents actions taken to correct nonconforming conditions or products.
- C. Inspection : The physical act of verifying by measurement and examination that the supplies and workmanship conform to approved documents and established quality requirements.
- D. (ATC) Inspection Plan : A description of the specific work areas and the extent to which these areas will be inspected by the Contractor.
- E. (ATC) Quality Assurance Plan: An identification of how the Contractor shall comply with or otherwise implement the ATC Quality Assurance Program for the time period or authorized phase of the Contract
- F. (ATC) Quality Assurance Program : An identification and correlation of a Contractor's quality-related policies, practices, procedures and methods which are required to assure compliance with Contract requirements.

##### 1.03 RELATED SECTIONS

- A. All Sections in the 16900 series.

## 1.04 QUALITY ASSURANCE PROGRAM

- A. The submitted Quality Assurance Program shall be organized as follows:
1. Name of Contractor and Contract
  2. Revision Dates
  3. Index
  4. Contents
    - a. Scope - provide a statement which identifies the work areas (or disciplines) essential to Contract performance. The (ATC) Quality Assurance Program shall apply to all ATC equipment, systems, and services included in the Specifications, except as otherwise stated. The work areas (or disciplines) shall include, but shall not be limited to: management, design, procurement, manufacture, installation, and inspection.
    - b. Program Requirements:
      - 1) Quality Management
        - a) Identify and describe the organizational units having responsibility and authority for development, implementation, and management of the (ATC) Quality Assurance Program. Achievement of quality objectives shall be verified by individuals and organizations who are responsible for checking, inspecting, auditing, or otherwise verifying that the work has been performed satisfactorily.
        - b) Identify the program for assuring that sufficient records are maintained to provide documentary evidence of the performance of activities affecting quality and for use in managing the Contract. Typical records shall include Quality Assurance Program, Quality Assurance Plans, procedures, instructions, non-conformance or defect reports, corrective action reports, and such other quality-related documents as are specified in the Contract specifications.
        - c) Identify the program for verifying and determining the cause of unsatisfactory product or workmanship quality and for initiating necessary improvements and corrections to preclude repetition. The Contractor's program should extend, when necessary, to the performance of subcontractors and suppliers.
      - 2) Design (and Development), where applicable:
        - a) Prepare and maintain a plan for inspecting the quality of design, development, testing and documentation activities. Identify the procedures, practices, tables, charts, and diagrams applicable to the effort.
        - b) Document the design criteria applicable to the ATC equipment, systems, subsystems, and software being supplied. Include performance objectives, operating ranges and conditions, interfacing protocols, requirements for safety, reliability, and availability, the requirements (codes, standards, and practices) for materials, fabrication, construction, testing, operation, maintenance, and quality assurance.
        - c) Engineering studies, to be conducted in support of the design (or development) activity, shall be identified. They shall include analysis of allowable "trade offs" and alternatives, identification of potential weaknesses, and the

- appropriate preventative design features, operating and maintenance practices, and safety precautions.
- d) Identify the program for assuring that specifications, drawings, and other engineering documents will delineate, as applicable:
    - (1) materials and methods, including fabrication, construction, installation, inspection, maintenance, cleaning, packaging, shipping, handling, and storage.
    - (2) traceability of materials, parts, components and processes through appropriate lot, piece part, serial, or other appropriate numbers.
    - (3) product or workmanship acceptance criteria and the checkpoints during the work process for verifying compliance with the criteria.
    - (4) appropriate functionality and operational protocol of all ATC software.
  - e) Identify the methods and procedures for defining and controlling design interfaces among other project participants and design organizations. The procedures shall cover the exchange of required design data, analysis, and resolution of design interface problems.
  - f) Identify procedures for controlling the release of documents for authorized use.
  - g) Identify procedures for documenting the reporting, verifying, analyzing, and correcting of troubles that occur during development.
- 3) Procurement:
- a) Identify the procedures for controlling the receipt, inspection, tests, handling, storage, and distribution of received equipment and its protection from damage, deterioration, loss or substitution. Inspection instructions and test procedures shall provide for verification of characteristics required by Contract Drawings and Specifications, and documentation of results.
  - b) Identify the procedures for controlling purchased items that do not conform to the Specifications. The procedures shall provide for prompt identification, documentation, segregation, technical review, and disposition of non-conforming items.
- 4) Manufacturing, Fabrication, and Assembly:
- a) Identify the procedures and instructions which will be used to assure that fabrication, processing, and assembly operations are being satisfactorily performed.
  - b) Identify the inspection and test plans which will be applied to all manufacturing activities for the purpose of verifying conformance to procedures and instructions.
  - c) Identify the method employed for tracing the identity of materials and items throughout fabrication, processing, or assembly operations.
  - d) Identify the procedures, instructions, and checklists for the control of fabrication and assembly processes. Include such items as shop orders, process sheets, travelers, and inspection instructions, covering all mechanical, electrical, and metallurgical processes. Inspection instructions shall

- identify the non-destructive examination processes employed.
  - e) Identify the methodology of the program including record maintenance.
  - f) Identify the procedures for prompt identification, documentation, segregation, technical review, and disposition of non-conforming items.
  - g) Identify the procedures and instructions for handling, preserving, packing, packaging, storing, and shipping items shipped to the construction site.
  - h) Identify the inspections and tests that will be performed upon completed parts, materials, components, assemblies or systems before they are delivered or installed.
- 5) Installation:
- a) Identify the procedures, checkoff lists, and instructions governing receipt inspection of equipment on arrival at the installation site. Include in the procedures the control of non-conforming items.
  - b) Identify the procedures for controlling configuration. This shall include the control of drawings, specifications, work instructions, quality-control procedures, inspection instructions, and testing procedures, used in connection with installation.
  - c) Identify the procedures and work instructions which apply to installation methods, tests, repairs and rework, cleaning, and protection.
  - d) Identify the inspections and tests to be performed to verify installation suitability.
  - e) Identify the procedures for controlling the identification, documentation, segregation, technical review, and disposition of non-conforming supplies or workmanship.
  - f) Inspection:
    - (1) Identify the inspection plan which will be used to perform the various types of inspections for supporting the Quality Assurance Program.
    - (2) Identify in the inspection plan the types of inspection (e.g., source, receiving, in process, installation) which will be performed by the Contractor.

## 1.05 SUBMITTAL

- A. The ATC Quality Assurance documents shall be submitted within 30 calendar days after Notice to Proceed. The submitted ATC Quality Assurance Program shall be complete with the exception of detailed processes and procedures governing the fabrication, test and inspection of equipment and systems that require development. Detailed test and inspection procedures required by the technical provisions shall be added to the approved ATC Quality Assurance Program after they are submitted and approved as required by the individual technical articles. Fabrication processes for equipment and systems which require development shall be added to the approved ATC Quality Assurance Program as the development work progresses.

## PART 2 PRODUCTS NOT USED

## PART 3 EXECUTION

### **3.01 QUALITY ASSURANCE COMPLIANCE**

- A. The prime Contractor shall employ and assign continuously, from the time any field installation of Train Control equipment commences until all Train Control field installation and testing is completed and approved, a qualified, full-time ATC Quality Assurance (Q.A.) Inspector who shall monitor all Train Control field installation work performed by the Contractor and report to the designated Resident Engineer every work day. The Q.A. Inspector shall have specialized training and experience in vital signal and train control systems design and installation work and have a working knowledge of applicable FRA regulations. The ATC Quality Assurance Inspector shall be employed exclusively for the purpose of overseeing and ensuring the quality of the ATC work performed on this Contract.
  
- B. To assure the Contractor's compliance with and conformance to an approved ATC Quality Assurance Program, such program will be subject to quality audits. ATC QA Audits will be scheduled by the designated Resident Engineer as required. Within 30 days of receiving the Audit Report, the Contractor shall provide in writing to the designated Resident Engineer a description of actions taken to correct deficiencies cited.

### **3.02 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. Factors which will be considered when determining Partial Payments for the ATC Quality Assurance Program will include the following:
  - 1. Approval of the Contractor's ATC Quality Assurance Program by the designated Resident Engineer.
  - 2. Continued satisfactory compliance with the requirements of the approved ATC Quality Assurance Program.
  - 3. Final acceptance of all Contract TCR areas by the Authority.

**END OF SECTION**

## SECTION 16990

### ATC DOCUMENTATION AND TRAINING and SPECIAL ATC APPENDICES (Table of Contents)

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This SECTION lists the various 16990-series ATC Documentation, Training, and Special ATC Appendices Sections:
1. ATC Drawings and Tracings (Section 16991)
  2. ATC Instruction Manuals (Section 16992)
  3. ATC Training Courses (Section 16993)
  4. ATC Appendix "C" - Index of ATC Drawings Section 16994)
  5. ATC Appendix "L" - ATC Design, Submittal  
Access, Energization and Completion Schedule (Section 16995)
  6. ATC Appendix "TA" - ATC Technical Appendix (Section 16996)
  7. ATC Appendix "SS" - RTU Scan Sheets (Section 16997)
  8. ATC Appendix "CD" -  
Correction of ATC Deficiencies (Section 16998)

#### PART 2- PRODUCTS

NOT USED

#### PART 3 - EXECUTION

NOT USED

END OF SECTION

## SECTION 16991

### ATC DRAWINGS AND TRACINGS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section contains Specifications for the production and furnishing of Train Control tracings, drawings, CD-ROMs, optical media, and microfilm aperture cards, and describes the general format of ATC drawings, types of ATC drawings, and the manner in which ATC information shall be displayed on these drawings.

##### 1.02 BASIC DESCRIPTION

- A. ATC drawings shall be divided into two basic types. Each type shall be furnished in a separate book. The typical drawings common to all TCR locations shall be contained in a "Book of Typical Plans." Drawings specific to a particular TCR location shall be contained in a "Room Book-of-Plans" for that particular room.
- B. ATC drawings for the existing Train Control systems are on file at the Authority's offices. The Contractor may refer to these drawings and may obtain prints, at no additional cost to the Authority, of any of these drawings required for completion of work under this Contract.
- C. When the work requires alteration or additions to existing ATC drawings, the Authority will furnish the original mylars of the Record Drawings which require revisions. From these the Contractor shall produce new tracings, drawings, CD-ROM's, optical media, and aperture cards to replace or supplement the existing drawings, all as specified herein.
- D. The effective date and identification number, to be inscribed on the final tracings, will be furnished by the designated Resident Engineer prior to the time the tracings reach As-Built condition and are ready for the Contractor's final processing.
- E. With the exception of certain relay type circuit drawings being replaced by microprocessor system drawings, the Contractor shall draw the various types of drawings required by these Specifications in a manner similar to that depicted on the corresponding typical drawings or example location drawings included in the Contract Drawings. Example location drawings included in this Contract are for Cleveland Park and Van Ness-UDC.

##### 1.03 RELATED SECTIONS

- A. Related work specified elsewhere shall include, but not be limited to, the following Sections:
  - 1. Division 1 Contract Record Drawings
  - 2. Section 01250 Contract Modification Procedures
  - 3. Section 16904 Current Metrorail Rapid Transit System
  - 4. Section 16911 Scope of ATC Work
  - 5. Section 16912 ATC Submittal Requirement
  - 6. Section 16916 Basic ATC Circuit Requirement
  - 7. Section 16927 ATC Microprocessor Support Systems
  - 8. Section 16931 ATC Maintenance and Test Facilities
  - 9. Section 16932 Spare ATC Equipment and Selectable Items

## 1.04 TYPES OF DRAWINGS

- A. The types of ATC drawings to be provided shall include, but not be limited to, the following as applicable:
1. Drawings indicating the track configuration including curvature and grade profile and showing the location of pertinent items of Train Control related facilities such as impedance bonds, signals, switch-and-lock movements, junction boxes, pushbuttons, signs, snowmelter control housings, TCRs, stations, marker coils and other wayside Train Control equipment and ancillary facilities. These drawings shall be drawn to a horizontal scale of 1 inch equals 100 feet, or 1 inch equals 50 feet and shall be known as Double Line Track Plans.
  2. Drawings showing ATP speed commands transmitted for each track section or block, for both the normal and reverse directions of traffic, depending upon track occupancy and, where applicable, upon the status of wayside IDW fence. These drawings shall also define and indicate the limits of approach locking. These drawings shall be known as ATP Speed Command Control Line Diagrams.
  3. Drawings showing the arrangement of equipment, facilities, or components in a room, rack, junction box, housing, cabinet or module shall be known as Arrangement Plans.
  4. Drawings showing the dimensions and internal mechanical and electrical details of particular pieces of equipment or assemblies shall be known as Product Drawings, but shall bear the title of the particular piece or type of equipment shown.
  5. Drawings on which detailed information is shown for the mechanical installation of Train Control equipment, such as signals, impedance bonds and switch-and-lock movements. These drawings shall be known as Installation Drawings.
  6. Drawings which indicate the point-to-point cable runs and identify cable make-up and conductor wire size. These drawings shall be known as Cable Plans.
  7. Drawings showing the exact location of direct burial and surface cable trench runs, as applicable, shall be known as Trenching Plans.
  8. Drawings showing the various types of control, operating and indication circuits required. These drawings shall bear the title of the particular function(s) performed by the circuits illustrated, but shall all be classified as Circuit Drawings.
  9. Schematic drawings of various energy distribution systems or subsystems. These drawings shall be known as Energy Distribution Schematics.
  10. Drawings showing the details of electrical connections for various pieces of train control equipment. These drawings shall bear the title of the particular piece of equipment, but shall all be classified as Wiring Diagrams. This category shall include "Back Panel Wiring Diagrams" for all control and indication panels provided under this Contract.
  11. Drawings showing the wiring and connection diagrams for individual systems and subsystems supplied on this Contract. Complete logic diagrams shall be included for all microprocessor-based systems and modules. These drawings shall bear the title of the applicable system or subsystem. For example, the separate drawings showing the TC Maintenance Telephone lines emanating from each TCR and showing all terminations of these lines within the Contract limits shall be known as TC Maintenance Telephone System Drawings. Wiring diagrams of the connections between the various parts of a system shall be fully detailed with all terminals and wire numbers. They shall be complete and all on one page if possible. No connections shall be omitted. All interface connections shall show destinations, preferably graphically, but if not practical, through the use of adequate nomenclature. Reference may be made to drawings in the "Room Book-of-Plans," or the "Book of Typical Plans."

12. Drawings showing complete Material Lists for all assemblies, subassemblies and components supplied on this Contract. These Material Lists shall include all information necessary for preparing an order to the supplier for replacement of such equipment. As an option, these Material Lists may be provided on 8.5 x 11 inch paper, or may be included as part of related drawings. All items shown on these material lists shall be completely described, to include identifying sources, size, configuration, mating and attaching characteristics, functional characteristics and performance requirements, and "form, fit and function" data contained on specification control drawings, catalog sheets, and outline drawings. Items such as resistors, capacitors, nuts, bolts, and other general hardware, shall be described only once for this Contract provided they are adequately cross-referenced.
13. Drawings entitled "List of Spare Parts" for all assemblies, subassemblies and components supplied on this Contract. These lists of spare parts shall include the recommended stock quantities for routine maintenance of the equipment for one year and shall include a sub-list of spare parts that are considered critical and for which extended amounts of time required for acquisition would create undesirable down-time for the equipment. See Section 16932, Spare ATC Equipment and Selectable Items.
14. Drawings entitled "List of Tools" for all assemblies, subassemblies and components requiring the use of tools. These drawings shall list all common and special tools required to perform inspection, adjustment, maintenance and repair. Special tools are those developed to perform a unique function related to a particular piece of equipment which are not available from common commercial sources. Special tools shall be so identified on the list. See Section 16931, ATC Maintenance and Test Facilities.
15. Drawings showing complete circuits which, with minor modifications and details added, will be used repetitively throughout the Contract work shall be known as Typical Circuit Drawings and shall have the word "Typical" included in the title along with the circuit or function name shown.
16. Index sheets for each room book of plans.
17. Drawings showing the logic coding for microprocessor logic modules together with their equivalent discrete- component circuits shall be identified as Equivalent Circuit Drawings, and shall include a separate drawing which lists (alphabetically and numerically) clear and concise definitions for every term and abbreviation used on these drawings.

#### **1.05 QUALITY ASSURANCE**

- A. The Contractor shall check drawings and final tracings for both form and content prior to submittal. Points to be checked shall include, but not be limited to, the following:
  1. Safety and operability of the circuits, devices and systems represented
  2. Conformance to the Specifications
  3. Logical grouping and arrangement of subject matter
  4. Accuracy
  5. Legibility
  6. Neatness
  7. Line Quality
  8. Lettering Quality
  9. Reproduction Quality
  10. Inclusion of proper interfaces internal to the ATC System
  11. Inclusion of Contract specified interfaces with related systems and contracts.

- B. Approval of drawings and tracings will be at the discretion of the designated Resident Engineer. The designated Resident Engineer will consider the same points enumerated above, with the basic criteria for obtaining approval being that drawings are accurate and easy to read, understand and use.

## 1.06 SUBMITTALS

- A. The Contractor shall submit drawings to the designated Resident Engineer for approval of ATC products, circuits, programming logic, subsystems, methods of installation, location arrangements, cut-in procedures, and such other items or functions as may be required by these Specifications. When submitting such drawings for approval, the Contractor shall submit all drawings germane to the subject at one time. This logical grouping of drawings, sufficient to completely cover the subject concerned, shall be known as a Submittal Package.
- B. The Contractor shall, unless otherwise directed, submit one reproducible, three magnetic or optical media, and three legible copies of all Train Control drawings to the designated Resident Engineer for approval. These drawings shall be complete and detailed. Train Control drawings shall include, but not be limited to, the following:
  - 1. Title Sheets
  - 2. Index Sheets
  - 3. Nomenclature Description Sheets
  - 4. Relay/Contact Location Charts
  - 5. Cable Plans
  - 6. Double Line Track Plans
  - 7. Arrangement Plans
  - 8. Product Drawings
  - 9. Equipment Installation Drawings
  - 10. Circuit Drawings
  - 11. Typical Drawings (circuits and/or equipment layouts)
  - 12. Energy Distribution Schematic
  - 13. Wiring Diagrams
  - 14. System Drawings
  - 15. Control Panel Drawings (to include Back Panel Wiring)
  - 16. Tie-in Drawings
  - 17. Interface Drawings
  - 18. Cut-In Drawings (as applicable)
  - 19. TC Maintenance Telephone System Drawings
  - 20. Trenching Plans (both direct burial and surface trench, as applicable)
  - 21. ATP Speed Command Control Line Diagrams
- C. The drawings shall be submitted using standard transmittal forms in accordance with detailed instructions furnished by the designated Resident Engineer. A supply of these forms will be furnished without cost to the Contractor. The Contractor shall provide the services of a local reproduction service to prepare three copies of all ATC submittals. Reproduction time shall be less than two business days.
- D. Before submitting Train Control drawings to the designated Resident Engineer for approval, the Contractor shall ascertain that:
  - 1. The drawings represent the coordinated efforts of all Train Control subcontractors involved;

2. The equipment, circuits, or subsystems represented are compatible with the directly related equipment, circuits and subsystems provided by other disciplines, based upon the most up-to-date information available, and;
  3. The equipment, circuits, or subsystems represented, and the manner in which they are represented, are in conformance with the requirements of these Specifications.
- E. Train Control drawings submitted for the approval of the designated Resident Engineer shall bear the Contractor's stamp of approval as evidence of such checking, coordination, and compatibility. Drawings submitted without this stamp of approval will be returned to the Contractor for resubmission.
- F. The form and content of Train Control drawings and tracings shall comply with the requirements set forth herein.
- G. If ATC drawings show variations from the Contract requirements because of standard shop practice or for other reasons, the Contractor shall describe such variations in his letter of transmittal. If acceptable, the designated Resident Engineer may approve any or all such variations, subject to a proper adjustment in the Contract. If the Contractor fails to describe such variations, he shall not be relieved of the responsibility for executing the work in accordance with the Contract, even though such drawings have been approved.
- H. If the drawings as submitted describe variations per paragraph **G.** above, and show a departure from the Contract requirements which the designated Resident Engineer finds to be in the interest of the Authority and to be so minor as not to involve a change in the Contract price or time for performance, the designated Resident Engineer may approve the drawings.
- I. If approved by the designated Resident Engineer, each copy of the Train Control drawings will be identified as having received such approval by being so stamped and dated. Train Control drawings stamped "Not Approved" and with required corrections shown will be returned to the Contractor for correction and resubmittal by the Contractor within two weeks. Resubmittals will be handled in the same manner as first submittals. When resubmitting drawings, the Contractor shall direct specific attention, either in the transmittal letter or on the resubmitted Train Control drawings, to revisions other than the corrections requested by the designated Resident Engineer on previous submissions. The Contractor shall make any corrections required by the designated Resident Engineer. If the Contractor considers any correction indicated on the ATC drawings to constitute a change to the Contract Drawings or Specifications, notice as required under Section 01250 Contract Modification Procedures, shall be given to the Contracting Officer. One reproducible set of Train Control drawings will be returned to the Contractor. The Contractor shall return 2 sets of prints to the Authority's designated Resident Engineer within 15 calendar days.
- J. When the Train Control drawings have been completed to the satisfaction of the designated Resident Engineer, the Contractor shall carry out the installation in accordance therewith and shall make no further changes therein except upon written instruction from the designated Resident Engineer.
- K. When drawings are approved by the designated Resident Engineer subject to certain revisions, the Contractor shall supply the designated Resident Engineer with four suitably revised prints of the approved drawings prior to installation of equipment.

- L. Before any payment is made for Train Control drawings, the Contractor shall furnish to the designated Resident Engineer three sets of record Train Control drawings, all clearly revised and completed and brought up to date, showing the permanent installation as actually made. Upon written approval of the final ATC As-Built tracings and drawings by the designated Resident Engineer, the Contractor shall reproduce the tracings on three sets of microfilm aperture cards of the type and size specified in Division 1, Contract Record Drawings, and deliver these tracings and aperture cards to the designated Resident Engineer.
- M. The Contractor shall submit three sets of prints and three sets of magnetic or optical media of As-Built drawings for review and approval not later than 10 days after final acceptance of the work. Additions and corrections shall be incorporated as required and originals with five copies of prints shall be delivered (one copy to the Train Control Rooms and four copies to the designated Resident Engineer) not later than 20 days after final acceptance of the work, and prior to the Operational Readiness Date. The final sets of As-Built drawings for the Train Control Rooms ("Book of Typical Plans" and "Room Book of Plans"), shall be legibly and permanently printed on special heavy duty, long lasting media of a type previously approved by the designated Resident Engineer, and bound using a method previously approved by the designated Resident Engineer.
- N. Final payment will not be made until the Contractor has submitted both CD-ROM and microfilmed record versions of each of the As-Built drawings for the completed work.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS FOR TRACINGS**

- A. The tracings for the final As-Built drawings shall be printed on four-mil-thick mylar in AutoCAD 20 format by automated techniques approved by the designated Resident Engineer.
- B. The materials and methods used to produce these tracings shall result in tracings which are durable, easily readable, and non-fading.

### **2.02 MICROFILM APERTURE CARDS**

- A. The aperture card reproductions of the final As-Built drawings shall be provided in accordance with the requirements stated in Division 1, Contract Record Drawings, of these Specifications.

### **2.03 BOOKS OF DRAWINGS**

- A. The Contractor shall supply books of specific ATC drawings for submittal packages and plan books as required elsewhere in these Specifications. These books of drawings shall consist of the following components:
  - 1. A group of drawings assembled in a logical order.
  - 2. An index sheet of the same size as the drawings.
  - 3. Protective cover and backing sheets. The name of the submittal package or name and location of the plan book shall be printed on the cover sheet in two-inch-high letters.
  - 4. A device for binding the left-hand edges of the drawings firmly, but in such a manner that drawings may be easily added, removed, or replaced without damage to the drawings or the binding.

## **PART 3 - EXECUTION**

### **3.01 BASIC FORMAT REQUIREMENTS FOR ATC DRAWINGS**

- A. Each ATC drawing (maximum size of sheet, 22 inches by 36 inches) shall have a blank area 3-1/2 inches by 3-1/2 inches, located adjacent to the title block in the lower right hand corner.
- B. The title block shall display the following:
  - 1. Number and type of drawing
  - 2. Date of drawing and all revisions
  - 3. Name of Route and, where applicable, specific Train Control Room area
  - 4. Name of Contractor and Subcontractor submitting drawing
  - 5. Clear identification of contents and location of the work
  - 6. Specification title and Contract number
- C. Drawings shall not be crowded or cluttered, but shall be arranged to be easily readable.
- D. All lettering or printing shall be at least 0.10 inches high and shall be produced by automated means. Freehand printing or lettering will not be acceptable.
- E. Wherever practical to do so, notes shall be located as far toward the right border of the drawing as possible.

### **3.02 SPECIAL REQUIREMENTS FOR ATC CIRCUIT DRAWINGS**

- A. Circuitry shall be presented on the drawing with a minimum of crossed or offset lines.
- B. Circuits shall not be drawn as schematics, but shall be drawn to reflect the actual wiring of the circuits. A uniform method shall be used to indicate the actual location of double wire connections when it is not desirable to show both wires at the point of termination. If the final circuit is not wired as shown on the Contractor's drawing, the Contractor shall revise his tracings to indicate the actual wiring before final, As-Built prints are made.
- C. The circuit drawings included in these Specifications do not dictate the location of double wire connections, but shall guide the Contractor insofar as circuitry, symbols, lettering, drawing size and layout are concerned.
- D. No more than two wires shall be shown connected to a single terminal or contact pin other than an AAR terminal unless specifically authorized by the designated Resident Engineer. No more than three wires shall be shown connected to a single AAR terminal.
- E. Complete circuits shall be shown on each drawing insofar as possible. A minimum of continuations shall be used. When continuations must be used, they shall be clear and specific and shall include the identity of the continuation sheet and the unique identity of the specific continuation. Wherever practicable, these "continuations" shall "line up" from drawing to drawing.
- F. Circuits shall be drawn with relay coils, timers, motors or other operated devices shown near the right or left border of the drawing wherever practical. Where there is a choice, the right border shall be favored.

- G. Track relay contacts in ATC circuits shall be inserted successively in conformance with the geographical succession of the track circuits themselves insofar as possible and practical.

### **3.03 PLAN BOOKS**

- A. The Contractor shall maintain two sets of plan books in each TCR in which ATC equipment is installed under this Contract. Each of these sets shall consist of two books of ATC drawings:
  - 1. One book shall consist of all the ATC drawings for the area controlled from that particular TCR and shall include applicable prints from adjacent TCRs to show the non-local portions of traffic circuits and other line circuits appearing in the local TCR. This book shall also include:
    - a. A copy of the wiring diagram for each DTS interface junction box served from the local TCR. See the Data Transmission System (DTS) portion of Section 16927, Microprocessor Support Systems.
    - b. A copy of the wiring diagram for each wayside Train Control junction box and control case located within the area controlled from that TCR.
    - c. Complete Train Control cable plans for the entire area controlled from that TCR.
  - 2. The second book shall consist of typical circuits and typical arrangement or internal layout plans and wiring diagrams for the various pieces of ATC equipment common to the various TCRs.
- B. Both sets of these books shall be updated immediately to reflect any changes made in the ATC circuits or equipment. Work shall not proceed within a TCR area of control until such updates are made. One set of these updated plan books for each TCR shall never leave the TCR, and shall be left in the TCR when the TCR is transferred to Authority control.
- C. In lieu of keeping stamped copies of drawings signed by the Authority's designated R.E. in each TCR, the Contractor shall maintain a log of drawing approval status indicating drawing revision number, any changes, dates of approval and approval status. Approved "as-corrected" drawings shall have corrections transferred to the Room Books of Plans and so noted on both the drawings and in the log.
- D. The Contractor shall maintain a complete set of up-to-date plan books for all TCR locations included in this Contract at his on-site headquarters.
- E. Three additional copies of the typical books and three additional copies of each TCR book of drawings shall be furnished to the Authority at the time the Contractor begins work in the TCR.

### **3.04 AS-BUILT DRAWINGS**

- A. The completed As-Built drawings shall bear the signature of an officer of the Contractor's organization, certifying compliance with as-built conditions, using a rubber stamp as follows

<p>AS-BUILT</p> <p>(Date)</p> <p>-----</p> <p>I certify that this drawing accurately depicts the work as installed.</p> <p><i>(An Officer of the Contractor)</i></p> <p>_____</p> <p>Signature Title</p> <p>CONTRACTOR'S NAME</p>
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**3.05 MICROFILMED RECORD DRAWINGS**

- A. The Contractor shall prepare Microfilmed Record Drawings following acceptance of the As-Built Drawings by the designated Resident Engineer.
- B. The Contractor shall maintain the original camera master film in roll form, in a covered metal container labeled with project identification and contents information.
- C. The Contractor shall furnish a typewritten index of the contents of the master film rolls.
- D. The Contractor shall deliver the master film, aperture cards and index to the designated Resident Engineer no later than 30 days after approval of the As-Built drawings.

**3.06 CD-ROMs**

- A. The individual formats required for the various CD-ROMs to be furnished by the Contractor shall be as directed by the designated Resident Engineer.

**3.07 MEASUREMENT FOR PARTIAL PAYMENTS**

- A. ATC drawings, tracings, CD-ROMs, plan books and aperture cards will be measured for payment based upon the delivery of the required As-Built drawings, tracings, CD-ROMs and aperture cards to the Train Control Rooms and to the designated Resident Engineer, and upon the approval of these items by the Authority.

**END OF SECTION**

## SECTION 16992

### ATC INSTRUCTION MANUALS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the production and furnishing of ATC Instruction Manuals, prescribes their contents, and describes the materials and general format to be used in their production.

##### 1.02 DESCRIPTION

- A. Assign a minimum of two experienced full-time personnel to the preparation of the required ATC Instruction Manuals. The preparation of the manuals shall commence immediately after the award of Contract. All required manuals shall be delivered during the field testing phase of this Contract as specified herein.
- B. All ATC Instruction Manuals shall be supplied in both printed text version and software version. Software format shall be standard, commercially available, with specific name brand to be determined, subject to the designated Resident Engineer's approval, during development of the Instruction Manuals.

##### 1.03 TYPES OF INSTRUCTION MANUALS REQUIRED

- A. Unless otherwise instructed in the section specifying the equipment, the Contractor shall provide three separate types of Instruction Manuals for the Automatic Train Control System and all items of equipment in the systems and subsystems therein:
  - 1. Operator's Instruction Manual
  - 2. Field Maintainer's Instruction Manual
  - 3. Shop Maintainer's Instruction Manual
- B. In the event the quantity of material for each type would make the manual too bulky or inconvenient to use, more than one binder may be used, but closely related subsystems shall be grouped under the same cover.
- C. The Contractor shall provide separate ATC Instruction Manuals for particular items of equipment if so specified in one or more other Sections of these Specifications.

##### 1.04 QUALITY ASSURANCE

- A. **Reproduction Quality:** The text of the ATC Instruction Manuals shall be cleanly defined and legible. It shall have the quality of line produced by a photo typesetter or laser printer.
  - 1. If a Computer-Aided Publishing System (CAP) is used (which is recommended for legibility and uniformity), the resolution shall be a minimum of 300 dots per inch, and it shall be capable of printing mixed text and graphics. Regardless of the reproduction system used, the Contractor shall submit to the designated Resident Engineer, within 30 working days of NTP, a sample of the final output for approval of the type form and legibility.
  - 2. If a computer-operated printer is used, it shall produce fully-formed letters or letters that are nearly fully-formed. Print output from printers that do not produce "lower case descenders" will not be approved. The Contractor shall use only letter quality (LQ) printers for this work.
  - 3. Printed text which obviously suffers from the effects of multiple copying will not be approved.

- B. The Contractor shall check the ATC Instruction Manuals for both form and content before submittal. Points to be checked shall include, but not be limited to, the following:
  - 1. Conformance to the Specifications
  - 2. Logical grouping and arrangement of subject matter
  - 3. Accuracy
  - 4. Legibility
  - 5. Neatness
  - 6. Line and lettering quality of figures
  - 7. Reproduction quality
  - 8. Recognition and inclusion of interfaces with other subsystems
  - 9. Binder material, labeling and adequacy of ring size

## **1.05 SUBMITTALS**

- A. Master ATC Instruction Manual List: Prior to the preparation of any ATC Instruction Manual, the Contractor shall submit, and obtain the designated Resident Engineer's approval of, a master list of all the ATC Instruction Manuals which he plans to furnish. This list shall show the separation of the manuals (for the entire Automatic Train Control System included in this Contract) into sections covering the system as a whole, and the individual subsystems, modules, and logical parts of subsystems. This list shall be entitled "Master ATC Instruction Manual List."
- B. ATC Instruction Manual Submittal Schedule: Prior to the submittal of any ATC Instruction Manual, the Contractor shall submit, and obtain the designated Resident Engineer's approval of, an ATC Instruction Manual Submittal Schedule which lists the Contractor's target dates for the submittal of all ATC instruction manuals in the first draft form. This schedule shall correspond on a one-for-one basis with the Master ATC Instruction Manual List.
- C. Manual Outline: Submit for approval, within 120 days of receipt of Notice to Proceed, a Preliminary Submittal consisting of an outline of the material to be included in each manual.
- D. First Draft Approval: Following the approval of the manual outline, submit to the designated Resident Engineer for approval, six copies of each ATC instruction manual in "first draft" form. This submittal shall take place during the construction phase of the Contract, as shown on the ATC Instruction Manual Submittal Schedule. The Contractor shall have submitted all of these manuals no later than 30 working days after field testing has begun. This will allow the review of the manuals at a time when all of the related drawings and information are available, and the approval of the manuals before use and possession of the train control equipment by the Authority.
- E. Approved ATC Instruction Manuals: When the Contractor has received written approval of his first draft submittal from the designated Resident Engineer, he shall, within 30 days, furnish 50 bound copies of each manual complete with corrections as approved. The Contractor shall also furnish at this time one unbound, unpunched master copy of each manual in an envelope, suitably marked with its contents, the number of pages in the complete manual, and the Contract number. The purpose of the master copy is to allow the Authority to produce additional copies of the manual. If the manual is to be used in a course of instruction by the Contractor as required by these Specifications, the quantity of manuals required for the course is in addition to the 50 copies required in the preceding paragraph.
- F. Previously Approved Manuals: Because of the revised requirements in this Contract, manuals approved on a previous Contract may not meet the requirements of this Section. Such manuals will not automatically be approved. The Contractor may submit, within 30 working days of NTP, a list of previously approved manuals or sections of manuals which he feels

meet the revised requirements and for which he desires approval under this Contract.

- G. Revisions :Revisions shall be made to ATC Instruction Manuals to accommodate any changes which are made in the equipment before, during or after its installation. ATC Instruction Manuals shall be up-to-date at the time revenue service begins and shall be kept up-to-date until Contract completion. Requirements for revisions to ATC Instruction Manuals are as follows:
1. Furnish with each revision submittal a replacement title page for the affected manual or manual section, with the current revision date in place.
  2. Six copies of the revision submittal shall be furnished by the Contractor and when he receives approval of the revision, he shall furnish 50 collated copies of the revisions with all pages punched. The 50 copies shall be furnished in an envelope or package marked with the Contract number, and the name and all other designations of the manual to be revised. An unbound, unpunched master copy of each revised page shall be submitted by the Contractor for the Authority's use in updating its master copy of the manual.
  3. Submit these revisions in groups which are not so small as to present a continual nuisance to the Authority and not so large that they overload review and approval personnel or delay getting needed revisions to the field.
- H. Personnel Qualifications :Submit to the Authority the names and proof of the qualifications of the personnel selected for preparing the ATC Instruction Manuals.
1. At least one person shall have demonstrated ability in the procedures of preparing manuals and shall be proficient in all of the following:
    - a. Technical Writing
    - b. Graphic Arts
    - c. Ability to read, understand and write the English Language clearly and accurately
    - d. Educational Training
  2. At least one person shall have demonstrated ability in comprehensive knowledge of the ATC system supplied by the Contractor under this Contract. Proof of this knowledge shall take the form of the following:
    - a. Specific information documenting prior experience with the design, installation and/or testing of a similar system
    - b. An engineering degree or equivalent work experience
    - c. Ability to read, understand and write the English Language clearly and accurately
    - d. Previous instruction manual experience.
  3. Proof of these qualifications may be one or more of the following items, but the submittal shall be adequate to provide that the candidate is qualified.
    - a. A resume
    - b. A certificate or diploma
    - c. A curriculum vitae
    - d. Documentary evidence of qualifications

## **PART 2 PRODUCTS**

### **2.01 BASIC REQUIREMENTS**

- A. Binder: Each ATC Instruction Manual furnished by the Contractor shall be bound in a high quality three-ring (minimum), lever operated, loose-leaf binder with the following characteristics:
1. The ring shall be sized so that all of the material in the book may be accommodated on one half of the ring when the rings are open. When the material occupies less than two thirds of a half-ring, a smaller ring size shall be selected. The maximum size of the rings shall be two and one quarter inches. When more material needs

to be bound than will fit in a two and one quarter inch ring binder, two or more binders shall be furnished with the material divided among them in a logical manner. The number of binders in a complete set of a divided manual shall be obvious from the title of each binder. If a three ring binder is used, the rings shall have the standard four and one quarter inch spacing.

2. The cover of the binder shall be constructed from rigid, heavy cardboard stock covered with cloth, or a high quality vinyl which will not become sticky or adhere to adjacent materials under conditions of heat and humidity. The color of each individual binder shall be uniform, but the colors of the various binders may vary, allowing one logical division of the material to have one color and other divisions to have their own uniform colors.
  3. A legend bearing the title of the manual shall be affixed to the outside of the binder in a manner which will last the life of the binder. The legend shall be located on the spine of the binder except that if the flat surface available on the spine is less than one inch, the legend may be located on the top half of the front cover. The legend shall contain the title of the manual and the name of the subdivision of which it is a part. Other markings such as the Contractor's name will be acceptable only if they do not interfere with, or detract from, the required legend. Such markings shall be as approved by the designated Resident Engineer.
  4. Each ATC Instruction Manual shall be equipped with a paper control device on each side of the loose leaf material to prevent punch-out of the paper margins at the holes.
- B. Dividers: Each ATC Instruction Manual shall be divided into logical sections by the use of clearly labeled tab dividers. Each divider shall bear a legend which identifies the contents of the section and is shown in the Table of Contents. The holes of the dividers shall be reinforced.
- C. Title Page: Each ATC Instruction Manual and manual section shall have a title page which explains in detail the content of the manual or manual section, its limits, and the system or subsystem of which it is a part. The title page shall also bear the name of the Contractor and the signature and title of the person designated by the Contractor as responsible for the content of the manual. The title page shall bear a numerical designation, such as a volume and part number, by which it may be uniquely identified and keyed to the Master ATC Instruction Manual List. The title page shall bear the date of the original issue (after approval) as well as the latest revision date, if any.
- D. Table of Contents:
1. Each ATC Instruction Manual shall have a Table of Contents located immediately after the title page. This table shall list all the articles that are contained within the manual and their page numbers. The articles shall be grouped into sections which correspond to the dividers. The page numbering shall list the numbers of the first and last page of each article.
  2. The text of articles which are long or cover various aspects of a subject, shall be further divided into paragraphs which are identified by headings. These headings shall be included in the Table of Contents with their page numbers.
  3. When the Table of Contents consists of more than one page, its pages shall be numbered consecutively.
  4. The Table of Contents shall account for each and every page in the manual, in a manner which will allow detection of a missing page.
- E. Composition of Each Section: Each section of an ATC Instruction Manual shall include:
1. The section title as listed in the Table of Contents;
  2. An Introduction, giving an overall view of the material covered by the section, and listing, in general terms, the equipment described;
  3. A General Description of the function of the equipment with an explanation of any

4. interfaces the equipment may have with other equipment, systems or subsystems;  
The balance of the detailed, explanatory content of the section, as required in these Specifications.
- F. Figures:
1. The manual shall utilize figures consisting of graphs, charts, drawings, diagrams and any other illustrative material in black and white, that can be reproduced by an office copier. Complicated half-tones, photographs, and colored printing may only be included by special request to, and approval of, the Engineer. The figures shall be located within the section of which they are a part and where possible, within, or following, the paragraph describing them. Figures shall be liberally utilized where they can contribute to the grasp and understanding of the subject. Each figure shall be titled. Figures shall be identified with a designation consisting of the word "Figure" (or "Fig."); the section number; a hyphen and a sequential number, starting with one at the beginning of each section. The use of drawings from the Room Book of Plans must be reproduced and included in the manual as a figure.
  2. Large size drawings may be reduced slightly for inclusion as figures in the manuals, but caution shall be exercised because the figure will not be acceptable if the information or printing becomes illegible because of excessive reduction. If large size drawings are included as figures, the drawing number, title block and border shall be removed and a figure number and proper title added. Large drawings, if used as figures, because of their size, shall be grouped together at the back of the book or in one section. These drawings shall be folded so that the page title and page number will be visible without unfolding the page.
- G. Page Size: The manual shall be composed of loose leaf pages of 60 pound paper, which are 8-1/2 inches wide by 11 inches high. To accommodate large drawings such as circuits, fold-out pages of the same weight or heavier paper may be utilized. These fold-out pages shall be a uniform size of 11 inches high by 17 inches wide. With the exception of large drawings, pages larger than 11 by 17 inches shall not be utilized and will not be approved.
- H. Page Margins:
1. Each page shall have an adequate margin at the left side for accommodating the ring holes. This margin shall not be less than one inch.
  2. Each page shall have a margin at the remaining three sides of not less than one-half inch.
  3. Page number and dates if any, shall be placed just above the bottom margin and within the side margin.
- I. Page Numbering: The pages of the section shall be identified at the bottom with a designation consisting of the section number, a hyphen, and a consecutive page number starting with one. At his option, the Contractor may precede this designation with a number or letter identifying the manner of which it is a part and a hyphen. This would provide each page with a unique number.
- J. Difficulty of Material:
1. Operator's Instruction Manuals and Field Maintainer's Instruction Manuals: The Contractor shall assume that a person reading an Operator's Instruction Manual has had the benefit of no more than a twelfth grade education, and a person reading a Field Maintainer's Instruction Manual, no more than that received through the twelfth grade plus two years in a technical school. Long and difficult words shall be avoided. Technical words may be used only where common words are inadequate, provided that words not likely to have been encountered with the education mentioned in this paragraph, are fully explained. Under no circumstances shall any form of slang, or jargon, applicable to a specific industry, be used unless it is thoroughly defined in common terms. Proper English shall be used throughout the text. All sentences shall be complete. Telegraphic or abbreviated sentences, leaving out words, such

- as "of" and "the" will not be acceptable.
2. Shop Maintainer's Instruction Manuals: The Contractor shall assume that a person reading a Shop Maintainer's Instruction Manual has received education through the twelfth grade, has had the benefit of sufficient additional education to comprehend the technical words common to the particular technology being discussed, is skilled in the use of electronic test equipment and is competent in the repair of electronic equipment. This does not however relieve the Contractor of the responsibility of explaining any technical words or procedures specific to the equipment being described. Slang or jargon shall not be used and will not be approved.

## **PART 3 - EXECUTION**

### **3.01 ORGANIZATION OF ATC INSTRUCTION MANUALS**

- A. Types of ATC Instruction Manuals: There shall be three types of manuals:
  1. Operator's Instruction Manual
    - a. This manual shall be used to describe the operation of the system and its various parts. One section of the operator's manual shall be furnished which covers the Automatic Train Control System as a whole. Other sections shall be furnished which explain the operation of each subsystem without getting into technical details of the actual functioning of the equipment. This manual shall contain, in addition to the general operation description, special operating instructions, block diagrams of the organization of the system, and information describing the relation of the system to other interface systems not covered by the manual or Contract. This manual shall be useful for training non-technical personnel in the operation of the equipment, and for purposes of overview by the Maintainers.
    - b. Sections of the Operator's Instruction Manual for separate facilities shall be kept separate. The operator of any facility shall only require a single comprehensive manual and shall not be required to refer to any other manual section.
  2. Field Maintainer's Instruction Manual:
    - a. The purpose of the Field Maintainer's Manual is to instruct the signal system maintainer in the field maintenance of all the equipment furnished by the Contractor in order to allow restoration of operation in the shortest possible time. The manual shall detail procedures for isolating trouble to the "smallest field replaceable device." The Field Maintainer's Manual shall contain complete technical descriptions of the operation of each and every item of equipment.
    - b. One manual section shall be supplied for each piece of equipment, or family of equipment in the Automatic Train Control System.
    - c. These manual sections shall include where applicable, but not be limited to, the following:
      - 1) Equipment Arrangement Drawings
      - 2) Module Arrangement Drawings
      - 3) Connection Wiring Diagrams
      - 4) Test Procedure Descriptions
      - 5) Routine Maintenance Procedures
      - 6) Special Maintenance Procedures
      - 7) Methods and Description of Repairs
      - 8) Trouble-Shooting Guide
      - 9) Trouble-Shooting Procedure Description
      - 10) List of Recommended Trouble-Shooting Test Equipment
      - 11) List of Spare Parts, to the board module level, with recommended

quantities

12) List of Special Tools

3. Shop Maintainer's Instruction Manuals:

- a. The Contractor shall furnish Shop Maintainer's Manuals for each piece of equipment which cannot be fully maintained in the field. This equipment will usually be of the type where the "smallest field replaceable device" is a printed circuit board or an electrical or mechanical subassembly.
- b. The Shop Maintainer's Manual shall provide all the information necessary for the trouble isolation and repair of the "smallest field replaceable device."
- c. When other sections of these Specifications require the Contractor to furnish special test equipment or test fixtures, the Shop Maintainer's Manual shall contain procedures which will instruct the Authority's maintenance personnel in the use and maintenance of this test equipment. These manuals shall provide all the necessary information for the shop maintenance of the equipment to the component level.
- d. These manuals shall contain, but not be limited to, the following:
  - 1) A technical operational description and schematics with full technical detail
  - 2) Maintenance Procedures for the unit
  - 3) Methods and Description of Repair and Calibration
  - 4) Point by point voltage charts
  - 5) A waveform analysis
  - 6) List of Spare Parts, to the component level, with recommended quantities. This shall include all items not included in the Field Maintenance Manual.

- B. Manual Organization: The Contractor shall key each ATC Instruction Manual and manual section to a submitted and approved Master ATC Instruction Manual List with a suitable numbering and titling system.

### 3.02 MEASUREMENT FOR PARTIAL PAYMENTS

- A. ATC Instruction Manuals will be measured for partial payments based upon the delivery of the required number of manuals to the Authority for preliminary approval, upon delivery of the required number of up-to-date manuals, and upon final approval of the updated manuals by the Authority.

**END OF SECTION**

## SECTION 16993

### ATC TRAINING COURSES

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. This Section specifies the basic requirements for training courses and associated training material which shall be provided by the Contractor in relation to certain items of ATC equipment or systems included in this Contract. These training courses shall be provided by the Contractor for those items of ATC equipment or systems which are to be used for the first time on the WMATA Metrorail System, and for certain other ATC equipment and systems specifically designated in other Sections of these Specifications. Further requirements for ATC training courses shall be as specified in the articles of these Specifications which describe the requirements for those items of equipment or systems.

##### 1.02 DESCRIPTION

- A. The ATC training courses shall include, but not be limited to, classroom courses of instruction for Authority-designated training instructors and maintenance personnel. The presentations shall include reference manuals, guides and, when required in other Sections of these Specifications, "hands-on" instruction for each participant. The presentations shall enable the participant to fully understand the use, servicing and maintenance of the equipment or system for which training is required. The training courses shall conform to the requirements of this Section and the other Sections of these Specifications which require them. The training courses shall be complete in all respects and shall be subject to the approval of the designated Resident Engineer who will be responsive to the needs of the WMATA Office of Quality Assurance and Training.
- B. The Contractor shall provide training courses for certain items of ATC equipment or systems as designated by the Section of these Specifications which describes the requirements of those items or systems. In addition, that Section will specify the following characteristics of the training program which shall be provided by the Contractor:
  - 1. The category of Authority personnel for whom the course is intended.
  - 2. The educational level for which the training program shall be written.
  - 3. Any "hands-on" training which the Contractor shall provide.
  - 4. Any special training equipment which the Contractor shall provide.
  - 5. The number of classes which the Contractor shall provide.
  - 6. The size of the classes for which the Contractor shall provide training.
  - 7. The number of days of instruction which the Contractor shall assign to each course of training.
  - 8. Whether a refresher course will be required and the duration and number of participants of the refresher course.
- C. The documents and the presentation for the training courses shall be written or presented in good English, utilizing all of the usual verbs and articles and they shall utilize a vocabulary consistent with the educational level of the course participant as specified in the article of these Specifications which requires the training course. This instructional material shall not be written in outline or "telegraphic" format. Highly technical or seldom used words shall be avoided. All necessary technical words shall be defined and explained, both in the written documents and in the verbal presentation.
- D. The Authority reserves the right to videotape or otherwise record any or all training performed by the Contractor. The Contractor shall cooperate with the designated Resident Engineer in facilitating any such recording effort by the Authority.

### 1.03 QUALITY ASSURANCE

- A. All printed materials necessary or required as an adjunct to the educational program shall be first quality and shall meet the following requirements:
1. The text of the material shall be cleanly defined and legible. It shall have the quality of line produced by a photo typesetter or laser printer.
  2. If a computer-aided publishing system (CAP) is used (which is recommended for legibility and uniformity) the CAP shall have a minimum resolution of 300 dots per inch. If a CAP is used, the Contractor shall submit to the designated Resident Engineer within 30 working days of Notice-To-Proceed, a sample of the final output for approval of the type form and legibility.
  3. If any form of computer based word processor is used, it shall be capable of printing mixed text and graphics.
  4. If a computer-operated printer is used, it shall produce fully formed letters or letters that are nearly fully formed. Print output from printers that do not produce "lower case descenders" will not be approved. The Contractor shall use near letter quality (NLQ) printers, or better, for this work.
  5. Printed text or graphic figures which obviously suffer from the effects of multiple copying will not be approved.
  6. All written courseware deliverables shall include complete camera-ready copy.
- B. All verbal training program instructions shall be clearly presented in a logical form which follows the outline closely. They shall be presented by a person who fully understands the system and who has received formal training in the delivery of such presentations.
- C. The Contractor shall check the presentation for both form and content before submittal or presentation. Points to be checked shall include, but not be limited to, the following:
1. Conformance to the requirements of these Specifications.
  2. Logical grouping and arrangement of subject matter.
  3. Accuracy.
  4. Correspondence between printed material, graphic material and the verbal presentation.
  5. Legibility.
  6. Intelligibility.
  7. Neatness.
  8. Line and lettering quality.
  9. Reproduction quality
  10. Inclusion of material describing the interfaces with other systems.

## PART 2 - PRODUCTS

### 2.01 BASIC REQUIREMENTS

- A. Provide the following four types of training courses in the manner specified. Each course shall be tailored to the specific equipment as supplied by the Contractor to WMATA.
1. Operator's Training Course: This course shall be designed to teach, to the course participant, the day-to-day operation of the equipment. This training shall be sufficient to bring the course participant to a level of operating proficiency such that routine vendor support is not needed.
  2. Field Maintainer's Training Course: This course shall be designed to teach, to the course participant, the knowledge and skills necessary for the field maintenance of the items of equipment or systems for which the training course is required. Field maintenance shall be understood to be that level of maintenance necessary to allow maintenance personnel to isolate troubles to the printed circuit board level and restore service by board replacement (and readjustment if necessary).

3. Shop Maintainer's Training Course: This course shall be designed to teach, to the course participant, the knowledge and skills necessary for the shop maintenance of all of the items of equipment or systems for which the training course is required. Shop maintenance shall be understood to be that level of maintenance necessary to allow maintenance shop personnel to isolate troubles to the component level and restore the printed circuit boards to operational status. The Contractor shall assume that the personnel performing these maintenance procedures are proficient in the skills necessary for the repair of printed circuit boards. This training shall include instruction in the following items:
    - a. The theory of operation, detailed to the system, module, board and board component level.
    - b. Component level troubleshooting and component replacement information.
    - c. Testing and alignment (adjustment) procedures of the repaired units.
  4. Refresher Course: This course, if required by an equipment specification Section, shall be designed to refresh the memories and job-related skills of former course participants. It shall be held on the Authority's premises for the specified number of participants and days, at a mutually acceptable date within one year of completion of the Contract. This refresher course shall be provided at no additional cost to the Authority.
- B. Unless otherwise specified, the course shall be presented before the completion of installation of the equipment for which the training course is intended.
  - C. If changes are made to the equipment during the course of the Contract, the Contractor shall update the training course material immediately. If the changes are the result of errors or miscalculations on the part of the Contractor, all costs for the change shall be borne by the Contractor at no additional cost to the Authority.
  - D. Unless otherwise specified in the article specifying the equipment, the Contractor shall assume for purposes of course development and presentation, that all WMATA students are high school graduates (or equivalent), and that maintenance personnel will already possess the ability to use basic hand tools and simple electronic test equipment.
  - E. The Contractor shall prepare and present to each course participant one or more written and/or practical tests to determine the knowledge transference resulting from the course presentation. The results of this testing shall be tabulated and presented to the designated Resident Engineer to be forwarded to the Rail Training branch. Satisfactory results will serve as evidence of the satisfactory fulfillment of the requirements for the course presentations.
  - F. Course material shall be provided for each course and shall consist of the following items:
    1. Instructor's Guide
      - a. This guide shall contain all the information and directions necessary for the instructor to make an effective presentation. It shall include the guidelines necessary to conduct a comprehensive training program.
      - b. The instructor's guide shall be complete enough and sufficiently detailed enough to allow a WMATA staff instructor to hold additional courses from time to time.
      - c. Individual lessons within the course shall be organized as separate modules (blocks) which may be taught as a unit. Each module shall cover completely one or more subjects or aspects of a subject. In some instances the same module may be used in more than one course. An example of this would be a section on the basic fundamentals of the operation of a microprocessor which could be used in both the field and shop level courses.
      - d. The guide shall be organized with each page divided into two columns. (The page width shall be 11 inches and the height 8-1/2 inches less a

- binding edge of 1-1/2 inches.) The left column shall be the instructional text and the right column the Instructor's directions for conducting the course.
- e. The Instructor's guide shall contain as a minimum, the following items:
    - 1) A statement of the overall program goals and course objectives.
    - 2) A lesson plan containing the following:
      - a) Student learning objectives, stated in measurable terms.
      - b) An overview of each lesson.
      - c) Suggested instructional methods.
      - d) Suggested learning activities.
      - e) Instructions for use of the required equipment.
      - f) A listing of references and resources.
      - g) A listing of where in the course, the audio-visual aids and mock-ups are to be used.
    - 3) An evaluation module, which contains instructions for presenting written or practical tests designed to measure the extent to which the course participants have attained the course objectives. An answer key shall be included for each of the tests.
  - f. At the conclusion of the course presentation, the Contractor shall revise the Instructor's guide with all changes resulting from the presentation, class questions and Authority comments. When approved by the designated Resident Engineer, the Contractor shall provide one camera-ready document and five copies of the revised Instructor's Guide for the Authority's Training Facility.
2. Student's Guide
- a. The Student's Guide shall include all materials necessary for the student to interact in the learning situation. The Student's Guide shall be similar to the Instructor's Guide except the portions of the Instructor's Guide devoted to directions for the instructor shall be left blank as a space for the students' notes. It shall contain as a minimum, the following items:
    - 1) A program overview.
    - 2) An introduction or preface.
    - 3) A statement of overall program goals.
    - 4) A statement of learning objectives, stated in measurable terms, that specifically describes desired behavior, procedures or knowledge to be gained by the student.
    - 5) A fully developed written presentation of the course content which is developed in the same modular organization as the Instructor's Guide.
    - 6) Illustrations, graphs, charts or tables as necessary to enhance the presentation and increase student understanding.
  - b. When the Student's Guide has been approved by the designated Resident Engineer, the Contractor shall provide one copy for each class participant. Five approved copies of the guide shall be provided, through the designated Resident Engineer, for the training facility Rail Technical Library. One camera-ready copy of the approved Student's Guide shall be provided, through the Engineer, for the training facility.
3. Audio-Visual Aids
- a. Audio-visual aids shall be used to enhance the course presentation wherever they will be helpful in increasing the student's comprehension of the subject. The Contractor shall consider and use, where appropriate, the following items:
    - 1) Handouts
    - 2) Transparencies
    - 3) Slides
    - 4) Films and/or Video Tapes
    - 5) Mock-ups

4. Supplemental Materials:
  - a. Applicable supplemental materials such as equipment setups, test fixtures, special tools, regulatory manuals or books shall be furnished by the Contractor and integrated into the various training courses required.
  - b. Interactive Video: Interactive video tapes may be utilized by the Contractor, with the Authority's permission, in lieu of, or in addition to, one or more sections of the live course presentation as required by the article of these Specifications which requires the training course. The Contractor shall submit the tape, or a detailed description of its contents and the depth of its instruction, to the designated Resident Engineer at least 60 days before the course is to be presented. The designated Resident Engineer will forward the tape or description to the WMATA Office of Quality Assurance and Training for approval. The Contractor will not be permitted to use such tapes as part of the course presentation(s) unless approval has been obtained from the designated Resident Engineer prior to the scheduled presentation date.

### **PART 3 - EXECUTION**

#### **3.01 COMMENCEMENT OF TRAINING PROGRAM WORK**

- A. The Contractor shall commence work on the ATC training program as soon as he is given the Notice-To-Proceed. Work on the training courses required in these Specifications shall be performed by a person whose primary responsibility is the production of the training courses required by these Specifications. The person charged with this responsibility shall not only be familiar with the production of training courses, but also must have a comprehensive understanding of the adult learning process and be familiar with the equipment for which the students are being trained.

#### **3.02 SUBMITTALS**

- A. The following documents shall be submitted to the designated Resident Engineer for approval at the time required. These submittals will also serve as proof that the training course is on schedule. (Payments for certain equipment will be linked to successful course completion as specified in Part 3.04 of this Section.) The documents to be submitted are:
  1. Training Course Schedule: The Contractor shall submit, within 45 calendar days of the Notice-To-Proceed, a training course schedule which provides the dates when all of the events required in this article will take place. This schedule shall include, but not be limited to:
    - a. The dates when the submittals will be received by the designated Resident Engineer.
    - b. The dates when training materials will be shipped.
    - c. The dates when the courses will be held.
  2. Instructor's Guides: The Contractor shall submit preliminary versions of the required Instructor's Guides within 60 calendar days of the Notice-To-Proceed.
  3. Student's Guides: The Contractor shall submit preliminary versions of the required Student's Guides according to the approved Instructor's Guide submittal. These manuals shall be in the designated Resident Engineer's hands at least 45 calendar days before the course is to be presented. Unless otherwise specified, the course shall be presented before the completion of installation of the equipment for which the training course is intended.
  4. Documents and Materials: All training documents, materials and supplemental materials required by these Specifications shall be delivered to the designated Resident Engineer at least 10 working days before the date of the course presentation. The designated Resident Engineer will forward all approved training

documents and materials directly to the WMATA Office of Quality Assurance and Training.

### 3.03 INSTRUCTOR QUALIFICATIONS

- A. The Contractor shall submit to the designated Resident Engineer for approval by the WMATA Office of Quality Assurance and Training at least 60 calendar days prior to the presentation of the training course, a description of the instructor's teaching qualifications. This description shall document a thorough knowledge of the functioning of the equipment for which the course is intended, an understanding of the adult learning process, and demonstrated experience in vocational instruction.
- B. Proof of these qualifications may be one or more of the following items, but the submittal shall be adequate to prove that the candidate meets the above requirements and is a qualified instructor:
  - 1. A resume
  - 2. A copy of a certificate or diploma
  - 3. A curriculum vitae
  - 4. Documentary evidence of technical and instructional qualifications

### 3.04 MEASUREMENT FOR PARTIAL PAYMENTS

- A. Training Courses will be measured for partial payments based upon:
  - 1. Timely delivery by the Contractor and approval by the designated Resident Engineer of the Training Course Schedule
  - 2. Timely delivery by the Contractor and approval by the designated Resident Engineer of all course materials
  - 3. Timely delivery by the Contractor of special training equipment which has been approved by the designated Resident Engineer
  - 4. Completion of the approved course presentation(s) in a manner satisfactory to the designated Resident Engineer.

### 3.05 PAYMENT

- A. The sum of payments for ATC Training Courses included under this Contract, will equal the Lump Sum Price listed in the Unit Price Schedule for:ATC TRAINING COURSES
- B. The Lump Sum Price for the ATC Training Courses listed in the Contract shall be divided by the number of courses required by the Contract, to produce the total payment per course. Payments for each course will be made as specified below:
  - 1. Upon delivery of the ATC Training Course Schedule 25% of Course Total
  - 2. Upon delivery of all ATC course materials and special training equipment 25% of Course Total
  - 3. Upon the successful completion of all of the course presentations as approved by the designated Resident Engineer 50% of Course Total

**END OF SECTION**

**SECTION 16994**

**ATC APPENDIX "C"  
INDEX OF ATC DRAWINGS**

**PART 1 - GENERAL**

**1.01 SECTION INCLUDES**

- A. A numerical listing of all ATC drawings in these Contract Documents.

**PART 2 - PRODUCTS**

**2.01 INDEX OF ATC DRAWINGS**

- A. NOTE: Drawing numbers not shown are not used in this Contract.

COVER PAGE

<u>File No.</u>	<u>Drawing Number</u>	<u>Rev. No.</u>	<u>Title</u>
M1xxx-001	ATCX-G-001		Key Plan
M1xxx-002	ATCX-G-002		Index of Drawings - Sheet 1

**Additional Drawings to be added as applicable  
Substitute applicable Route Designation letter for letter "X" following "ATC".**

**PART 3 - EXECUTION  
NOT USED**

**END OF SECTION**

**SECTION 16995**

**ATC APPENDIX "L"**

**ATC DESIGN, SUBMITTAL, ACCESS, ENERGIZATION AND COMPLETION SCHEDULE**

**PART 1 - GENERAL**

**1.01 SECTION INCLUDES**

- A. ATC Block Design Submittal Dates
- B. ATC Access Dates for Train Control Room(s)
- C. ATC Access Dates for Trackway(s)
- D. ATC Interim Completion Dates
- E. Propulsion Power Energization Dates
- F. Final ATC Installation and Testing Completion Dates
- G. Final ATC System Completion Date

**1.02 ATC DESIGN AND SUBMITTAL DATES**

- A. Preliminary Field Inspection Report: Within \_\_\_\_ Days of Field Inspection
- B. Block Design Simulation Program Flow Charts: No later than \_\_\_\_ Days Prior to ORD
- C. ATP Speed Command Control Line Diagrams: No later than \_\_\_\_ Days Prior to ORD
- D. Block Design Calculations: No later than \_\_\_\_ Days Prior to ORD
- E. Block Design Simulation Runs: No later than \_\_\_\_ Days Prior to ORD
- F. ATC Equipment Submittals: TBD
- G. Signal Cable Submittals: TBD (See Section 16949)
- H. Factory Test Procedures: TBD
- I. Field Test Procedures: TBD
- J. Factory Test Reports: TBD
- K. Field Test Reports
  - 1. Static Testing: TBD (See SECTION 16980)
  - 2. Dynamic Testing: TBD (See SECTION 16980)
- L. ATC Drawing Submittals: TBD (See Section 16991)
- M. ATC Instruction Manuals: TBD (See Section 16992)
- N. ATC Training Course Outlines: TBD (See Section 16993)

O. ATC Training Course Instructor Qualifications: TBD (See Section 16993)

P. Final Documentation: TBD (See Section 16911)

**1.03 TABULATION OF ATC ACCESS, ENERGIZATION AND COMPLETION DATES BY APPLICABLE FIELD LOCATION**

A. (To be provided by the Authority for the specific Project involved.)

**PART 2 - PRODUCTS**  
(NOT USED)

**PART 3 - EXECUTION**  
(NOT USED)

**END OF SECTION**

**SECTION 16996**  
**ATC TECHNICAL APPENDIX**

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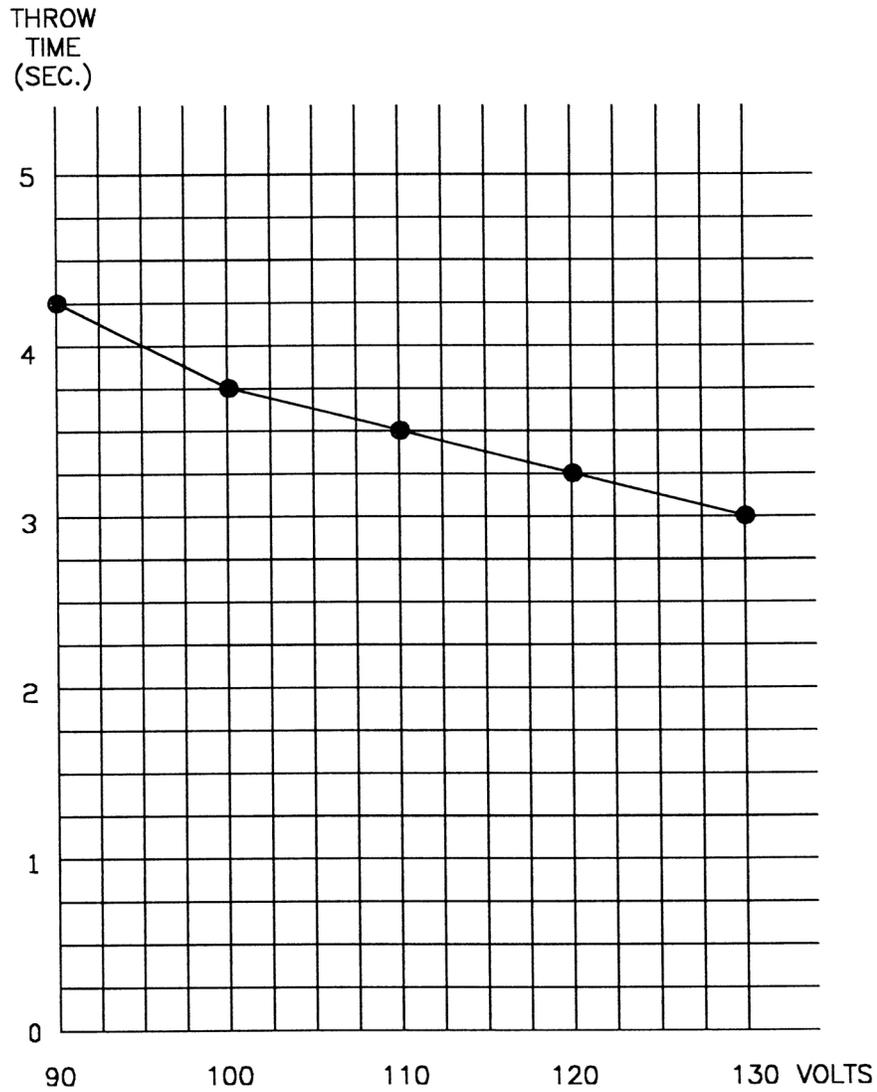
**SECTION 16996**

**ATC TECHNICAL APPENDIX**

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(Continued)**

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SWITCH OPERATING TIME vs. VOLTAGE



WHEN SWITCH-AND-LOCK MOVEMENT OPERATING VOLTAGE IS BETWEEN 90 VOLTS AND 130 VOLTS, SWITCH OPERATING TIME SHALL BE LESS THAN THE MAXIMUM THROW TIME INDICATED ABOVE.

$$\text{FOR } V=90-100, \quad T= 8.75 - .05 \times V$$

$$\text{FOR } V=100-130, \quad T= 6.25 - .025 \times V$$

TABLE OF DWELL TIMES

**EXAMPLE:**

<u>STATION NAME</u>	DWELL TIMES IN SECONDS			
	<u>Min. Dwell</u>	<u>Norm. Dwell</u>	<u>Max. Dwell</u>	<u>Actual Setting</u>
<b>"G" Route - Outbound - Addison Road to Largo Town Center</b>				
Addison Road	20	25	30	25
Summerfield	20	25	30	25
Largo Town Center	30	35	40	35
<b>"G" Route - Inbound - Largo Town Center to Addison Road</b>				
Largo Town Center	30	35	40	35
Summerfield	20	25	30	25
Addison Road	20	25	30	25

BASIC TRANSIT VEHICLE CHARACTERISTICS  
(SHEET 1 OF 2)

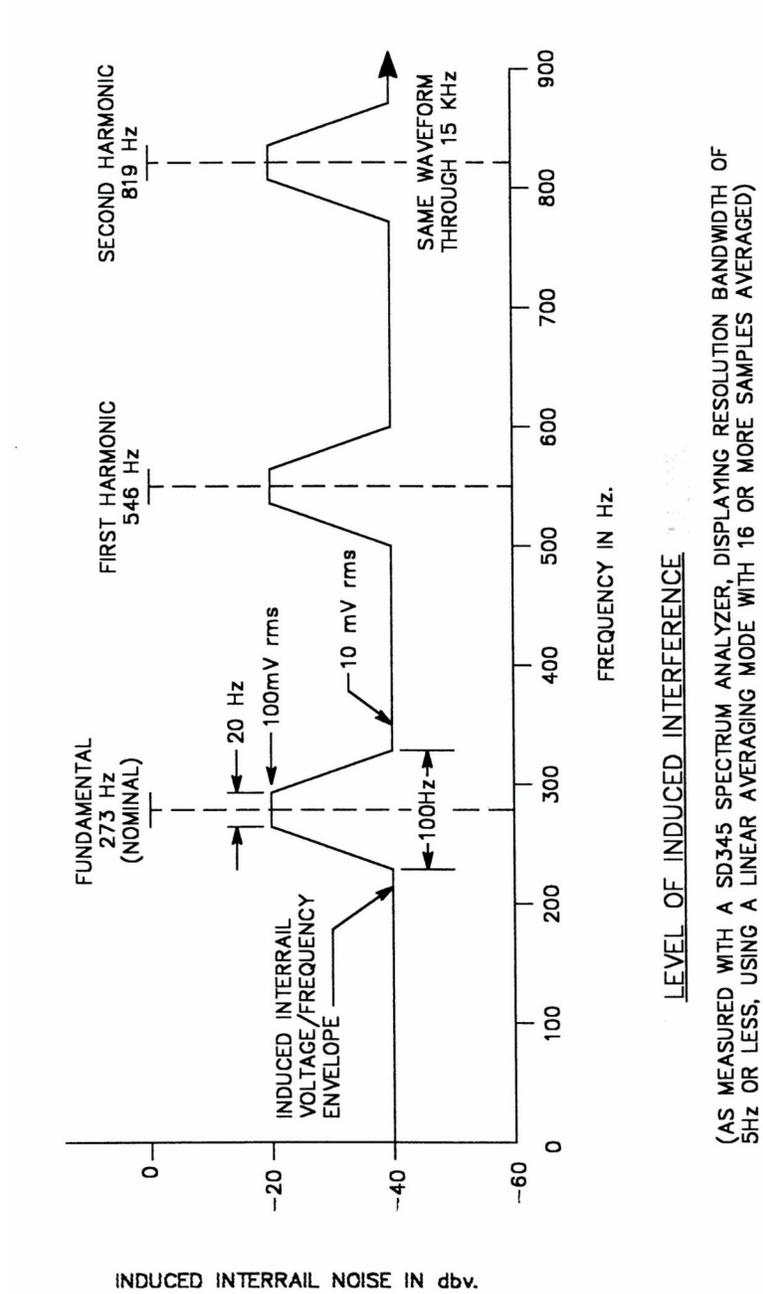
<u>CHARACTERISTIC</u>	<u>BREDA CARS</u>		<u>BREDA CARS</u>		<u>ROHR CARS</u>		<u>CAF CARS</u>	
	<u>Cam Type</u>	<u>Chopper Type</u>	<u>Chopper Type</u>	<u>4000 Series</u>	<u>A.C. Motors</u>	<u>1000AC Series</u>	<u>A.C. Motors</u>	<u>5000 Series</u>
Car Number Series	<u>2000 Series</u>	<u>3000 Series</u>						
Car Weight, empty:	78,500 lbs.	79,800 lbs.		80,000 lbs.		72,000 lbs.		90, ??? Lbs.
Car Length:	75.00 ft.	75.00 ft.		75.00 ft.		75.00 ft.		75.00 ft.
Car Width:	10.13 ft.	10.13 ft.		10.13 ft.		10.15 ft.		10.15 ft. ?
Car Frontal Area:	92 sq. ft.	92 sq. ft.		92 sq. ft.		92 sq. ft.		
Trucks:	SOFER - Rigid Frame, - Chevron Spring/ Air Suspension		SOFER-Rigid Frame - Chev. Spring/Air Suspension		Rockwell HPD-4, Air Suspension		???????	
Truck Centers:	52 ft.	52 ft.		52 ft.		52 ft.		52 ft.
Truck Wheel Base:	7.55 ft.	7.55 ft.		7.55 ft.		7.25 ft.		7.55 ft. ?
Wheel Dia. - New:	28 in.	28 in.		28 in.		28 in.		28 in.
Fully Worn:	25 in.	25 in.		25 in.		25 in.		25 in.
Motors:	4 - Westinghouse Elec. Type 1462BA	4 - W.E. Type 1462E1				4 - G.E. Type 5GE- B14A1		4 - C/D/B Type ????
Propulsion Voltage 3rd rail - nominal:	[----- 750 V dc; +30V/-100V -----]							
Maximum Time to Remove Power	1.50 sec.	1.50 sec.		1.50 sec.		1.50 sec.		1.50 sec.?
0 to 40 MPH:	1.06 sec.	1.06 sec.		1.06 sec.		1.06 sec.		1.06 sec.?
41 to 70 MPH:	0.35 sec.	0.35 sec.		0.35 sec.		0.35 sec.		0.35 sec.?
71 MPH & Up:								
Maximum Brake Buildup Time:	1.0 sec.to Full Svc.	1.0 sec. to Full Svc.		1.0 sec. to Full Svc.		1.2 sec.to Full Svc		1.2 sec.to Full Svc.

BASIC TRANSIT VEHICLE CHARACTERISTICS  
(SHEET 2 OF 2)

<u>CHARACTERISTIC</u>	<u>BREDA CARS</u> <u>Cam Type</u>	<u>BREDA CARS</u> <u>Chopper Type</u>	<u>ROHR CARS</u> <u>A.C. Motors</u>	<u>CAF CARS</u> <u>A.C. Motors</u>
Car Number Series	<u>2000 Series</u>	<u>3000 Series</u>	<u>1000AC Ser.</u>	<u>5000 Series</u>
Maximum Seating Capacity/Car:	68 psgrs.	68 psgrs.	81 psgrs.	<b>68 psgrs.?</b>
Seated Load/Car at 150 lbs./psgr.:	10,200 lbs.	10,200 lbs.	12,150 lbs.	<b>10,200 lbs.?</b>
Nominal Load/Car:	175 psgrs.	175 psgrs.	160 psgrs.	<b>175 psgrs.?</b>
at 150 lbs./psgr.:	26,250 lbs.	26,250 lbs.	24,000 lbs.	<b>26,250 lbs.?</b>
Crush Load/Car:	232 psgrs.	232 psgrs.	220 psgrs.	<b>232 psgrs.?</b>
at 150 lbs./psgr.:	34,800 lbs.	34,800 lbs.	33,000 lbs.	<b>34,800 lbs.?</b>
Nom. gross wt./car in working order:	104,750 lbs.	105,750 lbs.	96,000 lbs.	<b>106,???</b> lbs.
Max. gross wt./car (Crush Load):	113,300 lbs.	114,300 lbs.	105,000 lbs.	<b>114,???</b> Lbs.
Train Consist:	[-----1 to 4 married pairs (2, 4, 6, or 8 cars)-----]	[-----1 to 4 married pairs (2, 4, 6, or 8 cars)-----]	[-----600 feet-----]	[-----]
Max. Train Length:	[-----]	[-----]	[-----]	[-----]
Max. Acceleration on level, tangent track:	2.85 mphps +2/-0%	2.85 mphps +2/-0%	2.85 mphps +1/-0%	<b>2.85 mphps +2/-0%</b>
Full Service Brake Rate (Neg. Level 4) 0 mph to 50 mph: 50 mph to 75 mph:	2.2 mphps [-----]	2.2 mphps [-----]	2.2 mphps [-----]	<b>2.2 mphps [-----]</b>
Maximum Jerk Rate: Max. acceleration step change over 0.25 sec.:	2.2 mphpsps	2.2 mphpsps	2.0 mphpsps	<b>2.2 mphpsps</b>
	0.6 mphpsps	0.6 mphpsps	0.6 mphpsps	<b>0.6 mphpsps</b>

GRAPH 1

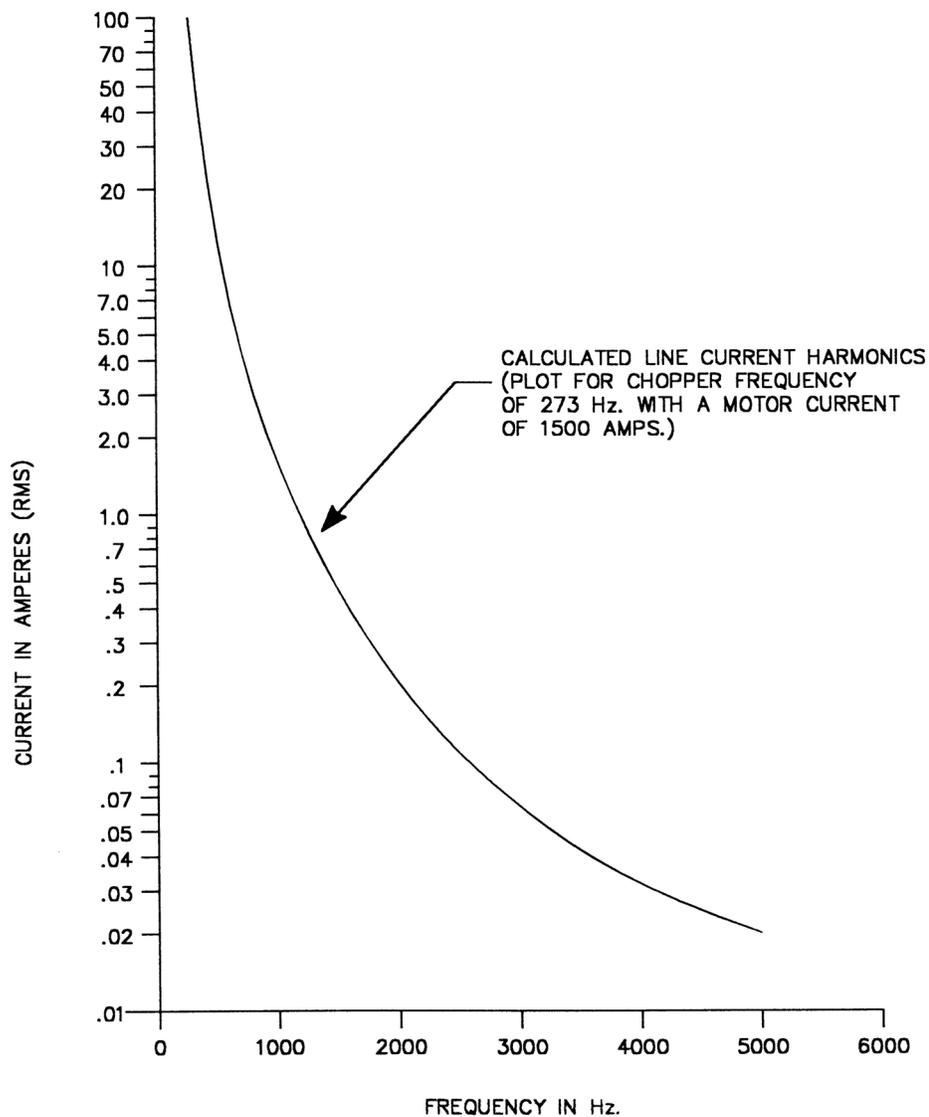
LEVEL OF INDUCED INTERFERENCE BY CHOPPER CONTROLLED TRANSIT VEHICLE



LEVEL OF INDUCED INTERFERENCE  
(AS MEASURED WITH A SD345 SPECTRUM ANALYZER, DISPLAYING RESOLUTION BANDWIDTH OF 5Hz OR LESS, USING A LINEAR AVERAGING MODE WITH 16 OR MORE SAMPLES AVERAGED)

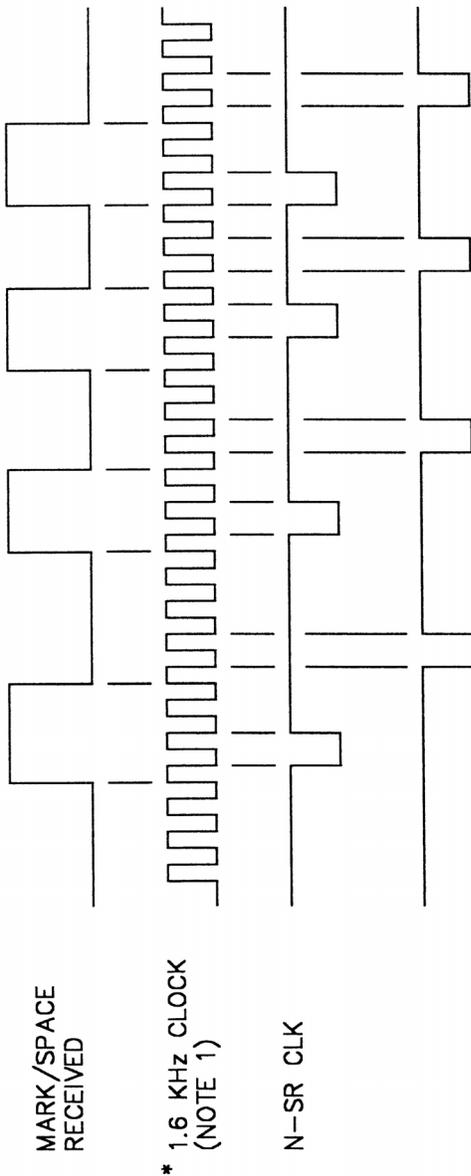
GRAPH 2

LEVEL OF CONDUCTIVE INTERFERENCE  
BY CHOPPER CONTROLLED TRANSIT VEHICLE



LEVEL OF CONDUCTIVE INTERFERENCE

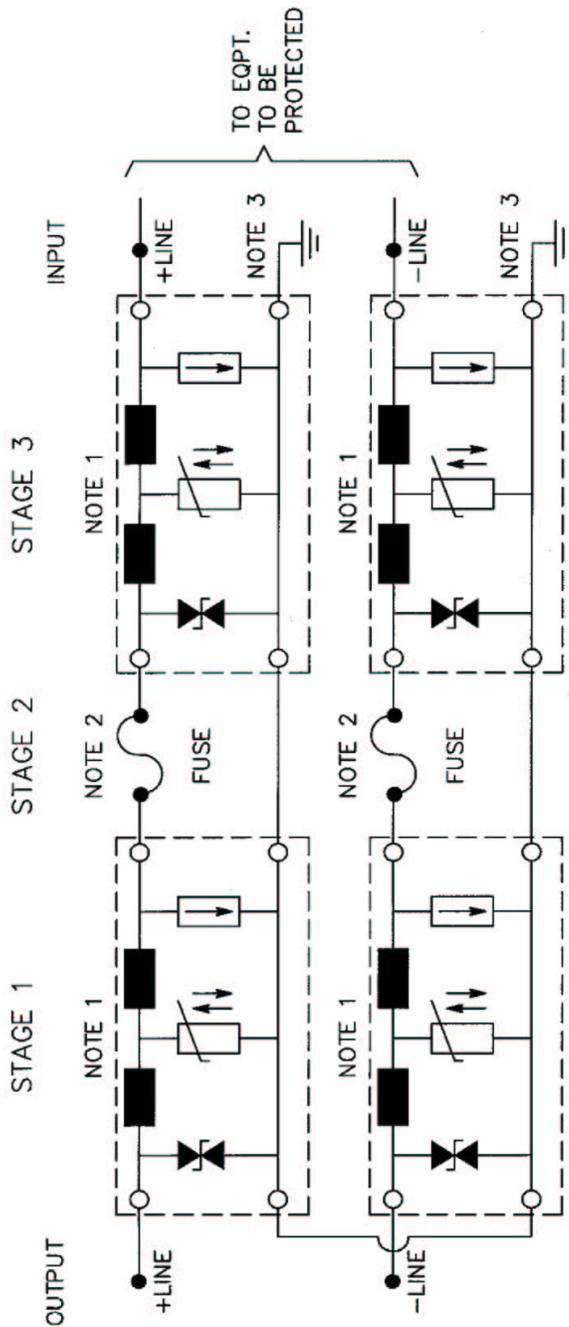
MASTER TIMING FOR TWC RECEIVERS



\* NOTE: 1. ON TWC FLYBY RECEIVER 1.6 KHz CLOCK IS INTERNALLY GENERATED. ON STATION TWC RECEIVER 1.6 KHz CLOCK SIGNAL IS RECEIVED FROM STATION TWC TRANSMITTER.

MASTER TIMING FOR TWC RECEIVERS

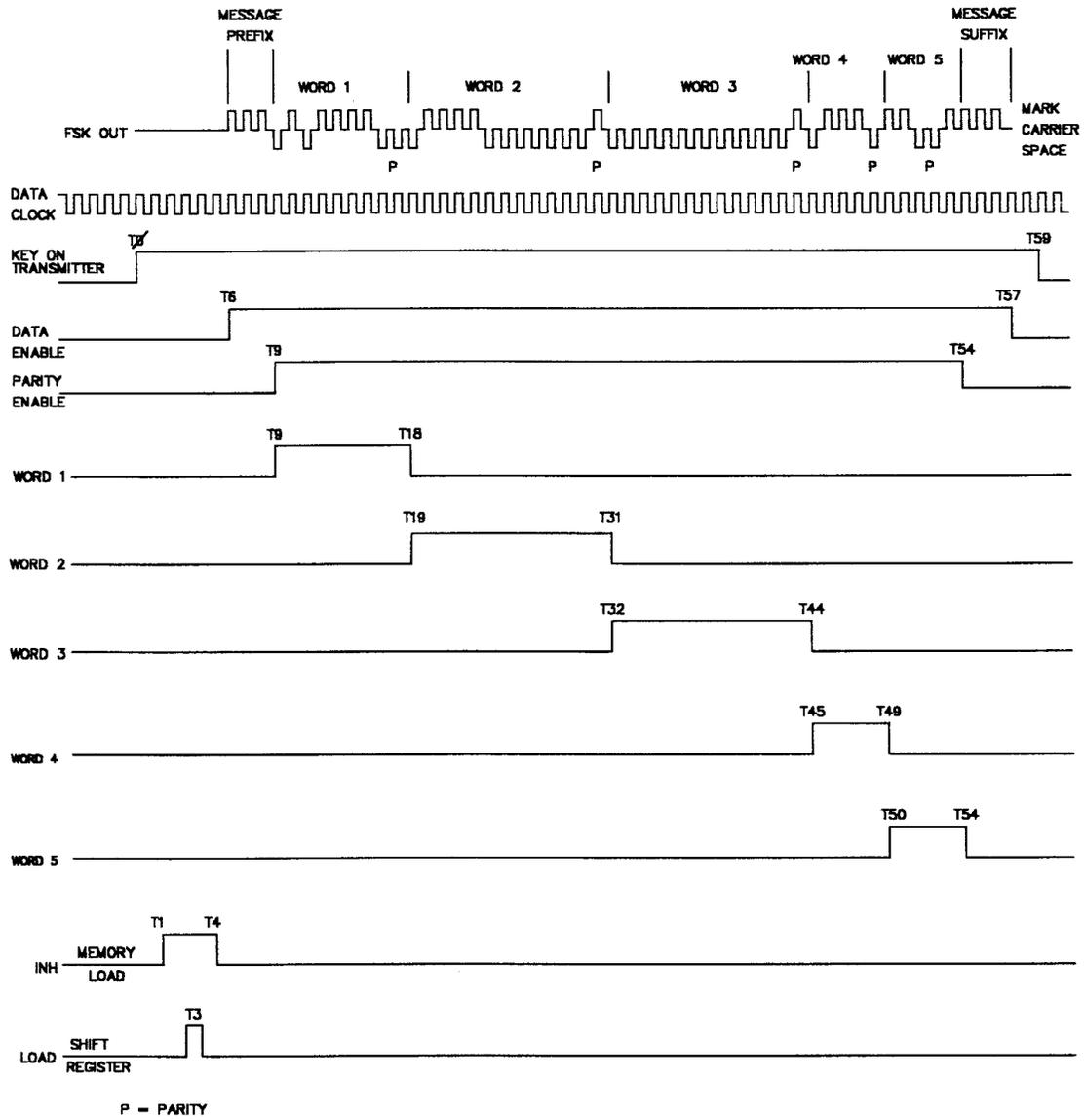
# THREE-STAGE SECONDARY SURGE PROTECTION



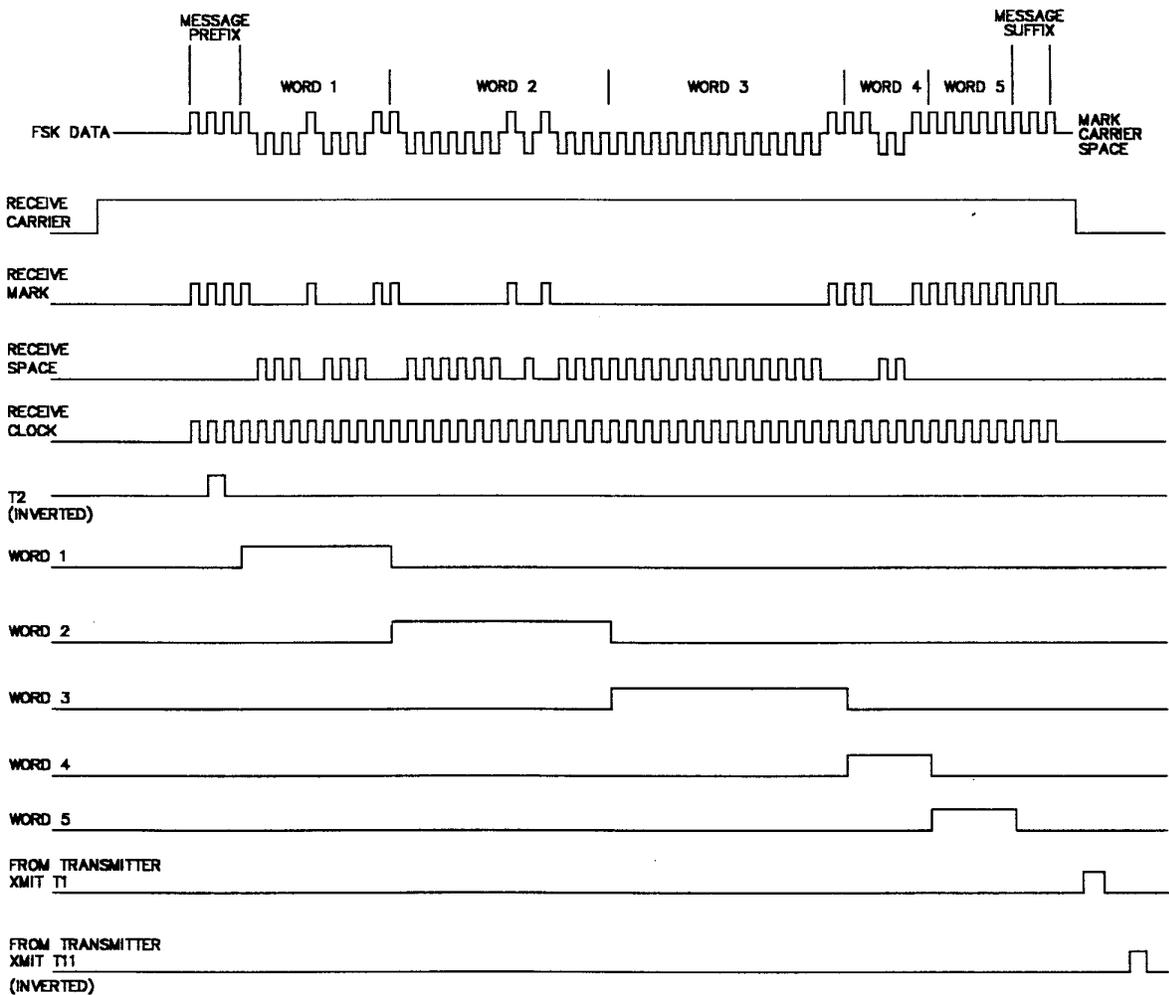
## NOTES:

1. OVERVOLTAGE DEVICES SHALL BE WEIDMULLER DKU-24DC.
2. FUSES SHALL BE RATED AT MAXIMUM CURRENT LINE DRIVER DEVICES CAN DELIVER.
3. ALL CONNECTIONS TO GROUND SHALL BE AS SHORT AS POSSIBLE. THE GROUND OF THE SURGE PROTECTION SHALL BE THE GROUND OF THE SURROUNDING STRUCTURE. THE SURROUNDING STRUCTURE SHALL BE GROUNDED DIRECTLY TO EARTH GROUND BY A METHOD APPROVED BY THE ENGINEER.

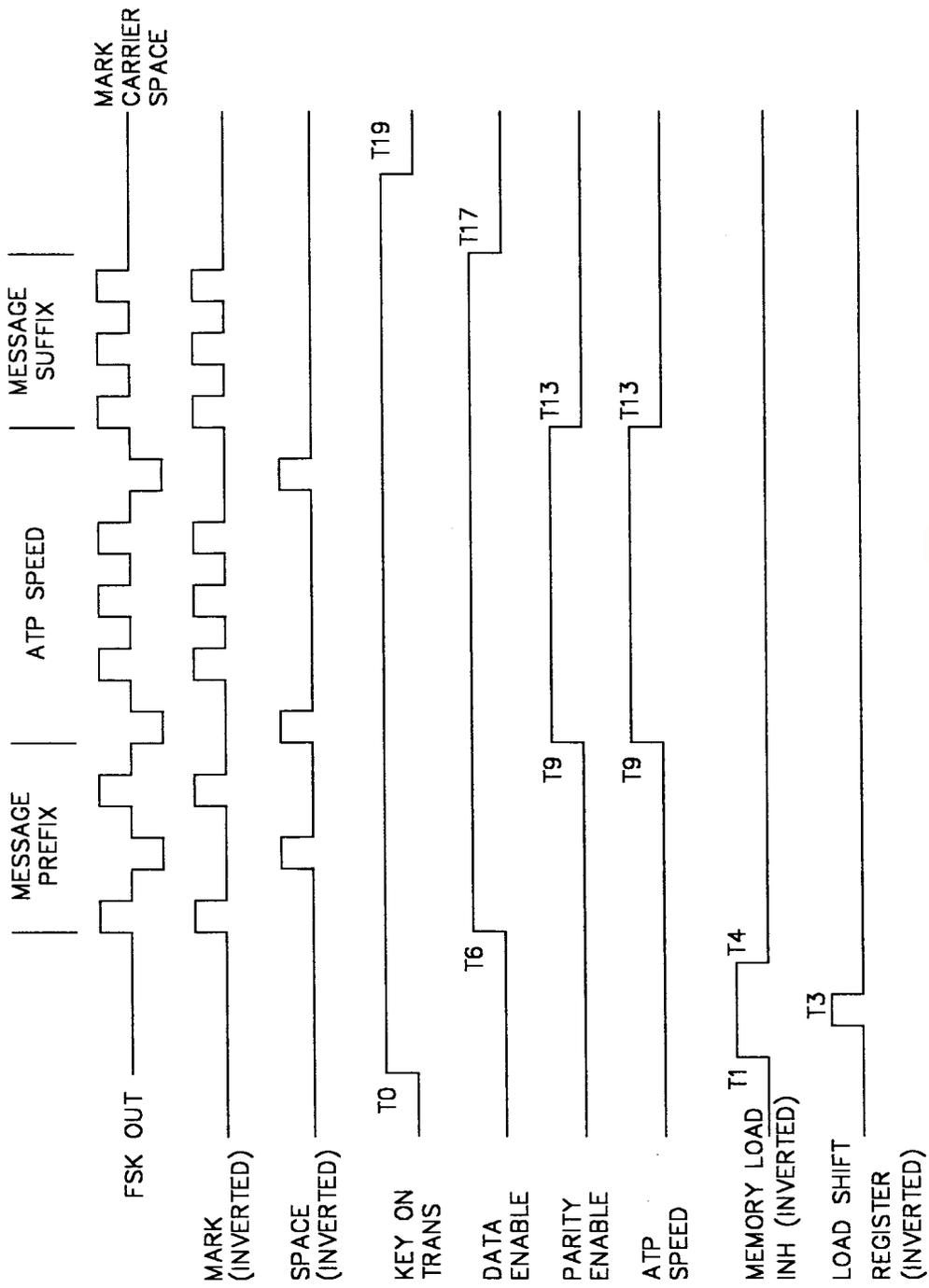
# TWC STATION TRANSMITTER TIMING DIAGRAM



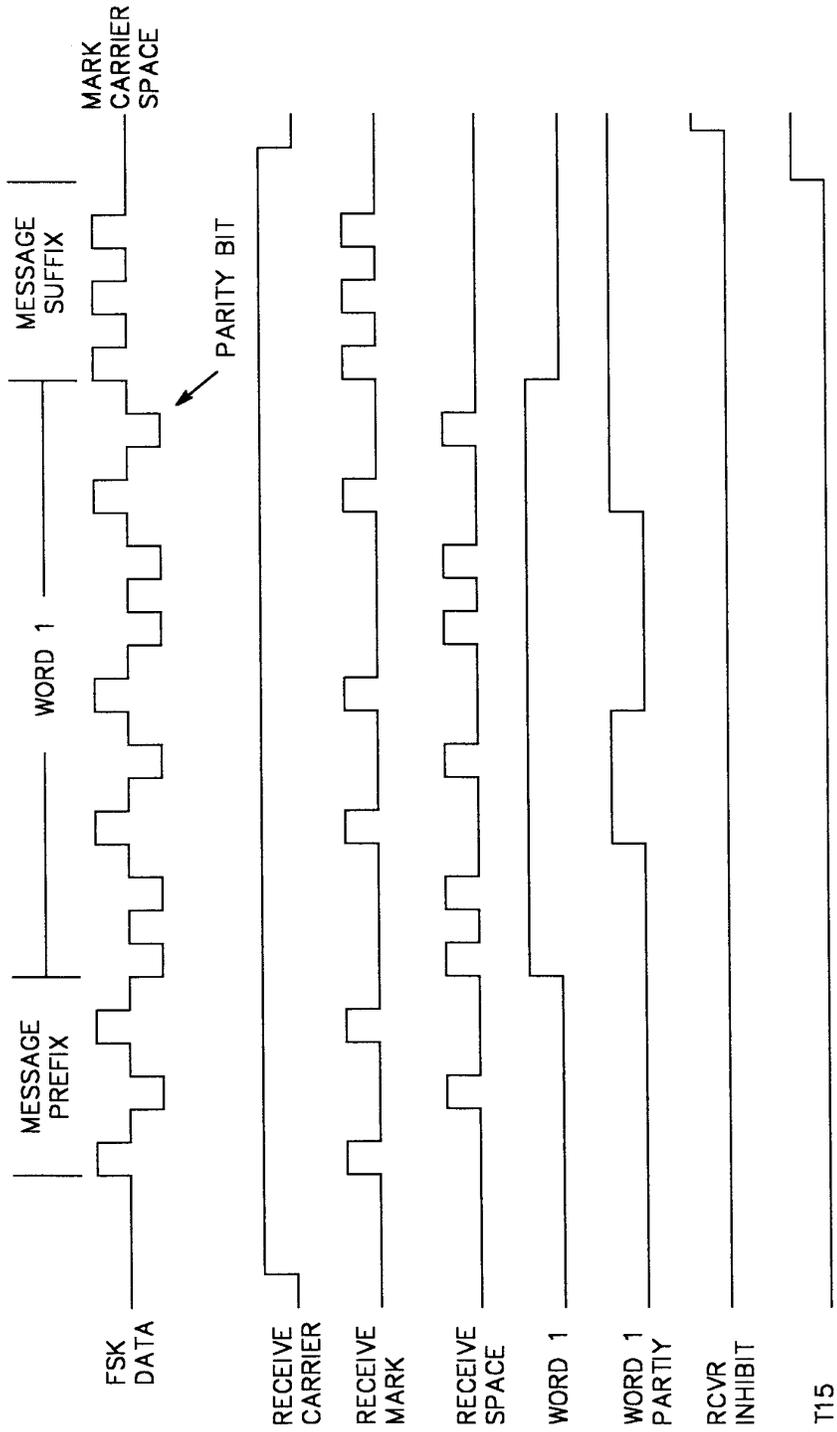
# TWC STATION RECEIVER TIMING DIAGRAM



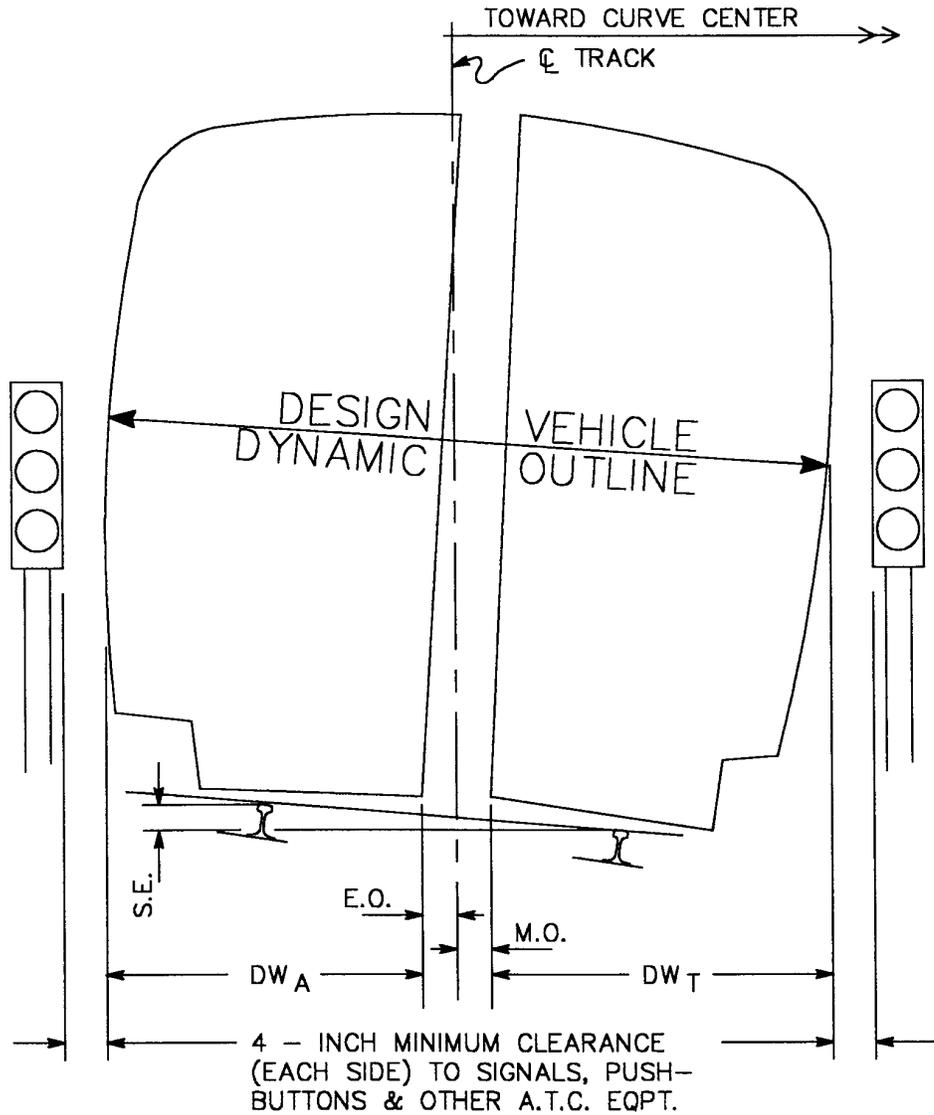
TWC FLYBY TRANSMITTER TIMING DIAGRAM



# TWC FLYBY RECEIVER TIMING DIAGRAM



A.T.C. CLEARANCE DIAGRAM



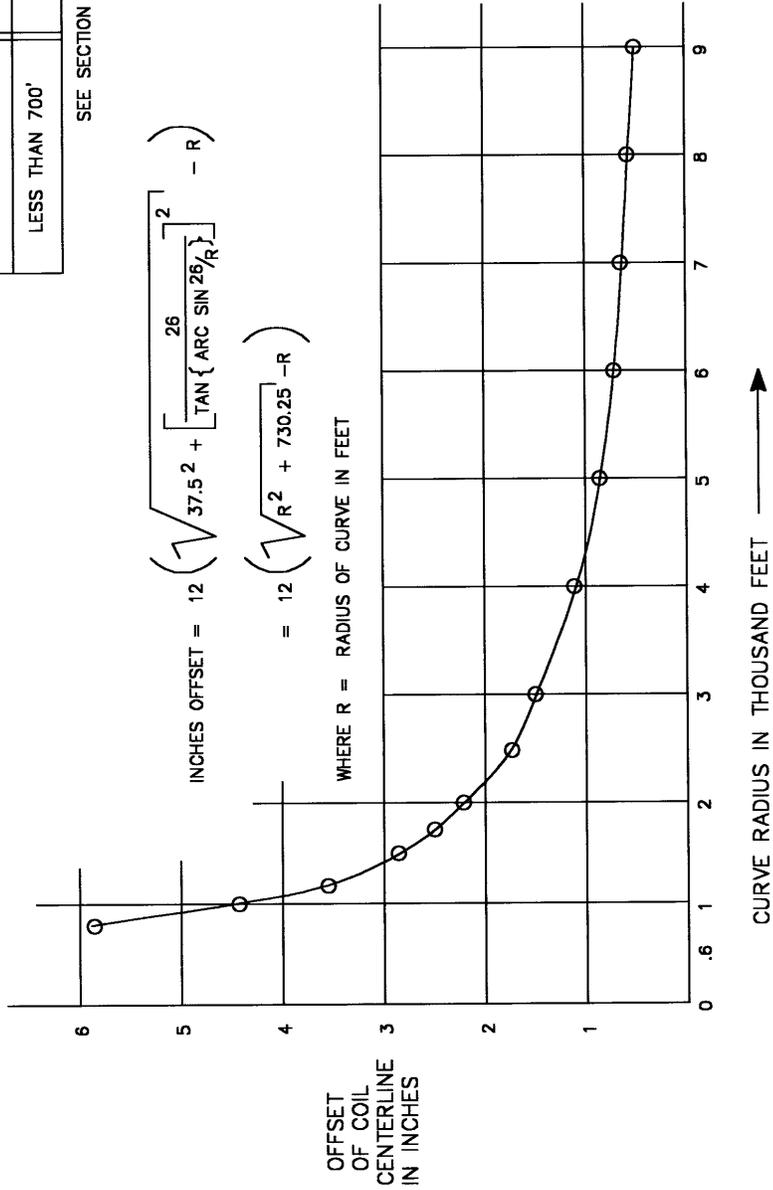
NOTES:

1. FOR DESIGN VEHICLE CLEARANCES, CONSIDER THE END OVERHANG, E.O., EQUAL TO THE MIDDLE ORDINATE, M.O.
2.  $M.O. (IN FT.) = R - \sqrt{R^2 - 676}$   
WHERE R = CURVE RADIUS (IN FT.).
3. FOR VALUES OF  $DW_A$  AND  $DW_T$ , SEE PAGES TA-15 & TA-16.
4. SEE ALSO DWG. ATCINF-CE-030, A.T.C. CLEARANCE ENVELOPE.

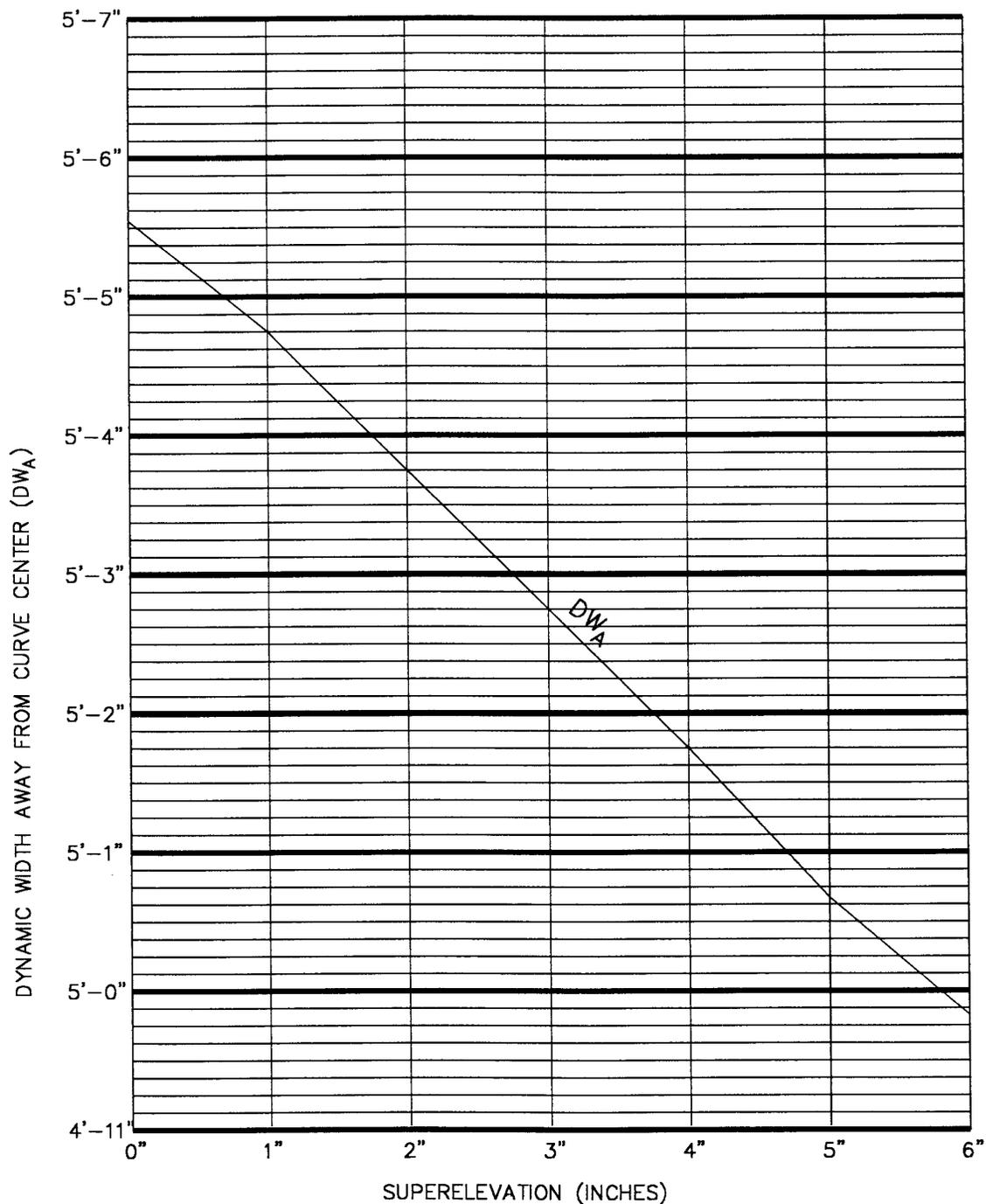
# MARKER COIL OFFSET vs. CURVE RADIUS

RADIUS OF CURVE	OFFSET FROM $\phi$
8500' - 2900'	1"
2900' - 1750'	2"
1750' - 1250'	3"
1250' - 975'	4"
975' - 800'	5"
800' - 700'	6"
LESS THAN 700'	7"

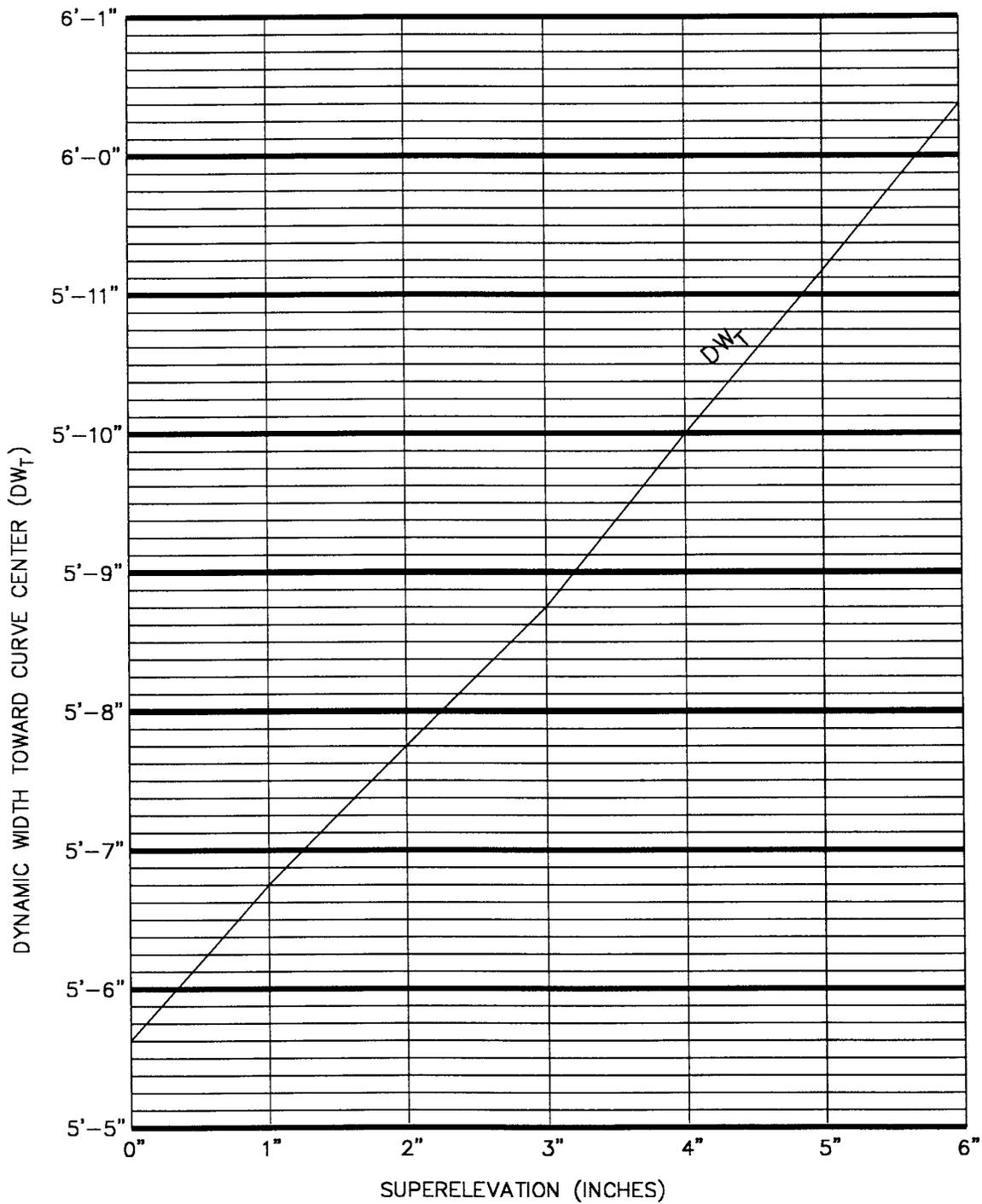
SEE SECTION 16967



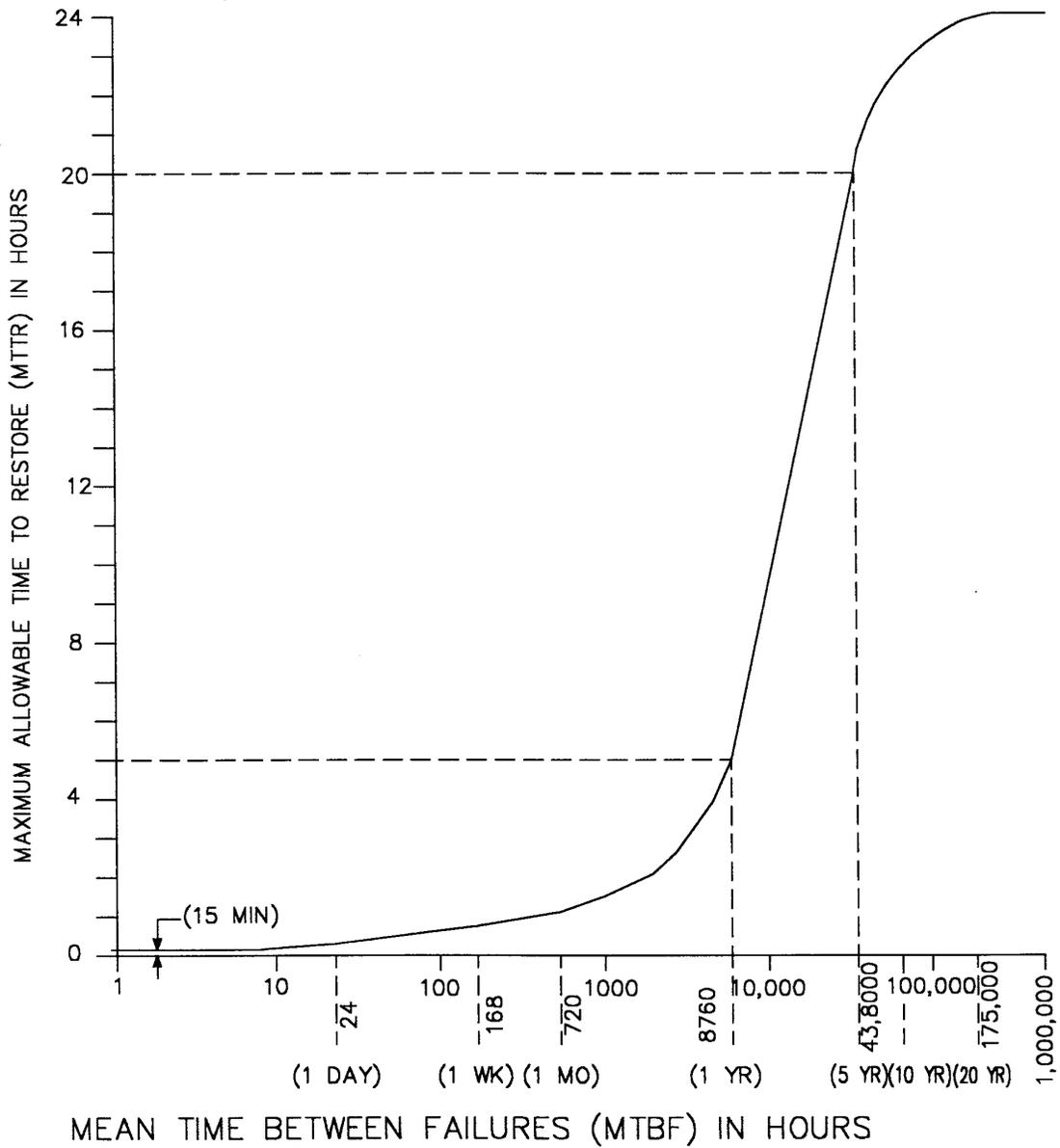
DYNAMIC WIDTH AWAY FROM CURVE CENTER



DYNAMIC WIDTH TOWARD CURVE CENTER



MICROPROCESSOR SYSTEM MTTR



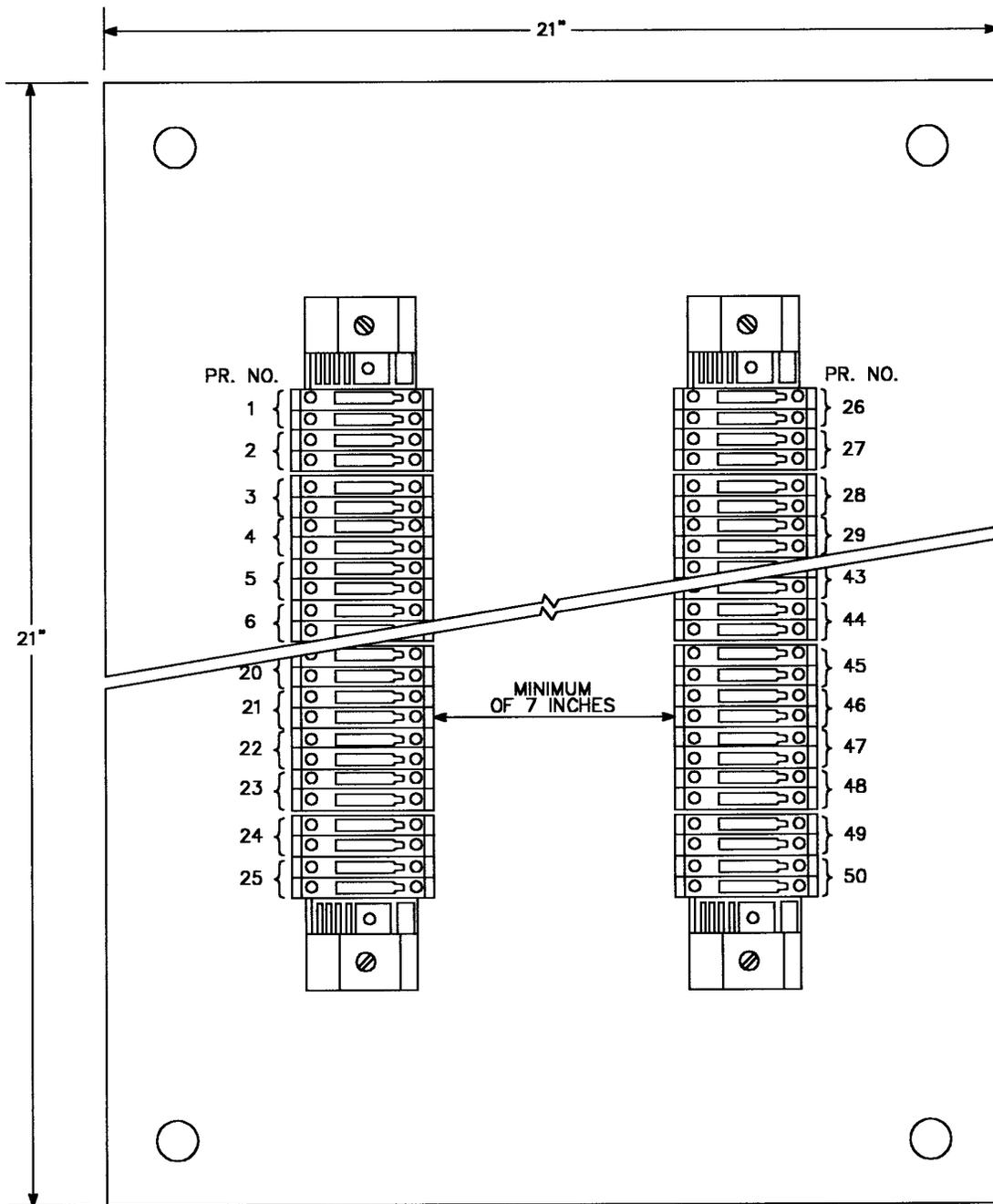
MICROPROCESSOR SYSTEM MTTR

GRAPH SHOWING THE MAXIMUM ALLOWABLE TIME TO RESTORE A MICROPROCESSOR SYSTEM FOR ANY MEAN TIME BETWEEN ITS FAILURES

TRAINING CLASSES --- GENERAL REQUIREMENTS

<u>EQUIPMENT/SYSTEM &amp; CLASS NAME</u>	<u>PRESENTATIONS &amp; DESCRIPTION</u>	<u>CLASS TIME &amp; TRAINEES</u>
Non-Vital Station Processor Maintainer's STAP Training Course	4 Presentations Operation and Maintenance of the STAP System	3 to 5 Days Each 12 Trainees Each See <b>Section 16924</b>
Non-Vital Station Processor Engineer's Station Processor Training Course	1 Presentation Programming, Reprogramming, and Maintenance of the STAP System to the board level	5 to 10 Days 12 Trainees See <b>Section 16924</b>
Data Transmission Sys.(DTS) DTS Field Maintainer's Training Course	4 Presentations - Operation and Maintenance of the RTU, CAU, A/D Converter and Multiplexer Equipment and Circuitry	5 Days Min., Each 12 Trainees Each See <b>Section 16925</b>
Data Transmission Sys.(DTS) DTS Shop Maintainer's Training Course	2 Presentations Troubleshooting to the Component Level	5 Days Each 8 Trainees Each See <b>Section 16925</b>
Data Transmission Sys.(DTS) Engineer's DTS Training Course	1 Presentation Program, Reprogram and Maintenance of DTS	5 Days Minimum 12 Trainees See <b>Section 16925</b>
Non-Vital Interlocking Processor (NVIP) Systems Field Maintainer's Training Course for NVIP Systems	1 Presentation Operation, Maintenance and Troubleshooting of Non-Vital portion of Interlocking Control System	5 to 10 Days 12 Trainees See <b>Section 16926</b>
Non-Vital Interlocking Processor (NVIP) Systems Engineer's Training Course for NVIP Systems	1 Presentation Operation, Maintenance and Troubleshooting of Non-Vital portion of Interlocking Control System	5 to 10 Days 12 Trainees See <b>Section 16926</b>
ATC System and IVP Systems Maintainer's ATC/IVP Training Course	4 Presentations Operation, Maintenance and Troubleshooting of the complete ATC System with Special emphasis on the Interlocking Vital Processor Systems	5 to 10 Days Each 12 Trainees See <b>Section 16928</b>
Interlocking Vital Processor Systems (IVP) Engineer's Training Course for IVP Systems	1 Presentation Programming, Maintenance and Re-Programming of the IVP Systems to the Board Level	5 to 10 Days 12 Trainees See <b>Section 16928</b>
Train Control Room (TCR) Equipment and Systems  TCR Maintenance Training Course	4 Presentations Operation, Maintenance and Troubleshooting of Vital Control Systems, Power Supply Systems, Grounding & Surge Protection Systems, and Non-Vital Systems	10 Days Each 12 Trainees Each
Wayside Equipment & Systems  Wayside Maintenance Training Course	4 Presentations Operation, Troubleshooting & Field Maintenance of Switch Machines, Signals, Impedance Bonds, Marker Coil Layouts, Signal & Negative-Return Bonding, Snowmelter Layouts, Vital & Non-Vital Relays, Test Equipment	10 Days Each 12 Trainees Each

TC/COMM INTERFACE CABINET LAYOUT



**TC/COMM INTERFACE CABINET LAYOUT**

USUALLY LOCATED IN COMMUNICATIONS EQUIPMENT ROOM  
(BY OTHER DISCIPLINES)

## TC/COMM INTERFACE CABINET WIRING

The TC/COMM INTERFACE CABINET located in the Communications Room at each Passenger Station included in this Contract, shall be wired or modified as indicated on the site-specific Interface Cabinet Wiring Diagram for that location, unless otherwise directed by the Designated Resident Engineer.

DTS FUNCTIONS - TABLE I  
TRAIN OPERATION CONTROLS

<u>NO.</u> 1A	<u>GROUP</u> Train/ Station	<u>NAME</u> Set Train Identification RUN NUMBER, PLATFORM DESTINATION, PLATFORM
------------------	-----------------------------------	--

FUNCTION

Assign Identification to a train; 3 BCD digits of RUN NUMBER (12 bits); 2 BCD digits of DESTINATION CODE (8 bits).

SIGNAL HIGH

Upon OCC command, or when an unupdated (with commanded identification) train reports CXR-ON at next downstream station (a retry feature up to 2 downstream stations) transmitted every DTS cycle.

SIGNAL LOW

Upon loss of TWC signal.

<u>NO.</u> 1B	<u>GROUP</u> Train/ Station	<u>NAME</u> HOLD WITH DOORS CLOSED
------------------	-----------------------------------	---------------------------------------

FUNCTION

Commands a train to remain at the station with doors closed after its doors have closed at end of dwell cycle.

SIGNAL HIGH

Upon OCC Command. Transmitted every DTS cycle.

SIGNAL LOW

Upon loss of TWC signal or issuance of either HOLD WITH DOORS OPEN or TERMINATE DWELL command by OCC.

<u>NO.</u> 1C	<u>GROUP</u> Train/ Station	<u>NAME</u> HOLD WITH DOORS OPEN
------------------	-----------------------------------	-------------------------------------

FUNCTION

Commands a train to remain at the station with doors open even after end of dwell cycle.

SIGNAL HIGH

Upon OCC command. Transmitted every DTS cycle.

SIGNAL LOW

Upon loss of TWC signal or issuance of either HOLD WITH DOORS CLOSED or TERMINATE DWELL command by OCC.

TABLE I - TRAIN OPERATION CONTROLS (Continued)

<u>NO.</u> 1D	<u>GROUP</u> Train/ Station	<u>NAME</u> TERMINATE DWELL
------------------	-----------------------------------	--------------------------------

FUNCTION

Commands a train to close doors and depart. Overrides local or OCC hold commands.

SIGNAL HIGH

Upon issuance of command by OCC. Transmitted for two DTS cycles.

SIGNAL LOW

Two DTS cycles from issuance of command.

<u>NO.</u> 1E	<u>GROUP</u> Train/ Station	<u>NAME</u> ATS PERFORMANCE, PLATFORM (Station Platform Number)
------------------	-----------------------------------	---

FUNCTION

Two bit performance level code. Cause the train not to exceed a certain ATS performance level speed until changed by next station or fly-by transmitter. MAXIMUM = 00 (PL1); NORMAL = 01 (PL2); REDUCED = 10 (PL3); RETARDED = 11 (PL4).

SIGNAL HIGH

Upon issuance of command.

SIGNAL LOW

Upon loss of CXR signal except when broadcast by OCC. If broadcast by OCC, then upon issuance of terminate/stop broadcast command by OCC.

<u>NO.</u> 1F	<u>GROUP</u> Train/ Station	<u>NAME</u> ATS-PERFORMANCE, FLY-BY (Fly-by transmitter No.)
------------------	-----------------------------------	--

FUNCTION

Two bit performance level code. Cause the train not to exceed a certain ATS performance level speed until changed by next station or fly-by transmitter. MAXIMUM = 00 (PL1); NORMAL = 01 (PL2); REDUCED = 10 (PL3); RETARDED = 11 (PL4).

SIGNAL HIGH

Triggered by software internally at OCC upon occupancy of trigger block by tracked block train.

SIGNAL LOW

Triggered by software internally at OCC upon vacancy of trigger block (different trigger block than signal high trigger block).

TABLE I - TRAIN OPERATION CONTROLS (Continued)

NO.GROUPNAME  
1GTrain/ATS-ACCELERATION,  
StationPLATFORM (Station  
Platform Number)

FUNCTION  
Sets half acceleration on train.

SIGNAL HIGHSIGNAL LOW  
Upon issuance of command for Same as 1E and/or  
half acceleration. issuance of full  
acceleration command.

NO.GROUPNAME  
1HTrain/StationSKIP-STOP (Marker  
Number)

FUNCTION  
Cancel station stop sent to Markers located at 500 ft. & 1200 ft. from center of station platform in both  
normal and reverse directions.

SIGNAL HIGHSIGNAL LOW  
Upon issuance of command to all Upon issuance of 'STOP'  
markers if command is for all skip-stop command to all  
trains. If command is for a markers if the command is  
specific train then when the for all trains. If the  
trigger block immediately command is for a specific  
upstream from the marker block train, then when the  
prior to the station, depending train occupies trigger  
on the direction of travel. block immediately  
downstream from the  
marker, depending on  
direction of travel.

NO.GROUPNAME  
1ITrain/StationDOOR CLOSE WARNING  
PLATFORM (Number)

FUNCTION  
Alert the train operator to close the train doors.

SIGNAL HIGHSIGNAL LOW  
Upon issuance of command Upon removal of command  
by OCC. by OCC.

TABLE I - TRAIN OPERATION CONTROLS (Continued)

<u>NO.</u> 1J	<u>GROUP</u> Track	<u>NAME</u> RESET IDW SYSTEM
------------------	-----------------------	---------------------------------

FUNCTION  
Resets IDW alarm if alarm is false.

SIGNAL HIGH  
Upon issuance of command by OCC. Transmitted for two DTS cycles.

SIGNAL LOW  
Two DTS cycles from issuance of command.

<u>NO.</u> 2A	<u>GROUP</u> Interlocking	<u>NAME</u> SET LOCAL CONTROL
------------------	------------------------------	----------------------------------

FUNCTION  
Transfers control of an interlocking from OCC to local.

SIGNAL HIGH  
Upon issuance of command.

SIGNAL LOW  
When LOCAL CONTROL indication is received or 60 seconds, whichever is earlier.

<u>NO.</u> 2B	<u>GROUP</u> Interlocking	<u>NAME</u> SET CENTRAL CONTROL
------------------	------------------------------	------------------------------------

FUNCTION  
Requesting transfer of control of an interlocking from local to OCC.

SIGNAL HIGH  
Upon issuance of command.

SIGNAL LOW  
When CENTRAL IN CONTROL indication is received or 60 seconds, whichever is earlier.

<u>NO.</u> 2C	<u>GROUP</u> Interlocking	<u>NAME</u> SET NORMAL SWITCH (No.)
------------------	------------------------------	--

FUNCTION  
Requests wayside to put normal call on a specific switch.

SIGNAL HIGH  
Upon issuance of command.

SIGNAL LOW  
When SWITCH (No.) CALLED NORMAL indication is received, or 10 seconds, whichever is earlier.

TABLE I - TRAIN OPERATION CONTROLS (Continued)

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
2D	Interlocking	SET REVERSE SWITCH (No.)

FUNCTION

Requests wayside to put reverse call on a specific switch.

SIGNAL HIGH

Upon issuance of command.

SIGNAL LOW

When SWITCH (No.) CALLED REVERSE indication is received, or 10 seconds, whichever is earlier.

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
2E	Interlocking	CANCEL SWITCH (Number)

FUNCTION

Requests wayside to remove all calls from a specific switch.

SIGNAL HIGH

Upon issuance of command.

SIGNAL LOW

When call indication is lost or 10 seconds, whichever is earlier.

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
2F	Interlocking	ROUTE REQUEST SIG (No.)

FUNCTION

Requests establishment of a route from a given entrance signal. The request may include a designated exit signal.

SIGNAL HIGH

Upon issuance of command to entrance signal and upon receipt of ENT RECV SIG (No.) indication (must be within 5 seconds from entrance request) from entrance signal. Or upon issuance of FLEET SIG (No.) or CANCEL FLEET SIG (No.) Command.

SIGNAL LOW

When ENT RECV SIG (No.) (Entrance Received) indication is received, or 5 seconds, whichever is earlier for entrance signal. When SIG CLEAR SIG (No.) indication for entrance signal is received or 10 seconds, whichever is earlier. When cancelling fleet, upon loss of fleet indication or 10 seconds, whichever is earlier. When requesting fleet, upon receipt of ENT RECV SIG (No.) indication or 5 seconds, whichever is earlier for a non-established route, and upon receipt of FLEETED TK (No.) SIG (No.) indication, or 10 seconds, whichever is earlier, for an established route.

TABLE I - TRAIN OPERATION CONTROLS (Continued)

<u>NO.</u> 2G	<u>GROUP</u> Interlocking	<u>NAME</u> CANCEL ROUTE
------------------	------------------------------	--------------------------------

FUNCTION

Requests cancellation of the established route from a given entrance signal.

SIGNAL HIGH

Upon issuance of command.

SIGNAL LOW

Upon loss of SIG CLEAR SIG (No.) indication or 10 seconds, whichever is earlier.

<u>NO.</u> 2H	<u>GROUP</u> Interlocking	<u>NAME</u> FLEET SIG (Number)
------------------	------------------------------	-----------------------------------

FUNCTION

Requests fleetting of an established route or establishment of a fleetted route from a given entrance signal.

SIGNAL HIGH

Upon issuance of command.

SIGNAL LOW

Upon receipt of FLEETED TK (No.) SIG (No.) indication or 10 seconds, whichever is earlier for an established route. Upon receipt of ENT RECV (entrance received) TK (No.) SIG (No.) indication from entrance signal or 5 seconds, whichever is earlier for a non-established route.

<u>NO.</u> 2I	<u>GROUP</u> Interlocking	<u>NAME</u> CANCEL FLEET SIG (No.)
------------------	------------------------------	---------------------------------------

FUNCTION

Requests fleetting to be cancelled but keeps the established route from the designated entrance signal.

SIGNAL HIGH

Upon issuance of command.

SIGNAL LOW

When FLEETED TK (No.) SIG (No.) indication is lost or 10 seconds whichever is earlier.

<u>NO.</u> 2J	<u>GROUP</u> Interlocking	<u>NAME</u> SET AUTO ROUTE SIG (No.)
------------------	------------------------------	---

FUNCTION

Request that a signal be put in the automatic mode of operation so that wayside can establish automatic routing.

SIGNAL HIGH

Upon issuance of command.

SIGNAL LOW

When AUTO ROUTE IN EFFECT SIG (No.) indication for the signal is received or 10 seconds, whichever is earlier.

TABLE I - TRAIN OPERATION CONTROLS (Continued)

<u>NO.</u> 2K	<u>GROUP</u> Interlocking	<u>NAME</u> CANCEL AUTO ROUTE SIG (Number)
<u>FUNCTION</u> Take a signal out of automatic mode of operation.		
<u>SIGNAL HIGH</u> Upon issuance of command.		<u>SIGNAL LOW</u> When AUTO ROUTE IN EFFECT SIG (No.) indication for the signal is lost or 10 seconds, whichever is earlier.
<hr/>		
<u>NO.</u> 2L	<u>GROUP</u> Interlocking	<u>NAME</u> INHIBIT AUTO OPER SIG (Number)
<u>FUNCTION</u> Prevents the wayside from establishing an automatic routing from the designated entrance signal at a divergent or terminal interlocking even if the signal is in automatic operation mode.		
<u>SIGNAL HIGH</u> At start of the computer system. Transmitted every DTS cycle except when software removes this signal, or when commanded by OCC post OCC command to stay low.		<u>SIGNAL LOW</u> When software removes the signal to allow wayside automatic routing until signal is clear, or 60 seconds from removal of signal, whichever is earlier, or when any block within the advance approach area is under dark (DTS down) area, or when commanded by OCC to stay low.
<hr/>		
<u>NO.</u> 2M	<u>GROUP</u> Interlocking	<u>NAME</u> CLEAR DEST REG SIG (No.) (Clear Destination Register for Signal__)
<u>FUNCTION</u> Clears all stored destinations from destination register for designated wayside destination controlled automatic signal.		
<u>SIGNAL HIGH</u> Upon issuance of command.		<u>SIGNAL LOW</u> Upon loss of destination indication or 10 seconds, whichever is earlier.
<hr/>		

TABLE I - TRAIN OPERATION CONTROLS (Continued)

NO.GROUPNAME  
 2NInterlockingTERMINAL MODE (Number)  
 FUNCTION  
 Set terminal in one of three operations modes.

SIGNAL HIGHSIGNAL LOW  
 Upon issuance of command.  
 When commanded Terminal Mode indication  
 (AUTO OPER MODE [No.]) is received,  
 or 10 seconds, whichever is earlier.

NO.GROUPNAME  
 2OInterlockingSET SNOWMELTER ON

FUNCTION  
 Turn wayside running rail and  
 switch rod heaters on to keep switches free of ice.

SIGNAL HIGHSIGNAL LOW  
 Upon issuance of command.10 DTS cycles from start,  
 or upon receipt of SNOWMELTER ON status,whichever is earlier.

NO.GROUPNAME  
 2PInterlockingSET SNOWMELTER OFF

FUNCTION  
 Turn wayside running rail and switch rod  
 heaters off when weather conditions are favorable.

SIGNAL HIGHSIGNAL LOW  
 Upon issuance of command.10 DTS cycles from start,  
 or loss of SNOWMELTER ON  
 status, whichever is earlier.

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
3A	Misc.	DESTINATION, PLATFORM (Number)

FUNCTION  
 Send information (2 BCD Digits) to station sign for the designated platform.

SIGNAL HIGH  
 60 seconds prior to estimated  
 arrival time of a train (for  
 less than 60 second runtime  
 upon departure, from previous  
 station), or after previous  
 train departure whichever  
 is later.

SIGNAL LOW  
 Upon train departure,  
 or 2 DTS cycles from  
 start.

TABLE I - TRAIN OPERATION CONTROLS (Continued)

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
3B	Misc.	TRAIN LENGTH, PLATFORM (Number)

FUNCTION  
1 BCD digit to control the platform edge lights.

SIGNAL HIGH  
60 seconds prior to estimated arrival time of a train (for less than 60 second runtime upon departure from previous station), or after previous train departure, whichever is later.

SIGNAL LOW  
Upon train departure, or 2 DTS cycles from start.

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
3C	Misc.	TIME PULSE-MIN

FUNCTION  
To keep the station clock in sync. with the OCC computer clock minutes.

SIGNAL HIGH  
At start of minute period (00 seconds) transmitted to all stations.

SIGNAL LOW  
1 second after start.

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
3D	Misc.	TIME PULSE-HRS/24 HRS

FUNCTION  
To keep the station clocks in sync with the OCC computer clock hour/day.

SIGNAL HIGH  
At 57:54 (mm:ss) each hour. Transmitted to all stations.

SIGNAL LOW  
8 seconds 58:02 (mm:ss) except 14 seconds at 2 a.m. until 2:58:08.

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
4A	Train Dispatch	TRAIN NEEDED, PLATFORM (Number)

FUNCTION  
Rings bell and turns Train Needed indicator light on in yard tower.

SIGNAL HIGH  
Start of train needed window.

SIGNAL LOW  
Start of dispatch/putin window.

TABLE I - TRAIN OPERATION CONTROLS (Continued)

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
4B	Train Dispatch	DISPATCH WARNING

FUNCTION

Turns dispatch warning lights on.

SIGNAL HIGH

Start of dispatch/putin window.

SIGNAL LOW

Expiration of dispatch window.

.....

DTS FUNCTIONS - TABLE II  
ELECTRICAL & SUPPORT EQUIPMENT CONTROLS

<u>NO.</u> 1A	<u>GROUP</u> Traction power (DCPWR)	<u>NAME</u> AC INC LINE BRK (Number) CLOSED (AC incoming line breaker).
------------------	--	--

FUNCTION  
Request breaker to close.

SIGNAL HIGH  
Upon execution of close command  
by OCC.

SIGNAL LOW  
2 seconds after execution  
of command.

<u>NO.</u> 1B	<u>GROUP</u> Traction power (DCPWR)
------------------	--

NAME  
AC INC LINE BRK (Number)  
TRIP (AC incoming line  
breaker).

FUNCTION  
Request breaker to trip.

SIGNAL HIGH  
Same as 1A except for trip  
command

SIGNAL LOW  
Same as for 1A

<u>NO.</u> 1C	<u>GROUP</u> Traction power (DCPWR)
------------------	--

NAME  
AC RECT TRANS FDR BRK  
(Number) CLOSED (AC rectifier  
transformer feeder breaker)

FUNCTION  
Request breaker to close.

SIGNAL HIGH  
Same as for 1A

SIGNAL LOW  
Same as for 1A

---

<u>NO.</u> 1D	<u>GROUP</u> Traction power (DCPWR)
------------------	--

NAME  
AC RECT TRANS FDR BRK (Number) TRIP (AC  
Rectifier Transformer Feeder Breaker).

FUNCTION  
Request breaker to trip.

SIGNAL HIGH  
Same as for 1B

SIGNAL LOW  
Same as for 1A

---

TABLE II - ELECTRICAL & SUPPORT EQUIPMENT CONTROLS (Continued)

<u>NO.</u> 1E	<u>GROUP</u> Traction power (DCPWR)	<u>NAME</u> DC FDR TIE BRK (Number) CLOSED (DC Feeder Tie Breaker)
------------------	--	---

FUNCTION  
Request breaker to close.

SIGNAL HIGH  
Same as for 1A

SIGNAL LOW  
Same as for 1A

---

<u>NO.</u> 1F	<u>GROUP</u> Traction power (DCPWR)	<u>NAME</u> DC FDR TIE BRK (Number) TRIP (DC Feeder Tie Breaker)
------------------	--	---

FUNCTION  
Request breaker to trip.

SIGNAL HIGH  
Same as for 1B

SIGNAL LOW  
Same as for 1A

---

<u>NO.</u> 2A	<u>GROUP</u> Ventilation	<u>NAME</u> FANS (No.) EMERGENCY OFF
------------------	-----------------------------	---

FUNCTION  
Request fans to stop immediately.

SIGNAL HIGH  
Upon execution of EMERGENCY OFF command by OCC

SIGNAL LOW  
Same as for 1A

---

<u>NO.</u> 2B	<u>GROUP</u> Ventilation	<u>NAME</u> FANS (No.) EMERGENCY ON
------------------	-----------------------------	--

FUNCTION  
Request fans to start immediately.

SIGNAL HIGH  
Same as for 1A except for EMERGENCY ON command by OCC.

SIGNAL LOW  
Same as for 1A

---

TABLE II - ELECTRICAL & SUPPORT EQUIPMENT CONTROLS (Continued)

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
2C	Ventilation	FANS (No.) AUTOMATIC ON

FUNCTION  
Request fans to go into automatic mode.

<u>SIGNAL HIGH</u>	<u>SIGNAL LOW</u>
Same as for 1A except for AUTOMATIC ON command by OCC	Same as for 1A

---

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
2D	Ventilation	FANS (No.) SUPPLY

FUNCTION  
Command along with either EMERGENCY ON or AUTOMATIC ON command to request air supply mode of operation.

<u>SIGNAL HIGH</u>	<u>SIGNAL LOW</u>
Upon execution of FANS SUPPLY command along with either EMERGENCY ON or AUTOMATIC ON command by OCC.	Same as for 1A

---

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
2E	Ventilation	FANS (No.) EXHAUST

FUNCTION  
Same as for 2D except request air exhaust mode.

<u>SIGNAL HIGH</u>	<u>SIGNAL LOW</u>
Same as for 2D except FANS EXHAUST command by OCC	Same as for 1A

---

DTS FUNCTIONS - TABLE III  
TRAIN OPERATION INDICATIONS

<u>NO.</u> 1A	<u>GROUP</u> Train to Wayside Communications (TWC)	<u>NAME</u> RUN NUMBER, PLATFORM (No.)
------------------	--	--

FUNCTION  
Indicates 3 BCD Digits run-number; 12-bits.

SIGNAL HIGH  
When front of the train is  
within the platform-limits and  
transmitting a "long" message.

SIGNAL LOW  
When front of the train  
is outside of the  
platform limits and/or  
not transmitting a "long"  
message.

<u>NO.</u> 1B	<u>GROUP</u> Train to Wayside Communications (TWC)	<u>NAME</u> DESTINATION, PLATFORM (No.)
------------------	--	---

FUNCTION  
Indicates 2 BCD Digits destination code;  
8-bits.

SIGNAL HIGH  
Same as for 1A.

SIGNAL LOW  
Same as for 1A.

<u>NO.</u> 1C	<u>GROUP</u> Train to Wayside Communications (TWC)	<u>NAME</u> TRAIN LENGTH, PLATFORM (No.)
------------------	--	--

FUNCTION  
Indicates 1 BCD digit of train length 4 bits.

SIGNAL HIGH  
Same as for 1A and/or when the  
train is at a put-in location  
(at yard or tail track)  
and train attendant presses  
ATO-Start button on board  
train.

SIGNAL LOW  
Same as for 1A and/or  
3 seconds duration  
maintained by wayside  
from put-in locations.

TABLE III - TRAIN OPERATION INDICATIONS (Continued)

<u>NO.</u> 1D	<u>GROUP</u> Train to Wayside Communications (TWC)	<u>NAME</u> DOOR OPEN MANUAL TK (number)
------------------	--	--

FUNCTION

Indicates whether train door opening is being controlled manually.

SIGNAL HIGH

Same as for 1A and doors are being opened under manual control.

SIGNAL LOW

Same as for 1A and doors are not being opened under manual control.

<u>NO.</u> 1E	<u>GROUP</u> Train to Wayside Communications (TWC)	<u>NAME</u> TRAIN READY TRACK (Number)
------------------	--	--

FUNCTION

Indicates whether train is ready for automatic operation.

SIGNAL HIGH

When the train is at "put in" location or at a platform and train attendant presses ATO Start button onboard train.

SIGNAL LOW

3 seconds duration maintained by wayside & carborne ATC.

<u>NO.</u> 1F	<u>GROUP</u> Train to Wayside Communications (TWC)	<u>NAME</u> TRAIN BERTHED TRACK (Number)
------------------	--	--

FUNCTION

Indicates whether train is berthed at a station.

SIGNAL HIGH

Wayside equipment receives this from train when train reaches 7 MPH speed during it's programmed stop.

SIGNAL LOW

When the dwell time is complete.

TABLE III - TRAIN OPERATION INDICATIONS (Continued)

<u>NO.</u> 1G	<u>GROUP</u> Train to Wayside Communications (TWC)	<u>NAME</u> TRAIN MOTION TRACK (Number)
------------------	--	---

FUNCTION  
Indicates whether train is moving.

SIGNAL HIGH  
Same as for 1A and the train is moving 3 MPH or higher speed within platform area.

SIGNAL LOW  
Same as for 1A and/or train is stopped or moving below 3MPH speed.

<u>NO.</u> 1H	<u>GROUP</u> TWC	<u>NAME</u> DOOR CLOSE (RIGHT OR LEFT) Track (Number)
------------------	---------------------	--

FUNCTION  
Indicates whether applicable (side) train doors are closed.

SIGNAL HIGH  
Same as for 1A and applicable (side) train doors are closed.

SIGNAL LOW  
Same as for 1A and applicable (side) train doors are not closed.

<u>NO.</u> 1I	<u>GROUP</u> TWC	<u>NAME</u> PSS ACTIVE TK (Number)
------------------	---------------------	---------------------------------------

FUNCTION  
Indicates whether Program Station Stop feature is active.

SIGNAL HIGH  
Same as for 1A and PSS feature is active.

SIGNAL LOW  
Same as for 1A and PSS feature is not active.

<u>NO.</u> 1J	<u>GROUP</u> TWC	<u>NAME</u> ATP CUTOUT TK (Number)
------------------	---------------------	---------------------------------------

FUNCTION  
Indicates status of ATP System on Train.

SIGNAL HIGH  
Same as for 1A and ATP System is cut in.

SIGNAL LOW  
Same as for 1A and ATP System is cut out.

TABLE III - TRAIN OPERATION INDICATIONS (Continued)

<u>NO.</u> 1K	<u>GROUP</u> TWC	<u>NAME</u> TRAIN IN ATO TK (Number)
------------------	---------------------	--

FUNCTION  
Indicates whether train is in automatic mode.

SIGNAL HIGH  
Same as for 1A and train is in Automatic Operation mode.

SIGNAL LOW  
Same as for 1A and train is not in Automatic Operation mode.

<u>NO.</u> 2A	<u>GROUP</u> Track	<u>NAME</u> BLK OCCP TK (No.) (Block Occupancy)
------------------	-----------------------	---

FUNCTION  
Indicates track block occupied/unoccupied.

SIGNAL HIGH  
When a track block is occupied.

SIGNAL LOW  
When a track block is unoccupied.

<u>NO.</u> 2B	<u>GROUP</u> Track	<u>NAME</u> TEMP SPEED RESTRICTION TK (No. - Direction)
------------------	-----------------------	---

FUNCTION  
Indicates whether restricted speed has been set manually. (Locally)

SIGNAL HIGH  
When no manual/local restriction in speed is in effect.

SIGNAL LOW  
When manual/local restriction in speed is in effect.

<u>NO.</u> 2C	<u>GROUP</u> Track	<u>NAME</u> RIGHT OF WAY HAZARD (No.) TK (Number)
------------------	-----------------------	---

FUNCTION  
Indicates whether METRO system's r/w (adjacent to other r/w) has been violated.

SIGNAL HIGH  
When METRO r/w has been violated.

SIGNAL LOW  
When METRO r/w has not been violated.

TABLE III - TRAIN OPERATION INDICATIONS (Continued)

<u>NO.</u> 2D	<u>GROUP</u> Track	<u>NAME</u> DRAGGING EQUIPMENT DETECTED FOR (RR) TK (Number)
------------------	-----------------------	--

FUNCTION

Indicates detection of derailment or equipment dragging from train on adjacent railroad.

SIGNAL HIGH

When derailed/dragging equipment is detected.

SIGNAL LOW

When detector is quiescent.

<u>NO.</u> 3A	<u>GROUP</u> Interlocking	<u>NAME</u> LOCAL IN CONTROL
------------------	------------------------------	---------------------------------

FUNCTION

Indicates whether interlocking is under field control.

SIGNAL HIGH

When interlocking is under field control.

SIGNAL LOW

When interlocking is not under field control.

<u>NO.</u> 3B	<u>GROUP</u> Interlocking	<u>NAME</u> CENTRAL IN CONTROL
------------------	------------------------------	-----------------------------------

FUNCTION

Indicates whether interlocking under OCC control.

SIGNAL HIGH

When interlocking is under OCC control.

SIGNAL LOW

When interlocking is not under OCC control.

<u>NO.</u> 3C	<u>GROUP</u> Interlocking	<u>NAME</u> LOCAL CONTROL REQUEST
------------------	------------------------------	--------------------------------------

FUNCTION

Indicates whether field is requesting OCC to transfer control of the interlocking to the field.

SIGNAL HIGH

When REQUEST push button is pressed at the field location.

SIGNAL LOW

When REQUEST push button is released or OCC-to-field transfer of control is completed.

TABLE III - TRAIN OPERATION INDICATIONS (Continued)

<u>NO.</u> 3D	<u>GROUP</u> Interlocking	<u>NAME</u> SWITCH (No.) CALLED NORMAL
------------------	------------------------------	--

FUNCTION  
Indicates whether a specific switch has normal call.

SIGNAL HIGH  
When the specific switch has normal call as a result of routing or call normal control.

SIGNAL LOW  
when the specific switch does not have normal call.

<u>NO.</u> 3E	<u>GROUP</u> Interlocking	<u>NAME</u> SWITCH (No.) CALLED REVERSE
------------------	------------------------------	---

FUNCTION  
Indicates whether a specific switch has reverse call.

SIGNAL HIGH  
Same as for 3D except for reverse call.

SIGNAL LOW  
Same as for 3D except for reverse call.

<u>NO.</u> 3F	<u>GROUP</u> Interlocking	<u>NAME</u> SWITCH (No.) NORMAL
------------------	------------------------------	------------------------------------

FUNCTION  
Indicates normal correspondence of a switch.

SIGNAL HIGH  
When switch is reporting normal correspondence.

SIGNAL LOW  
When switch is not reporting correspondence.

<u>NO.</u> 3G	<u>GROUP</u> Interlocking	<u>NAME</u> SWITCH (No.) REVERSE
------------------	------------------------------	-------------------------------------

FUNCTION  
Same as 3F for except for reverse correspondence.

SIGNAL HIGH  
Same as for 3F except for reverse correspondence.

SIGNAL LOW  
Same as for 3F except for reverse correspondence.

TABLE III - TRAIN OPERATION INDICATIONS (Continued)

<u>NO.</u> 3H	<u>GROUP</u> Interlocking	<u>NAME</u> SIG CLEAR TK (No.) SIG (Number) (Signal Clear)
------------------	------------------------------	---

FUNCTION

Indicates whether specific signal is clear with established route.

SIGNAL HIGH

When a specific signal is clear.

SIGNAL LOW

When a specific signal is red.

<u>NO.</u> 3I	<u>GROUP</u> Interlocking	<u>NAME</u> ENT RECV TK (No.) SIG (Number) (Entrance Received)
------------------	------------------------------	---

FUNCTION

Request for a route is acknowledged by specific signal as entrance or exit signal.

SIGNAL HIGH

Signal is ready to accept a route request as entrance or exit or when route is established for a home signal. Signal is not ready to accept a route request for a turnback signal.

SIGNAL LOW

Home signal is not ready to accept a route request as entrance or exit i.e., when a routing is in progress. Turnback signal is ready to accept a route request.

<u>NO.</u> 3J	<u>GROUP</u> Interlocking	<u>NAME</u> FLEETED TK (No.) SIG (No.)
------------------	------------------------------	--

FUNCTION

Indicates whether specific signal is fleeted to an established route.

SIGNAL HIGH

When a specific signal is fleeted.

SIGNAL LOW

When a specific signal is not fleeted.

TABLE III - TRAIN OPERATION INDICATIONS (Continued)

NO.GROUPNAME  
3KInterlockingAUTO ROUTE IN EFFECT  
SIG (Number)  
FUNCTION

Indicates whether automatic routing mode is in effect in the field for the specified signal.

SIGNAL HIGHSIGNAL LOW  
When a specific signal is in a When a specific signal is  
condition to establish automaticnot in a condition to  
routing.establish automatic  
routing.

NO.GROUPNAME  
3LInterlockingAPPR LKD TK (No.) SIG  
(No.) (Approach Locked)  
FUNCTION

Approach locking indication for the specified signal.

SIGNAL HIGHSIGNAL LOW  
When approach locking is inWhen approach locking is  
locked state.in released state.

NO.GROUPNAME  
3MInterlockingRTE LKD TK (Number)  
(Route Locked over  
Track No.)  
FUNCTION

Route locked indication for a given track.

SIGNAL HIGHSIGNAL LOW  
When a designated When the designated track  
track is locked due tois not locked, due to  
an established route.the absence of an  
established route over.  
that track.

TABLE III - TRAIN OPERATION INDICATIONS (Continued)

NO.GROUPNAME  
3NInterlockingAUTO OPER MODE (No.)  
(Automatic Operation Mode)

FUNCTION

Indicates one of three modes of operation at a terminal interlocking.

SIGNAL HIGHSIGNAL LOW

Individual bit indicates particular (one of three) operation mode in effect. Individual bit indicates not in that particular mode of operation.

NO.GROUPNAME  
3OInterlockingCENTRAL LOCKED OUT  
SIG (No., No., No.)

FUNCTION

Indicates wayside routing is in progress for an automatic signal group.

SIGNAL HIGHSIGNAL LOW

When wayside automatic routing is in progress. Locks out OCC initiated routing involving the signal group. When wayside automatic routing is not in progress. Allows OCC to initiate routes or switch movements.

NO.GROUPNAME  
3PInterlockingDEST SIG (No.)  
(Destination Signal)

FUNCTION

Indicates destination of first upstream train within the advance approach area of a destination controlled automatic signal at a divergent interlocking.

SIGNAL HIGHSIGNAL LOW

When wayside equipment releases the decoded destination readin storage for the from a train and stored on a designated signal first-in/first-out basis for or when train accepts the designated signal. When no destination is in storage for the designated signal and passes the signal.

TABLE III - TRAIN OPERATION INDICATIONS (Continued)

NO.GROUPNAME  
3QInterlockingTRAFFIC DIRECTION  
NORMAL (or REVERSE)  
TK (No. & Direction of Traffic Zone)  
FUNCTION  
Indicates specific direction of traffic in specific traffic zone on designated track.

SIGNAL HIGHSIGNAL LOW  
When in a specific traffic zoneWhen in a specific zone and  
in specific direction trafficno traffic is locked in  
is locked due to block occupancythe specific direction.  
or set route.

NO.GROUPNAME  
3RInterlockingSNOWMELTER ON

FUNCTION  
Indicates switch heater status.

SIGNAL HIGHSIGNAL LOW  
When heaters are on.When heaters are off.

NO.GROUPNAME  
3SInterlockingPROCESSOR FOR INTLKG  
FAILURE  
FUNCTION

Indicates processor shutdown.

SIGNAL HIGHSIGNAL LOW  
When processor is not shutdown.When processor is shutdown.

TABLE III - TRAIN OPERATION INDICATIONS (Continued)

<u>NO.</u> 3T	<u>GROUP</u> Interlocking	<u>NAME</u> PROCESSOR FOR INTLK PROBLEM or; PROCESSOR FOR STATION PROBLEM
------------------	------------------------------	---

FUNCTION

Indicates detection of trouble in processor but system is operational.

SIGNAL HIGH

When processor is not in warning state.

SIGNAL LOW

When processor is in warning state.

<u>NO.</u> 4A	<u>GROUP</u> Misc. Train Control Room	<u>NAME</u> CIRCUIT POWER FAILURE
------------------	--	--------------------------------------

FUNCTION

Indicates loss of power in Train Control Room electrical circuit(s).

SIGNAL HIGH

When all Train Control Room power voltages are available and no ground fault is detected.

SIGNAL LOW

When power in Train Control Room fails in one or more electrical circuits, or when ground fault is detected.

<u>NO.</u> 4B	<u>GROUP</u> Misc. Train Control Room	<u>NAME</u> POWER TRANSFER
------------------	--	-------------------------------

FUNCTION

Indicates failure of transfer switch or when the transfer switch is thrown to secondary source of power.

SIGNAL HIGH

When transfer switch is thrown to secondary source of power or failure of transfer switch.

SIGNAL LOW

When transfer switch is in normal position (primary power source).

DTS FUNCTIONS - TABLE IV  
ELECTRICAL & SUPPORT EQUIPMENT INDICATIONS (2 BITS)

<u>NO.</u> 1Ai	<u>GROUP</u> Traction Power (DCPWR)	<u>NAME</u> AC INC LINE BRK (No.) CLOSED (AC Incoming Line Breaker)
-------------------	--	---

FUNCTION  
Indicates whether designated breaker is closed or not.

SIGNAL HIGH  
Indicates breaker in closed status.

SIGNAL LOW  
Indicates breaker not in closed status.

---

<u>NO.</u> 1Aii	<u>GROUP</u> Traction Power (DCPWR)	<u>NAME</u> AC INC LINE BRK (No.) TRIP.
--------------------	--	---

FUNCTION  
Indicates whether designated breaker is tripped or not.

SIGNAL HIGH  
Indicates breaker is in tripped status

SIGNAL LOW  
Indicates breaker not in tripped status.

---

<u>NO.</u> 1Bi	<u>GROUP</u> Traction Power (DCPWR)	<u>NAME</u> AC SEC TIE BRK (No.) CLOSED (AC Section Tie Breaker).
-------------------	--	---

FUNCTION  
Same as for 1Ai.

SIGNAL HIGH  
Same as for 1Ai. Alarm state.

SIGNAL LOW  
Same as for 1Ai. No alarm state.

---

<u>NO.</u> 1Bii	<u>GROUP</u> Traction Power (DCPWR)	<u>NAME</u> AC SEC TIE BRK (No.) TRIP. Same as for 1Aii.
--------------------	--	--

SIGNAL HIGH  
Same as for 1Aii. No alarm state.

SIGNAL LOW  
Same as for 1Aii. Alarm state.

---

TABLE IV - ELECTRICAL & SUPPORT EQUIPMENT INDICATIONS  
(2 BITS) (Continued)

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
1Ci	Traction Power (DCPWR)	AC RECT TRANS FDR BRK (No.) CLOSED (AC Rectifier Transformer Feeder Breaker)

FUNCTION

Same as for 1Ai.

SIGNAL HIGH  
Same as for 1Ai.

SIGNAL LOW  
Same as for 1Ai.

---

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
1Cii	Traction Power (DCPWR)	AC RECT TRANS FDR BRK (No.) TRIP (AC Rectifier Transformer Feeder Breaker)

FUNCTION

TRIP. Same as for 1Aii.

SIGNAL HIGH  
Same as for 1Aii.

SIGNAL LOW  
Same as for 1Aii.

---

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
1Di	Traction Power (DCPWR)	AC FDR BRK, AUX PWR TRANS (No.) CLOSED (AC Feeder Breaker for Auxiliary Power Transformer)

FUNCTION

CLOSE. Same as for 1Aii.

SIGNAL HIGH  
Same as for 1Ai.

SIGNAL LOW  
Same as for 1Ai.

---

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
1Dii	Traction Power (DCPWR)	AC FDR BRK, AUX PWR TRANS (No.) TRIP (AC Feeder Breaker for Auxiliary Power Transformer)

FUNCTION

Same as for 1Aii.

SIGNAL HIGH  
Same as for 1Aii.

SIGNAL LOW  
Same as for 1Aii.

---

TABLE IV - ELECTRICAL & SUPPORT EQUIPMENT INDICATIONS  
(2 BITS) (Continued)

NO.            GROUP  
1Ei            Traction Power (DCPWR)

NAME  
DC RECT BRK (No.)  
CLOSED (DC Rectifier  
Transformer Breaker)

FUNCTION  
Same as for 1Ai.

SIGNAL HIGH  
Same as for 1Aii.

SIGNAL LOW  
Same as for 1Aii.

---

NO.            GROUP  
1Eii            Traction Power (DCPWR)

NAME  
DC RECT BRK (No.) TRIP  
(DC Rectifier Transformer  
Breaker).

FUNCTION  
Same as for 1Aii.

SIGNAL HIGH  
Same as for 1Aii.  
Alarm state.

SIGNAL LOW  
Same as for 1Aii.  
No alarm state.

---

NO.            GROUP  
1Fi            Traction Power (DCPWR)

NAME  
DC FDR TIE BRK (No.)  
CLOSED (DC Feeder  
Tie Breaker)

FUNCTION  
Same as for 1Ai.

SIGNAL HIGH  
Same as for 1Ai.

SIGNAL LOW  
Same as for 1Ai.

---

NO.            GROUP  
1Fii            Traction Power (DCPWR)

NAME  
DC FDR TIE BRK (No.)  
TRIP (DC Feeder  
Tie Breaker)

FUNCTION  
Same as for 1Aii.

SIGNAL HIGH  
Same as for 1Aii.

SIGNAL LOW  
Same as for 1Aii.

---

TABLE IV - ELECTRICAL & SUPPORT EQUIPMENT INDICATIONS  
(2 BITS) (Continued)

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
1Gi	Traction Power (DCPWR)	TRANS OVER TEMP (No.) NOR/OFF (Transformer over temperature)

FUNCTION

Indicates whether the equipment temperature is normal or not.

SIGNAL HIGH

Indicates temperature normal status and no alarm state.

SIGNAL LOW

Indicates temperature not normal status and alarm state.

---

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
1Gii	Traction Power (DCPWR)	TRANS OVER TEMP (No.) ABN/ON (Transformer over temperature)

FUNCTION

Indicates whether the equipment is overheated or not.

SIGNAL HIGH

Indicates temperature abnormal status and alarm state.

SIGNAL LOW

Indicates temperature not abnormal and no alarm state.

---

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
1Hi	Traction Power (DCPWR)	RECT OVER TEMP (No.) NOR/OFF (Rectifier over temperature)

FUNCTION

Same as for 1Gi.

SIGNAL HIGH

Same as for 1Gi.

SIGNAL LOW

Same as for 1Gi.

---

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
1Hii	Traction Power (DCPWR)	RECT OVER TEMP (No.) ABN/ON (Rectifier over temperature)

FUNCTION

Same as for 1Gii.

SIGNAL HIGH

Same as for 1Gii.

SIGNAL LOW

Same as for 1Gii.

---

TABLE IV - ELECTRICAL & SUPPORT EQUIPMENT INDICATIONS  
(2 BITS) (Continued)

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
1Ii	Traction Power (DCPWR)	RECT TRANS LOCKOUT (No.) NOR/OFF (Rectifier Transformer Lockout)

FUNCTION

Indicates whether the equipment is in locked out state or not.

SIGNAL HIGH  
Indicates normal status  
and no alarm state.

SIGNAL LOW  
Indicates not normal  
and alarm state

---

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
1Iii	Traction Power (DCPWR)	RECT TRANS LOCKOUT (No.) ABN/ON (Rectifier Transformer Lockout)

FUNCTION

Indicates whether the equipment is in lockout condition or not.

SIGNAL HIGH  
Indicates locked out status  
and alarm state.

SIGNAL LOW  
Indicates not locked out  
and not in alarm state.

---

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
1Ji	Traction Power (DCPWR)	AC INC LINE VOLTS (No.) NOR/OFF (AC Incoming Line Voltage)

FUNCTION

Indicates whether line voltage condition is within limit or not.

SIGNAL HIGH  
Indicates line voltage within  
limits and no alarm condition.

SIGNAL LOW  
Indicates line voltage  
not within limits and  
alarm state.

---

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
1Jii	Traction Power (DCPWR)	AC INC LINE VOLTS (No.) ABN/ON (AC Incoming Line Voltage)

FUNCTION

Indicates whether line voltage condition out of limits or not.

SIGNAL HIGH  
Indicates line voltage out of  
limits and alarm state.

SIGNAL LOW  
Indicates line voltage  
not out of limits and no alarm state.

TABLE IV - ELECTRICAL & SUPPORT EQUIPMENT INDICATIONS  
(2 BITS) (Continued)

<u>NO.</u> 1Ki	<u>GROUP</u> Traction Power (DCPWR)	<u>NAME</u> AC SUPPLY (No.) TO SWGR FAIL NOR/OFF (AC supply to switch gear control circuit failure)
-------------------	--	---

FUNCTION  
Indicates whether the ac voltage is present or not.

SIGNAL HIGH  
Indicates voltage present  
condition and no alarm state.

SIGNAL LOW  
Indicates voltage not  
present and alarm state.

---

<u>NO.</u> 1Kii	<u>GROUP</u> Traction Power (DCPWR)	<u>NAME</u> AC SUPPLY (No.) TO SWGR FAIL ABN/ON (AC supply to switch gear control circuit failure)
--------------------	--	--

FUNCTION  
Indicates whether the ac voltage has failed or not.

SIGNAL HIGH  
Indicates voltage failure and  
alarm state.

SIGNAL LOW  
Indicates not a voltage  
failure and no alarm state.

---

<u>NO.</u> 1Li	<u>GROUP</u> Traction Power (DCPWR)	<u>NAME</u> AUX PWR TRANSFER SW (No.) NOR/OFF (Auxiliary power transfer switch)
-------------------	--	--

FUNCTION  
Indicates whether the switch is in normal position or not.

SIGNAL HIGH  
Indicates the switch is in normal  
(primary source of power)  
position and not in alarm state.

SIGNAL LOW  
Indicates the switch is  
not in normal position  
and in alarm state.

---

<u>NO.</u> 1Lii	<u>GROUP</u> Traction Power (DCPWR)	<u>NAME</u> AUX PWR TRANSFER SW (No.) ABN/ON (Auxiliary power transfer switch)
--------------------	--	---

FUNCTION  
Indicates whether the switch is in abnormal position or not.

SIGNAL HIGH  
Indicates switch is in abnormal  
(secondary source of power)  
position and in alarm state.

SIGNAL LOW  
Indicates the switch is  
not in abnormal position  
and not in alarm state.

---

TABLE IV - ELECTRICAL & SUPPORT EQUIPMENT INDICATIONS  
(2 BITS) (Continued)

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
1Mi	Traction Power (DCPWR)	BAT CHARGE RLY (No.) NOR/OFF (Battery Charge Relay)

FUNCTION

Indicates whether the Relay is in charging position or not.

SIGNAL HIGH

Indicates the relay is in charging position and no alarm state.

SIGNAL LOW

Indicates the Relay is not in charging position and in alarm state.

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
1Mii	Traction Power (DCPWR)	BAT CHARGE RLY (No.) ABN/ON (Battery Charge Relay)

FUNCTION

Indicates whether the relay is in not charging position or not.

SIGNAL HIGH

Indicates the relay is in not charging position and in alarm state.

SIGNAL LOW

Indicates the relay is not in the not charging position and not in alarm state.

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
1Ni	Traction Power (DCPWR)	AC FDR BRK, AUX PWR TRANS TEMP NOR/OFF (AC Feeder Breaker Auxiliary power transformer temperature)

FUNCTION

Same as for 1Gi.

SIGNAL HIGH

Same as for 1Gi

SIGNAL LOW

Same as for 1Gi.

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
1Nii	Traction Power (DCPWR)	AC FDR BRK, AUX PWR TRANS TEMP ABN/ON (AC Feeder Breaker Auxiliary power transformer temperature)

FUNCTION

Same as for 1Gii.

SIGNAL HIGH

Same as for 1Gi.

SIGNAL LOW

Same as for 1Gi.

TABLE IV - ELECTRICAL & SUPPORT EQUIPMENT INDICATIONS  
(2 BITS) (Continued)

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
10i	Traction Power (DCPWR)	AC GROUP NOR/OFF (Incoming line and brk and inc. line volt)

FUNCTION  
Indicates inc. line breaker and inc. line volt when combined in a normal state.

<u>SIGNAL HIGH</u> Indicates normal state.	<u>SIGNAL LOW</u> Indicates not normal and in alarm state.
---	--

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
10ii	Traction Power (DCPWR)	AC GROUP ABN/ON (Incoming line and brk and inc. line volt)

FUNCTION  
Indicates inc. line breaker and/or inc. line volts in and abnormal state.

<u>SIGNAL HIGH</u> Indicates abnormal state; alarm state.	<u>SIGNAL LOW</u> Indicates not abnormal state; not alarm state.
---	--

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
1Pi	Traction Power (DCPWR)	RECT GROUP NOR/OFF

FUNCTION  
Indicates transformer over temp, rectifier over temp, and rect. lockout when combined in normal state.

<u>SIGNAL HIGH</u> Indicates normal state.	<u>SIGNAL LOW</u> Indicates not normal state.
---	--

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
1Pii	Traction Power (DCPWR)	RECT GROUP ABN/ON

FUNCTION  
Indicates trans over temp, rect overtemp and rect lockout when combined in abnormal state.

<u>SIGNAL HIGH</u> Indicates abnormal alarm state.	<u>SIGNAL LOW</u> Indicates not abnormal and no alarm state.
---	---

TABLE IV - ELECTRICAL & SUPPORT EQUIPMENT INDICATIONS  
(2 BITS) (Continued)

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
1Qi	Traction Power (DCPWR)	BATTERY CHARGE GROUP (No.) NOR/OFF
<u>FUNCTION</u>		
Indicates battery charger, transfer switch and invert output status when combined in normal state.		
<u>SIGNAL HIGH</u>		<u>SIGNAL LOW</u>
Indicates normal, non-alarm state.		Indicates not normal, alarm state.

---

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
1Qii	Traction Power (DCPWR)	BATTERY CHARGE GROUP (No.) ABN/ON
<u>FUNCTION</u>		
Indicates battery charger, transfer switch and invert output status when combined in abnormal alarm state.		
<u>SIGNAL HIGH</u>		<u>SIGNAL LOW</u>
Indicates abnormal, alarm state.		Indicates not abnormal, non-alarm state.

---

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
2Ai	AC Service Room (ACPWR)	AC INC LINE BRK (No.) CLOSED (AC Incoming line breaker).
<u>FUNCTION</u>		
Same as for 1Ai.		
<u>SIGNAL HIGH</u>		<u>SIGNAL LOW</u>
Same as for 1Ai. No alarm state.		Same as for 1Aii. Alarm state.

---

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
2Aii	AC Service Room (ACPWR)	AC INC LINE BRK (No.) TRIP (AC Incoming line breaker).
<u>FUNCTION</u>		
Same as for 1Aii.		
<u>SIGNAL HIGH</u>		<u>SIGNAL LOW</u>
Same as for 1Aii. Alarm State.		Same as for 1Aii. No Alarm State.

---

TABLE IV - ELECTRICAL & SUPPORT EQUIPMENT INDICATIONS  
(2 BITS) (Continued)

<u>NO.</u> 2Bi	<u>GROUP</u> AC Service Room (ACPWR)	<u>NAME</u> AC SEC MAIN BRK (No.) CLOSED (AC Secondary main breaker).
<u>FUNCTION</u> Same as for 1Ai.		
<u>SIGNAL HIGH</u> Same as for 2Ai.		<u>SIGNAL LOW</u> Same as for 2Ai.
<hr/>		
<u>NO.</u> 2Bii	<u>GROUP</u> AC Service Room (ACPWR)	<u>NAME</u> AC SEC MAIN BRK (No.) TRIP (AC Secondary Main Breaker).
<u>FUNCTION</u> Same as for 1Aii.		
<u>SIGNAL HIGH</u> Same as for 2Aii.		<u>SIGNAL LOW</u> Same as for 2Aii.
<hr/>		
<u>NO.</u> 2Ci	<u>GROUP</u> AC Service Room (ACPWR)	<u>NAME</u> AC SEC TIE BRK (No.) CLOSED (AC Secondary Tie Breaker).
<u>FUNCTION</u> Same as for 1Ai.		
<u>SIGNAL HIGH</u> Same as for 1Bi.		<u>SIGNAL LOW</u> Same as for 1Bi.
<hr/>		
<u>NO.</u> 2Cii	<u>GROUP</u> AC Service Room (ACPWR)	<u>NAME</u> AC SEC TIE BRK (No.) TRIP (AC Secondary Tie Breaker).
<u>FUNCTION</u> Same as for 1Aii.		
<u>SIGNAL HIGH</u> Same as for 1Bii.		<u>SIGNAL LOW</u> Same as for 1Bii.
<hr/>		
<u>NO.</u> 2Di	<u>GROUP</u> AC Service Room (ACPWR)	<u>NAME</u> AC TRANS OVER TEMP (No.) NOR/OFF (AC Transformer over temperature).
<u>FUNCTION</u> Same as for 1Gi		
<u>SIGNAL HIGH</u> Same as for 1Gi.		<u>SIGNAL LOW</u> Same as for 1Gi.
<hr/>		

TABLE IV - ELECTRICAL & SUPPORT EQUIPMENT INDICATIONS  
(2 BITS) (Continued)

<u>NO.</u> 2Dii	<u>GROUP</u> AC Service Room (ACPWR)	<u>NAME</u> AC TRANS OVER TEMP (No.) ABN/ON (AC Transformer over temperature).
--------------------	---	--

FUNCTION  
Same as for 1Gii.

SIGNAL HIGH  
Same as for 1Gii.

SIGNAL LOW  
Same as for 1Gii.

---

<u>NO.</u> 2Ei	<u>GROUP</u> AC Service Room (ACPWR)	<u>NAME</u> BATTERY ROOM EXHAUST FAN (Number) NOR/OFF
-------------------	---	---

FUNCTION  
Indicates whether fan is operational or not.

SIGNAL HIGH  
Indicates Fan is operational  
No alarm state.

SIGNAL LOW  
Indicates Fan is not in  
operational mode.  
Alarm State.

---

<u>NO.</u> 2Eii	<u>GROUP</u> AC Service Room (ACPWR)	<u>NAME</u> BATTERY ROOM EXHAUST FAN (Number) ABN/ON
--------------------	---	--

FUNCTION  
Indicates whether fan is in not operational mode or not.

SIGNAL HIGH  
Indicates fan is not operational.  
Alarm state.

SIGNAL LOW  
Indicates fan is not in  
not operational mode. No alarm state.

---

<u>NO.</u> 2Fi	<u>GROUP</u> AC Service Room (ACPWR)	<u>NAME</u> AC EMERG TRANSFER SW (No.) NOR/OFF (AC Emergency Transfer Switch)
-------------------	---	--

FUNCTION  
Same as for 1Li.

SIGNAL HIGH  
Same as for 1Li.

SIGNAL LOW  
Same as for 1Li.

---

TABLE IV - ELECTRICAL & SUPPORT EQUIPMENT INDICATIONS  
(2 BITS) (Continued)

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
2Fii	AC Service Room (ACPWR)	AC EMERG TRANSFER SW No. ABN/ON (AC Emergency Transfer Switch)

FUNCTION  
Same as for 1Lii.

SIGNAL HIGH  
Same as for 1Lii.

SIGNAL LOW  
Same as for 1Lii.

---

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
2Gi	AC Service Room (ACPWR)	AC BAT CHARGE RELAY (No.) NOR/OFF (AC Battery Charge Relay).

FUNCTION  
Same as for 1Mi.

SIGNAL HIGH  
Same as for 1Mi.

SIGNAL LOW  
Same as for 1Mi.

---

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
2Gii	AC Service Room (ACPWR)	AC BAT CHARGE RELAY (No.) ABN/ON (AC Battery Charge Relay).

FUNCTION  
Same as for 1Mii.

SIGNAL HIGH  
Same as for 1Mii.

SIGNAL LOW  
Same as for 1Mii.

---

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
3Ai	Misc.	INVERTER OUTPUT (No.) NOR/OFF

FUNCTION  
Indicates whether output is normal or not.

SIGNAL HIGH  
Indicates output is normal.  
No alarm state.

SIGNAL LOW  
Indicates output is not  
normal. Alarm state.

---

TABLE IV - ELECTRICAL & SUPPORT EQUIPMENT INDICATIONS  
(2 BITS) (Continued)

<u>NO.</u> 3Aii	<u>GROUP</u> Misc.	<u>NAME</u> INVERTER OUTPUT (No.) ABN/ON
--------------------	-----------------------	--

FUNCTION  
Indicates whether output is abnormal or not.

SIGNAL HIGH  
Indicates output is abnormal.  
Alarm state.

SIGNAL LOW  
Indicates output is not  
abnormal. No alarm state.

---

<u>NO.</u> 3Bi	<u>GROUP</u> Misc.	<u>NAME</u> FANS (No.) EMERGENCY OFF
-------------------	-----------------------	---

FUNCTION  
Indicates whether equipment is in emergency off status or not.

SIGNAL HIGH  
Indicates fan is in emergency  
off status.

SIGNAL LOW  
Indicates fan is not in  
emergency off status.

---

<u>NO.</u> 3Bii	<u>GROUP</u> Misc.	<u>NAME</u> FANS (No.) EMERGENCY ON
--------------------	-----------------------	--

FUNCTION  
Indicates whether equipment is in emergency on status or not.

SIGNAL HIGH  
Indicates fan is in  
emergency on status.

SIGNAL LOW  
Indicates fan is not in  
emergency on status.

---

<u>NO.</u> 3Di	<u>GROUP</u> Misc.	<u>NAME</u> THIRD RAIL HEATER (No.) ON
-------------------	-----------------------	--

FUNCTION  
Indicates heater is on.

SIGNAL HIGH  
Heater is on.

SIGNAL LOW  
Heater is not on.

---

TABLE IV - ELECTRICAL & SUPPORT EQUIPMENT INDICATIONS  
(2 BITS) (Continued)

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
3Dii	Misc.	THIRD RAIL HEATER (No.) OFF

FUNCTION  
Indicates heater is off.

SIGNAL HIGH  
Heater is off.

SIGNAL LOW  
Heater is not off.

- NOTE 1: When alarm states are not mentioned, equipment is controllable from OCC. Commanded state is non-alarm state. All other states are alarmable including two-bit status High-High or Low-Low, except Low-Low status for fan indicates AUTO mode, and Low-Low for pump indicates ON status. When status for these two are received and commanded, it is not an alarm state.
- NOTE 2: When alarm state is indicated, equipment is not controllable from OCC. Two-bit status of High-High and Low-Low are alarm states.
- NOTE 3: "00" state for FANS is considered to be AUTO state, and is not a "PROBLEM 00" state. "00" state for PUMP is ON state and not "PROBLEM 00" state.

DTS FUNCTIONS - TABLE V  
ELECTRICAL & SUPPORT EQUIPMENT INDICATIONS (1 BIT)

<u>NO.</u> 1A	<u>GROUP</u> Tunnel	<u>NAME</u> FANS (No.) SUPPLY
------------------	------------------------	----------------------------------

FUNCTION

Indicates whether the mode of operation is in supply or exhaust.

SIGNAL HIGH  
Indicates supply.

SIGNAL LOW  
Indicates exhaust.

<u>NO.</u> 1B	<u>GROUP</u> Tunnel	<u>NAME</u> FAN SHAFT DAMPER (No.) ABN/ON
------------------	------------------------	---

FUNCTION

Indicates whether damper (open or close) position is matching with fans operational state.

SIGNAL HIGH  
Indicates unmatched position.  
Alarm state.

SIGNAL LOW  
Indicates matching  
position. Non-alarm state.

<u>NO.</u> 1C	<u>GROUP</u> Tunnel	<u>NAME</u> VENT SHAFT DAMPER (No.) ABN/ON
------------------	------------------------	--

FUNCTION

Same as for 1B.

SIGNAL HIGH  
Same as for 1B.

SIGNAL LOW  
Same as for 1B.

<u>NO.</u> 1D	<u>GROUP</u> Tunnel	<u>NAME</u> FANS (No.) OPERATION ABN/ON
------------------	------------------------	---

FUNCTION

Indicates whether the fan is operating as commanded or not.

SIGNAL HIGH  
Indicates Fan is not operating  
as commanded. Alarm state.

SIGNAL LOW  
Indicates Fan is  
operating as commanded.  
Non-alarm state.

TABLE V - ELECTRICAL & SUPPORT EQUIPMENT INDICATIONS  
(1 BIT) (Continued)

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
1E	Tunnel	FANS (No.) REMOTE CONTROL ABN/ON

FUNCTION

Indicates whether remote control circuitry is operational or not.

SIGNAL HIGH

Indicates remote control circuitry is not operational. Alarm state.

SIGNAL LOW

Indicates remote control circuitry is operational. Non-alarm state.

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
1F	Tunnel	TUNNEL TEMP (No.) HIGH ABN/ON

FUNCTION

Indicates whether temperature is above high limit or not.

SIGNAL HIGH

Indicates temperature above high limit. Alarm state.

SIGNAL LOW

Indicates temperature not above high limit. Non-alarm state.

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
1G	Tunnel	TUNNEL TEMP (No.) LOW ABN/ON

FUNCTION

Indicates whether temperature is below low limit or not.

SIGNAL HIGH

Indicates temperature below low limit. Alarm state.

SIGNAL LOW

Indicates temperature not below low limit. Non-alarm state.

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
2A	Station	STATION AMBIENT TEMPERATURE ABN/ON

FUNCTION

Indicates whether station temperature is within limits or not.

SIGNAL HIGH

Indicates temperature is above high or below low limit. state.

SIGNAL LOW

Indicates temperature is within limits. Non-alarm Alarm state.

TABLE V - ELECTRICAL & SUPPORT EQUIPMENT INDICATIONS  
(1 BIT) (Continued)

<u>NO.</u> 2B	<u>GROUP</u> Station	<u>NAME</u> ACU FAN (No.) ABN/ON (Air Conditioning Unit Fan)
<u>FUNCTION</u> Indicates whether ACU fan is in proper operation or not.		
<u>SIGNAL HIGH</u> Indicates improper operation. Alarm state.		<u>SIGNAL LOW</u> Indicates proper operation. Non-alarm state.
<u>NO.</u> 2C	<u>GROUP</u> Station	<u>NAME</u> FRESH AIR AHU FAN (No.) ABN/ON. (Fresh Air Air Handling Unit Fan)
<u>FUNCTION</u> Indicates whether AHU Fan is in proper operation or not.		
<u>SIGNAL HIGH</u> Same as for 2B.		<u>SIGNAL LOW</u> Same as for 2B.
<u>NO.</u> 4A	<u>GROUP</u> Misc.	<u>NAME</u> Subway DPS (No.) ABN/ON (Subway Drainage Pumping Station).
<u>FUNCTION</u> Indicates whether water level is above normal or not.		
<u>SIGNAL HIGH</u> Indicates water level is above normal. Alarm state.		<u>SIGNAL LOW</u> Indicates water level is not above normal. Non-alarm state.

TABLE V - ELECTRICAL & SUPPORT EQUIPMENT INDICATIONS  
(1 BIT) (Continued)

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
4B	Misc.	SEWAGE PUMP (No.) AIR ABN/ON

FUNCTION

Indicates whether air pressure is below operational level or not.

SIGNAL HIGH

Indicates pressure below  
operational level.  
Alarm state.

SIGNAL LOW

Indicates pressure not  
below operational level.  
Non-Alarm state.

---

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
4C	Misc.	FVD WARNING ACTIVE/ON (Flammable Vapor)

FUNCTION

Indicates whether FVD system at warning level or not.

SIGNAL HIGH

Indicates warning level.  
Alarm state.

SIGNAL LOW

Indicates not at warning  
level. Non-Alarm state.

---

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
4D	Misc.	FVD ALARM ACTIVE/ON

FUNCTION

Indicates whether FVD System at danger level or not.

SIGNAL HIGH

Indicates danger level.  
Alarm state.

SIGNAL LOW

Indicates not danger  
level. Non-Alarm state.

---

<u>NO.</u>	<u>GROUP</u>	<u>NAME</u>
4E	Misc.	FIRE ALARM (No.) ACTIVE/ON

FUNCTION

Indicates whether fire alarm system is active or not.

SIGNAL HIGH

Indicates active state.  
Alarm state.

SIGNAL LOW

Indicates non-active.  
Non-Alarm state.

---

TABLE V - ELECTRICAL & SUPPORT EQUIPMENT INDICATIONS  
(1 BIT) (Continued)

<u>NO.</u> 4F	<u>GROUP</u> Misc.	<u>NAME</u> UNAUTHORIZED ENTRANCE (No.) ACTIVE/ON
------------------	-----------------------	---

FUNCTION  
Indicates whether intrusion detected or not.

SIGNAL HIGH  
Indicates intrusion detected.  
Alarm state.

SIGNAL LOW  
Indicates intrusion not  
detected. Non-Alarm  
state.

<u>NO.</u> 4G	<u>GROUP</u> Misc.	<u>NAME</u> BLDG AMBIENT TEMP ABN/ON
------------------	-----------------------	---

FUNCTION  
Indicates whether building ambient temperature is normal or not.

SIGNAL HIGH  
Indicates abnormal temperature.  
Alarm state.

SIGNAL LOW  
Indicates normal temperature.  
Non-Alarm state.

<u>NO.</u> 4H	<u>GROUP</u> Misc.	<u>NAME</u> SUMP PUMP (No.) ABN/ON
------------------	-----------------------	---------------------------------------

FUNCTION  
Indicates whether sump pump is operating properly or not.

SIGNAL HIGH  
Indicates improper operation.  
Alarm state.

SIGNAL LOW  
Indicates proper operation.  
Non-Alarm state.

<u>NO.</u> 4I	<u>GROUP</u> Misc.	<u>NAME</u> GARAGE EXH FAN (No.) ABN/ON
------------------	-----------------------	---

FUNCTION  
Indicates whether garage exhaust fan is operating properly or not.

SIGNAL HIGH  
Indicates improper operation.  
Alarm state.

SIGNAL LOW  
Indicates proper operation.  
Non-Alarm state.

NOTE: When alarm state is not mentioned, equipment is controllable from OCC. Commanded state is non-alarm state and other state is alarm state.

END OF SECTION

**SECTION 16997**

**ATC APPENDIX "SS"**

**RTU SCAN SHEETS**

**PART 1 - GENERAL**

**1.01 SECTION INCLUDES**

- A. TABLE OF CONTENTS of wayside TCR locations involved.
- B. Explanation of notations used to define modifications to Scan Sheets at location(s) currently in service.

Example TABLE OF CONTENTS

<u>Location</u>	<u>Type</u>	<u>Code</u>	<u>Frame Type</u>	<u>Sheets</u>
Tie-In Loc.	Rev.	X03	Control Status	X03-C1-C12* X03-S1-S16*
Hooterville	New	X04	Control Status	X04-C1-C10* X04-S1-S16*
End-of-Line Terminal	New	X05	Control Status	X05-C1-C12* X05-S1-S18*

NOTES:

1. Where an equipment function may be added or activated in the future, the notation "(FUTU)" in the Scan Sheet following the function name has the following meaning:
  - a. (FUTU) = Inactive now, but all DTS hardware and wiring shall be provided by the Contractor under this Contract at "New" locations to facilitate possible future use.
2. Revised functions, PC card types, or energy feeds for the existing Tie-In location RTU are indicated by an alphabetical character in the Scan Sheet column preceding the function names. The characters used, and their meanings, are as follows:
  - a. A = ADD
  - b. C = CHANGE
  - c. D = DELETE
  - d. E = ENERGIZE/ACTIVATE (a pre-wired point)
  - e. M = MOVED HERE (point or card) (May include a CHANGE)
  - f. R = RESERVE (for specific future use)  
or  
1) REMOVE (existing wired point to be removed at the appropriate time)
  - g. V = VERIFY (that the indicated change has been made)
3. The old (previously assigned) names for the functions at the point locations revised are shown in brackets following the new names.
4. All deleted DTS function wiring shall be tagged and taped by the Contractor.
5. Control card types (and associated energization) for new Remote Terminal Units are shown for illustrative purposes only. The Contractor may use Relay-Single, Relay-Pair, or Electronic PC Control cards, or any combination thereof, for these

new units, along with appropriate wiring. The energization and card type(s) shall be fully documented in the RTU circuits and Scan Sheets submitted by the Contractor. (See Section 16925, Data Transmission System.)

- C. RTU Control and Status Scan Sheets for new mainline locations.
- D. RTU Control and Status Scan Sheets required to reflect necessary changes at pre-existing mainline Tie-In locations.

**1.02 RTU SCAN SHEETS BY LOCATION**

- E. Location Name (Location Code) Control Frames
- F. Location Name (Location Code) Status Frames
- G. The above to be added by the Authority for the applicable New and/or Tie-In mainline locations. Example Location follows.

**1.03 R.T.U. SCAN SHEET – EXAMPLE LOCATION**

ANACOSTIA RTU (F06) CONTROL FRAMES

F	W	BT	BT	FUNCTION	LOCATION
0	0	0	2	HOUSEKEEPING	
0	0	1	3	HOUSEKEEPING	
0	0	2	4	HOUSEKEEPING	
0	0	3	5	HOUSEKEEPING	
0	0	4	6	RUN NUMBER, PLATFORM 1 MSB-MSD	
0	0	5	7	RUN NUMBER, PLATFORM 1	
0	0	6	8	RUN NUMBER, PLATFORM 1	
0	0	7	9	RUN NUMBER, PLATFORM 1 LSB-MSD	
0	0	8	10	RUN NUMBER, PLATFORM 1 MSB-MD	
0	0	9	11	RUN NUMBER, PLATFORM 1	
0	0	10	12	RUN NUMBER, PLATFORM 1	
0	0	11	13	RUN NUMBER, PLATFORM 1 LSB-MD	
0	0	12	14	RUN NUMBER, PLATFORM 1 MSB-LSD	
0	0	13	15	RUN NUMBER, PLATFORM 1 STROBE	

ELECTRONIC CARD

F	W	BT	BT	FUNCTION	LOCATION
0	1	0	2	RUN NUMBER, PLATFORM 1	
0	1	1	3	RUN NUMBER, PLATFORM 1 LSB-LSD	
0	1	2	4	DESTINATION, PLATFORM 1 MSB-MSD	(TWC STA RCVR)
0	1	3	5	DESTINATION, PLATFORM 1	(TWC STA RCVR)
0	1	4	6	DESTINATION, PLATFORM 1	(TWC STA RCVR)
0	1	5	7	DESTINATION, PLATFORM 1 LSB-MSD	(TWC STA RCVR)
0	1	6	8	DESTINATION, PLATFORM 1 MSB-LSD	(TWC STA RCVR)

0	1	7	9	DESTINATION, PLATFORM 1	(TWC STA RCVR)
0	1	8	10	DESTINATION, PLATFORM 1	(TWC STA RCVR)
0	1	9	11	DESTINATION, PLATFORM 1 LSB-LSD	(TWC STA RCVR)
0	1	10	12	SPARE	
0	1	11	13	ATS-ACCELERATION, PLATFORM 1	
0	1	12	14	ATS-PERFORMANCE, PLATFORM 1 MSB	
0	1	13	15	ATS-PERFORMANCE, PLATFORM 1 LSB	
				STROBE	

ELECTRONIC CARD

SHEET F06 - C1

ANACOSTIA RTU (F06)

CONTROL FRAMES

F	W	BT	BT	FUNCTION	LOCATION
0	2	0	2	HOLD WITH DOORS CLOSED, PLATFORM 1	
0	2	1	3	HOLD WITH DOORS OPEN, PLATFORM 1	
0	2	2	4	TERMINATE DWELL, PLATFORM 1	
0	2	3	5	DOOR CLOSE WARNING, PLATFORM 1	
0	2	4	6	SPARE	
0	2	5	7	SPARE	
0	2	6	8	SPARE	
0	2	7	9	E SKIP STOP MARKER 1N1200	(F1-192)
0	2	8	10	E SKIP STOP MARKER 1N500	(F06-3AT)
0	2	9	11	SKIP STOP MARKER 1R1200	(F1-170)
0	2	10	12	SKIP STOP MARKER 1R500	(F1-178)
0	2	11	13	SPARE	
0	2	12	14	SPARE	
0	2	13	15	TIME PULSE-MIN	
				STROBE	

RELAY PAIR CARD

F	W	BT	BT	FUNCTION	LOCATION
0	3	0	2	SPARE	
0	3	1	3	SPARE	
0	3	2	4	R SPARE [DEST, PLATFORM 1 MSB-MSD	(FUT. DEST. SGN)]
0	3	3	5	R SPARE [DEST, PLATFORM 1	(FUT. DEST. SGN)]
0	3	4	6	R SPARE [DEST, PLATFORM 1	(FUT. DEST. SGN)]
0	3	5	7	R SPARE [DEST, PLATFORM 1 LSB-MSD	(FUT. DEST. SGN)]
0	3	6	8	R SPARE [DEST, PLATFORM 1 MSB-LSD	(FUT. DEST. SGN)]
0	3	7	9	R SPARE [DEST, PLATFORM 1	(FUT. DEST. SGN)]
0	3	8	10	R SPARE [DEST, PLATFORM 1	(FUT. DEST. SGN)]
0	3	9	11	R SPARE [DEST, PLATFORM 1 LSB-LSD	(FUT. DEST. SGN)]
0	3	10	12	TRAIN LENGTH, PLATFORM 1 MSB	
0	3	11	13	TRAIN LENGTH, PLATFORM 1	
0	3	12	14	TRAIN LENGTH, PLATFORM 1	
0	3	13	15	TRAIN LENGTH, PLATFORM 1 LSB	

STROBE

ELECTRONIC CARD

LEGEND:

- E = ENERGIZE/ACTIVATE PRE-WIRED POINT.
- R = CONTRACTOR SHALL REMOVE WIRED POINT AND UPDATE SCAN SHEET AND DRAWINGS.

SHEET F06 – C2

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

CONTROL FRAMES

F	W	BT	BT	FUNCTION	LOCATION
1	0	0	2	SPARE	
1	0	1	3	SPARE	
1	0	2	4	SPARE	
1	0	3	5	SPARE	
1	0	4	6	RUN NUMBER, PLATFORM 2 MSB-MSD	
1	0	5	7	RUN NUMBER, PLATFORM 2	
1	0	6	8	RUN NUMBER, PLATFORM 2	
1	0	7	9	RUN NUMBER, PLATFORM 2 LSB-MSD	
1	0	8	10	RUN NUMBER, PLATFORM 2 MSB-MD	
1	0	9	11	RUN NUMBER, PLATFORM 2	
1	0	10	12	RUN NUMBER, PLATFORM 2	
1	0	11	13	RUN NUMBER, PLATFORM 2 LSB-MD	
1	0	12	14	RUN NUMBER, PLATFORM 2 MSB-LSD	
1	0	13	15	RUN NUMBER, PLATFORM 2	
				STROBE	

ELECTRONIC CARD

F	W	BT	BT	FUNCTION	LOCATION
1	1	0	2	RUN NUMBER, PLATFORM 2	
1	1	1	3	RUN NUMBER, PLATFORM 2 LSB-LSD	
1	1	2	4	DESTINATION, PLATFORM 2 MSB-MSD	(TWC STA RCVR)
1	1	2	4	DESTINATION, PLATFORM 2	(TWC STA RCVR)
1	1	4	6	DESTINATION, PLATFORM 2	(TWC STA RCVR)
1	1	5	7	DESTINATION, PLATFORM 2 LSB-MSD	(TWC STA RCVR)
1	1	6	8	DESTINATION, PLATFORM 2 MSB-LSD	(TWC STA RCVR)
1	1	7	9	DESTINATION, PLATFORM 2	(TWC STA RCVR)
1	1	8	10	DESTINATION, PLATFORM 2	(TWC STA RCVR)
1	1	9	11	DESTINATION, PLATFORM 2 LSB-LSD	(TWC STA RCVR)
1	1	10	12	SPARE	
1	1	11	13	ATS-ACCELERATION, PLATFORM 2	
1	1	12	14	ATS-PERFORMANCE, PLATFORM 2 MSB	

1 1 13 15 ATS-PERFORMANCE, PLATFORM 2 LSB  
STROBE

ELECTRONIC CARD

SHEET F06 – C3

ANACOSTIA RTU (F06)

CONTROL FRAMES

F	W	BT	BT	FUNCTION	LOCATION
1	2	0	2	HOLD WITH DOORS CLOSED, PLATFORM 2	
1	2	1	3	HOLD WITH DOORS OPEN, PLATFORM 2	
1	2	2	4	TERMINATE DWELL, PLATFORM 2	
1	2	3	5	DOOR CLOSE WARNING, PLATFORM 2	
1	2	4	6	SPARE	
1	2	5	7	SPARE	
1	2	6	8	SPARE	
1	2	7	9	SKIP STOP MARKER 2N1200	(F2-170)
1	2	8	10	SKIP STOP MARKER 2N500	(F2-179)
1	2	9	11	E SKIP STOP MARKER 2R1200	(F2-192)
1	2	10	12	E SKIP STOP MARKER 2R500	(F06-1BT)
1	2	11	13	SPARE	
1	2	12	14	SPARE	
1	2	13	15	TIME PULSE-HRS/24 HRS STROBE	

RELAY PAIR CARD

F	W	BT	BT	FUNCTION	LOCATION
1	3	0	2	SPARE	
1	3	1	3	SPARE	
1	3	2	4	R SPARE [DEST,PLATFORM 2 MSB-MSD	(FUT. DEST. SGN)]
1	3	3	5	R SPARE [DEST,PLATFORM 2	(FUT. DEST. SGN)]
1	3	4	6	R SPARE [DEST,PLATFORM 2	(FUT. DEST. SGN)]
1	3	5	7	R SPARE [DEST,PLATFORM 2 LSB-MSD	(FUT. DEST. SGN)]
1	3	6	8	R SPARE [DEST,PLATFORM 2 MSB-LSD	(FUT. DEST. SGN)]
1	3	7	9	R SPARE [DEST,PLATFORM 2	(FUT. DEST. SGN)]
1	3	8	10	R SPARE [DEST,PLATFORM 2	(FUT. DEST. SGN)]
1	3	9	11	R SPARE [DEST,PLATFORM 2 LSB-LSD	(FUT. DEST. SGN)]
1	3	10	12	TRAIN LENGTH, PLATFORM 2 MSB	
1	3	11	13	TRAIN LENGTH, PLATFORM 2	
1	3	12	14	TRAIN LENGTH, PLATFORM 2	
1	3	13	15	TRAIN LENGTH. PLATFORM 2 LSB STROBE	

ELECTRONIC CARD

LEGEND:

E = ENERGIZE/ACTIVATE PRE-WIRED POINT.

R = CONTRACTOR SHALL REMOVE WIRED POINT  
AND UPDATE SCAN SHEET AND DRAWINGS.

SHEET F06 – C4

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

CONTROL FRAMES

F	W	BT	BT	FUNCTION	LOCATION
2	0	0	2	SET LOCAL CONTROL	
2	0	1	3	SET CENTRAL CONTROL	
2	0	2	4	SPARE	
2	0	3	5	SPARE	
2	0	4	6	SET NORMAL SWITCH 1	
2	0	5	7	SET REVERSE SWITCH 1	
2	0	6	8	CANCEL SWITCH 1	
2	0	7	9	SET NORMAL SWITCH 3	
2	0	8	10	SET REVERSE SWITCH 3	
2	0	9	11	CANCEL SWITCH 3	
2	0	10	12	ROUTE REQUEST SIG 2	
2	0	11	13	CANCEL ROUTE SIG 2	
2	0	12	14	FLEET SIG 2	
2	0	13	15	CANCEL FLEET SIG 2	
				STROBE	

RELAY PAIR CARD

F	W	BT	BT	FUNCTION	LOCATION
2	1	0	2	D SPARE [SET AUTO ROUTE SIG 2]	
2	1	1	3	D SPARE [CANCEL AUTO ROUTE SIG 2]	
2	1	2	4	ROUTE REQUEST SIG 4	
2	1	3	5	CANCEL ROUTE SIG 4	
2	1	4	6	FLEET SIG 4	
2	1	5	7	CANCEL FLEET SIG 4	
2	1	6	8	ROUTE REQUEST SIG 6	
2	1	7	9	CANCEL ROUTE SIG 6	
2	1	8	10	FLEET SIG 6	
2	1	9	11	CANCEL FLEET SIG 6	
2	1	10	12	D SPARE [SET AUTO ROUTE SIG 6]	
2	1	11	13	D SPARE [CANCEL AUTO ROUTE SIG 6]	
2	1	12	14	ROUTE REQUEST SIG 8	
2	1	13	15	CANCEL ROUTE SIG 8	
				STROBE	

RELAY PAIR CARD

LEGEND:

D = DELETE WIRED POINT AFTER CUTOVER.

SHEET F06 – C5

ANACOSTIA RTU (F06)

CONTROL FRAMES

F	W	BT	BT	FUNCTION	LOCATION
2	2	0	2	FLEET SIG 8	
2	2	1	3	CANCEL FLEET SIG 8	
2	2	2	4	D SPARE [SET AUTO ROUTE SIG 8]	
2	2	3	5	D SPARE [CANCEL AUTO ROUTE SIG 8]	
2	2	4	6	E ROUTE REQUEST SIG 10	
2	2	5	7	E CANCEL ROUTE SIG 10	
2	2	6	8	E FLEET SIG 10	
2	2	7	9	E CANCEL FLEET SIG 10	
2	2	8	10	E ROUTE REQUEST SIG 14	
2	2	9	11	E CANCEL ROUTE SIG 14	
2	2	10	12	E FLEET SIG 14	
2	2	11	13	E CANCEL FLEET SIG 14	
2	2	12	14	E ROUTE REQUEST SIG 20	
2	2	13	15	E CANCEL ROUTE SIG 20	
				STROBE	

RELAY PAIR CARD

F	W	BT	BT	FUNCTION	LOCATION
2	3	0	2	E FLEET SIG 20	
2	3	1	3	E CANCEL FLEET SIG 20	
2	3	2	4	E ROUTE REQUEST SIG 24	
2	3	3	5	E CANCEL ROUTE SIG 24	
2	3	4	6	E FLEET SIG 24	
2	3	5	7	E CANCEL FLEET SIG 24	
2	3	6	8	D SPARE [TERMINAL MODE 1]	
2	3	7	9	D SPARE [TERMINAL MODE 2]	
2	3	8	10	D SPARE [TERMINAL MODE 3]	
2	3	9	11	SPARE	
2	3	10	12	SPARE	
2	3	11	13	SPARE	
2	3	12	14	SPARE	
2	3	13	15	SPARE	
				STROBE	

RELAY PAIR CARD

LEGEND:

D = DELETE WIRED POINT AFTER CUTOVER.

E = ENERGIZE/ACTIVATE PREVIOUSLY WIRED POINT.

SHEET F06 – C6

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

CONTROL FRAMES

F	W	BT	BT	FUNCTION	LOCATION
3	0	0	2	SPARE	
3	0	1	3	SPARE	
3	0	2	4	SPARE	
3	0	3	5	SPARE	
3	0	4	6	SPARE	
3	0	5	7	SPARE	
3	0	6	8	SPARE	
3	0	7	9	SPARE	
3	0	8	10	SPARE	
3	0	9	11	SPARE	
3	0	10	12	SPARE	
3	0	11	13	SPARE	
3	0	12	14	SPARE	
3	0	13	15	SPARE	
				STROBE	

RELAY PAIR SPARE CARD

F	W	BT	BT	FUNCTION	LOCATION
3	1	0	2	SPARE	
3	1	1	3	SPARE	
3	1	2	4	SPARE	
3	1	3	5	SPARE	
3	1	4	6	SPARE	
3	1	5	7	SPARE	
3	1	6	8	SPARE	
3	1	7	9	SPARE	
3	1	8	10	SPARE	
3	1	9	11	SPARE	
3	1	10	12	SPARE	
3	1	11	13	SPARE	
3	1	12	14	SPARE	
3	1	13	15	SPARE	
				STROBE	

NO CARD

SHEET F06 – C7

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

CONTROL FRAMES

F	W	BT	BT	FUNCTION	LOCATION
3	2	0	2	VACANT	
3	2	1	3	VACANT	
3	2	2	4	VACANT	
3	2	3	5	VACANT	
3	2	4	6	VACANT	
3	2	5	7	VACANT	
3	2	6	8	VACANT	
3	2	7	9	VACANT	
3	2	8	10	VACANT	
3	2	9	11	VACANT	
3	2	10	12	VACANT	
3	2	11	13	VACANT	
3	2	12	14	VACANT	
3	2	13	15	VACANT	

VACANT SLOT

F	W	BT	BT	FUNCTION	LOCATION
3	3	0	2	VACANT	
3	3	1	3	VACANT	
3	3	2	4	VACANT	
3	3	3	5	VACANT	
3	3	4	6	VACANT	
3	3	5	7	VACANT	
3	3	6	8	VACANT	
3	3	7	9	VACANT	
3	3	8	10	VACANT	
3	3	9	11	VACANT	
3	3	10	12	VACANT	
3	3	11	13	VACANT	
3	3	12	14	VACANT	
3	3	13	15	VACANT	

VACANT SLOT

SHEET F06 – C8

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

CONTROL FRAMES

F	W	BT	BT	FUNCTION	LOCATION
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4	0	0	2	DC PWR AC INC LINE BRK 01 CLOSED	(SS)
4	0	1	3	DC PWR AC INC LINE BRK 01 TRIP	(SS)
4	0	2	4	DC PWR AC INC LINE BRK 02 CLOSED	(SS)
4	0	3	5	DC PWR AC INC LINE BRK 02 TRIP	(SS)
4	0	4	6	DC PWR AC RECT TRANS FDR BRK (INIT) 11 CLOSED	(SS)
4	0	5	7	DC PWR AC RECT TRANS FDR BRK (INIT) 11 TRIP	(SS)
4	0	6	8	DC PWR AC RECT TRANS FDR BRK (INIT) 12 CLOSED	(SS)
4	0	7	9	DC PWR AC RECT TRANS FDR BRK (INIT) 12 TRIP	(SS)
4	0	8	10	DC PWR AC RECT TRANS FDR BRK (FUTU) 13 CLOSED	(SS)
4	0	9	12	DC PWR AC RECT TRANS FDR BRK (FUTU) 13 TRIP	(SS)
4	0	10	12	DC PWR AC RECT TRANS FDR BRK (FUTU) 14 CLOSED	(SS)
4	0	11	13	DC PWR AC RECT TRANS FDR BRK (FUTU) 14 TRIP	(SS)
4	0	12	14	SPARE	
4	0	13	15	SPARE	
				COMMON B28G	
				STROBE	

RELAY SINGLE CARD

F	W	BT	BT	FUNCTION	LOCATION
4	1	0	2	DC PWR DC FDR TIE BRK 31 CLOSED	(SS)
4	1	1	3	DC PWR DC FDR TIE BRK 31 TRIP	(SS)
4	1	2	4	DC PWR DC FDR TIE BRK 32 CLOSED	(SS)
4	1	3	5	DC PWR DC FDR TIE BRK 32 TRIP	(SS)
4	1	4	6	DC PWR DC FDR TIE BRK 33 CLOSED	(SS)
4	1	5	7	DC PWR DC FDR TIE BRK 33 TRIP	(SS)
4	1	6	8	DC PWR DC FDR TIE BRK 34 CLOSED	(SS)
4	1	7	9	DC PWR DC FDR TIE BRK 34 TRIP	(SS)
4	1	8	10	DC PWR DC FDR TIE BRK 36 CLOSED	(SS)
4	1	9	11	DC PWR DC FDR TIE BRK 36 TRIP	(SS)
4	1	10	12	R SPARE [DC PWR DC FDR TIE BRK 41 CLOSED	(FUT TBS)]
4	1	11	13	R SPARE [DC PWR DC FDR TIE BRK 41 TRIP	(FUT TBS)]
4	1	12	14	R SPARE [DC PWR DC FDR TIE BRK 42 CLOSED	(FUT TBS)]
4	1	13	15	R SPARE [DC PWR DC FDR TIE BRK 42 TRIP	(FUT TBS)]
				COMMON B28G	
				STROBE	

RELAY SINGLE CARD

LEGEND:

R = CONTRACTOR SHALL REMOVE WIRED POINT  
AND UPDATE SCAN SHEET AND DRAWINGS.

SHEET F06 – C9

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

CONTROL FRAMES

F	W	BT	BT	FUNCTION	LOCATION
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4	2	0	2	R	SPARE [DC PWR DC FDR TIE BRK 43 CLOSED	(FUT TBS))
4	2	1	3	R	SPARE [DC PWR DC FDR TIE BRK 43 TRIP	(FUT TBS))
4	2	2	4	R	SPARE [DC PWR DC FDR TIE BRK 44 CLOSED	(FUT TBS))
4	2	3	5	R	SPARE [DC PWR DC FDR TIE BRK 44 TRIP	(FUT TBS))
4	2	4	6		SPARE	
4	2	5	7		SPARE	
4	2	6	8		SPARE	
4	2	7	9		SPARE	
4	2	8	10		SPARE	
4	2	9	11		SPARE	
4	2	10	12		SPARE	
4	2	11	13		SPARE	
4	2	12	14		SPARE	
4	2	13	15		SPARE	
					COMMON B28G	
					STROBE	

RELAY SINGLE SPARE CARD

F	W	BT	BT	FUNCTION	LOCATION
4	3	0	2	FANS 1 EMERGENCY OFF	(NEAR)
4	3	1	3	FANS 1 EMERGENCY ON	(NEAR)
4	3	2	4	FANS 1 AUTOMATIC ON	(NEAR)
4	3	3	5	FANS 1 SUPPLY	(NEAR)
4	3	4	6	FANS 1 EXHAUST	(L-NEAR)
4	3	5	7	FANS 2 EMERGENCY OFF	(FAR)
4	3	6	8	FANS 2 EMERGENCY ON	(FAR)
4	3	7	9	FANS 2 AUTOMATIC ON	(FAR)
4	3	8	10	FANS 2 SUPPLY	(FAR)
4	3	9	11	FANS 2 EXHAUST	(R-FAR)
4	3	10	12	SPARE	
4	3	11	13	SPARE	
4	3	12	14	SPARE	
4	3	13	15	SPARE	
				COMMON B28G	
				STROBE	

RELAY SINGLE CARD

LEGEND:

R = CONTRACTOR SHALL REMOVE WIRED POINT  
AND UPDATE SCAN SHEET AND DRAWINGS.

SHEET F06 – C10

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

CONTROL FRAMES

F	W	BT	BT	FUNCTION	LOCATION
5	0	0	2	FANS 3 EMERGENCY OFF	(DOME NEAR)
5	0	1	3	FANS 3 EMERGENCY ON	(DOME NEAR)
5	0	2	4	FANS 3 AUTOMATIC ON	(DOME NEAR)
5	0	3	5	FANS 3 SUPPLY	(DOME NEAR)
5	0	4	6	FANS 3 EXHAUST	(L-DOME)
5	0	5	7	FANS 4 EMERGENCY OFF	(DOME FAR)
5	0	6	8	FANS 4 EMERGENCY ON	(DOME FAR)
5	0	7	9	FANS 4 AUTOMATIC ON	(DOME FAR)
5	0	8	10	FANS 4 SUPPLY	(DOME FAR)
5	0	9	11	FANS 4 EXHAUST	(R-DOME)
5	0	10	12	SPARE	
5	0	11	13	SPARE	
5	0	12	14	SPARE	
5	0	13	15	SPARE	
				COMMON B28G	
				STROBE	

RELAY SINGLE CARD

F	W	BT	BT	FUNCTION	LOCATION
5	1	0	2	FANS 5 EMERGENCY OFF	(FS-F06)
5	1	1	3	FANS 5 EMERGENCY ON	(FS-F06)
5	1	2	4	FANS 5 AUTOMATIC ON	(FS-F06)
5	1	3	5	FANS 5 SUPPLY	(FS-F06)
5	1	4	6	FANS 5 EXHAUST	(FS-F06)
5	1	5	7	SPARE	
5	1	6	8	SPARE	
5	1	7	9	SPARE	
5	1	8	10	SPARE	
5	1	9	11	SPARE	
5	1	10	12	SPARE	
5	1	11	13	SPARE	
5	1	12	14	SPARE	
5	1	13	15	SPARE	
				COMMON B28G	
				STROBE	

RELAY SINGLE CARD

SHEET F06 – C11

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

CONTROL FRAMES

F	W	BT	BT	FUNCTION	LOCATION
5	2	0	2 R	SPARE [CHLR WATER PUMP EMERGENCY STOP	(CHP-F02)]

5	2	1	3	R	SPARE [CHLR WATER PUMP STOP	(CHP-F02))
5	2	2	4	R	SPARE [CHLR WATER PUMP START	(CHP-F02))
5	2	3	5	R	SPARE [CHLR MOTOR NO.1 STOP	(CHP-F02))
5	2	4	6	R	SPARE [CHLR MOTOR NO.1 START	(CHP-F02))
5	2	5	7		SPARE	
5	2	6	8		SPARE	
5	2	7	9		SPARE	
5	2	8	10		SPARE	
5	2	9	11		SPARE	
5	2	10	12		SPARE	
5	2	11	13		SPARE	
5	2	12	14		SPARE	
5	2	13	15		SPARE	
					COMMON B28G	

STROBE

RELAY SINGLE SPARE CARD

F	W	BT	BT	FUNCTION	LOCATION
5	3	0	2	SPARE	
5	3	1	3	SPARE	
5	3	2	4	SPARE	
5	3	3	5	SPARE	
5	3	4	6	SPARE	
5	3	5	7	SPARE	
5	3	6	8	SPARE	
5	3	7	9	SPARE	
5	3	8	10	SPARE	
5	3	9	11	SPARE	
5	3	10	12	SPARE	
5	3	11	13	SPARE	
5	3	12	14	SPARE	
5	3	13	15	SPARE	
				COMMON B28G	
				STROBE	

RELAY SINGLE SPARE CARD

LEGEND:

R = CONTRACTOR SHALL REMOVE WIRED POINT  
AND UPDATE SCAN SHEET AND DRAWINGS.

SHEET F06 – C12\*

R.T.U. SCAN SHEET - EXAMPLE LOCATION

ANACOSTIA RTU (F06)

STATUS FRAMES

F	W	BT	BT	FUNCTION	LOCATION
0	0	0	2	HOUSEKEEPING	
0	0	1	3	HOUSEKEEPING	
0	0	2	4	HOUSEKEEPING	
0	0	3	5	HOUSEKEEPING	
0	0	4	6	RUN NUMBER, PLATFORM 1 MSB-MSD	
0	0	5	7	RUN NUMBER, PLATFORM 1	
0	0	6	8	RUN NUMBER, PLATFORM 1	
0	0	7	9	RUN NUMBER, PLATFORM 1 LSB-MSD	
0	0	8	10	RUN NUMBER, PLATFORM 1 MSB-MD	

0	0	9	11	RUN NUMBER, PLATFORM 1
0	0	10	12	RUN NUMBER, PLATFORM 1
0	0	11	13	RUN NUMBER, PLATFORM 1 LSB-MD
0	0	12	14	RUN NUMBER, PLATFORM 1 MSB-LSD
0	0	13	15	RUN NUMBER, PLATFORM 1

COMMON N28G

LATCHING CARD

F	W	BT	BT	FUNCTION	LOCATION
0	1	0	2	RUN NUMBER, PLATFORM 1	
0	1	1	3	RUN NUMBER, PLATFORM 1 LSB-LSD	
0	1	2	4	DESTINATION, PLATFORM 1 MSB-MSD	
0	1	3	5	DESTINATION, PLATFORM 1	
0	1	4	6	DESTINATION, PLATFORM 1	
0	1	5	7	DESTINATION, PLATFORM 1 LSB-MSD	
0	1	6	8	DESTINATION, PLATFORM 1 MSB-LSD	
0	1	7	9	DESTINATION, PLATFORM 1	
0	1	8	10	DESTINATION, PLATFORM 1	
0	1	9	11	DESTINATION, PLATFORM 1 LSB-LSD	
0	1	10	12	TRAIN LENGTH, PLATFORM 1 MSB	
0	1	11	13	TRAIN LENGTH, PLATFORM 1	
0	1	12	14	TRAIN LENGTH, PLATFORM 1	
0	1	13	15	PSS ACTIVE TK 1	

COMMON N28G

LATCHING CARD

SHEET F06 – S1

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

STATUS FRAMES

F	W	BT	BT	FUNCTION	LOCATION
0	2	0	2	TRAIN IN ATO TRACK 1	
0	2	1	3	ATP CUTOUT TK 1	
0	2	2	4	TRAIN IN ATO TRACK 2	
0	2	3	5	ATP CUTOUT TK 2	
0	2	4	6	RUN NUMBER, PLATFORM 2 MSB-MSD	
0	2	5	7	RUN NUMBER, PLATFORM 2	
0	2	6	8	RUN NUMBER, PLATFORM 2	
0	2	7	9	RUN NUMBER, PLATFORM 2 LSB-MSD	
0	2	8	10	RUN NUMBER, PLATFORM 2 MSB-MD	
0	2	9	11	RUN NUMBER, PLATFORM 2	
0	2	10	12	RUN NUMBER, PLATFORM 2	
0	2	11	13	RUN NUMBER, PLATFORM 2 LSB-MD	
0	2	12	14	RUN NUMBER, PLATFORM 2 MSB-LSD	
0	2	13	15	RUN NUMBER, PLATFORM 2	

COMMON N28G

LATCHING CARD

F	W	BT	BT	FUNCTION	LOCATION
0	3	0	2	RUN NUMBER, PLATFORM 2	

0	3	1	3	RUN NUMBER, PLATFORM 2 LSB-LSD
0	3	2	4	DESTINATION, PLATFORM 2 MSB-MSD
0	3	3	5	DESTINATION, PLATFORM 2
0	3	4	6	DESTINATION, PLATFORM 2
0	3	5	7	DESTINATION, PLATFORM 2 LSB-MSD
0	3	6	8	DESTINATION, PLATFORM 2 MSB-LSD
0	3	7	9	DESTINATION, PLATFORM 2
0	3	8	10	DESTINATION, PLATFORM 2
0	3	9	11	DESTINATION, PLATFORM 2 LSB-LSD
0	3	10	12	TRAIN LENGTH, PLATFORM 2 MSB
0	3	11	13	TRAIN LENGTH, PLATFORM 2
0	3	12	14	TRAIN LENGTH, PLATFORM 2
0	3	13	15	PSS ACTIVE TK 2
				COMMON N28G

LATCHING CARD

SHEET F06 – S2

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

STATUS FRAMES

F	W	BT	BT	FUNCTION	LOCATION
1	0	0	2	SPARE	
1	0	1	3	SPARE	
1	0	2	4	SPARE	
1	0	3	5	PROCESSOR FOR STATION PROBLEM	
1	0	4	6	PROCESSOR FOR INTLKG PROBLEM	
1	0	5	7	CIRCUIT POWER FAILURE	
1	0	6	8	E TEMP SPEED RESTRICTION TRACK 1R	
1	0	7	9	TEMP SPEED RESTRICTION TRACK 1N	
1	0	8	10	DOOR CLOSE RIGHT TK 1	
1	0	9	11	DOOR CLOSE LEFT TK 1	
1	0	10	12	TRAIN READY TRACK 1	
1	0	11	13	TRAIN BERTHED TRACK 1	
1	0	12	14	TRAIN MOTION TRACK 1	
1	0	13	15	DOOR OPEN MANUAL TK 1	
				COMMON N28G	

LATCHING CARD

F	W	BT	BT	FUNCTION	LOCATION
1	1	0	2	SPARE	
1	1	1	3	SPARE	
1	1	2	4	SPARE	
1	1	3	5	SPARE	
1	1	4	6	SPARE	
1	1	5	7	POWER TRANSFER	
1	1	6	8	TEMP SPEED RESTRICTION TRACK 2R	
1	1	7	9	E TEMP SPEED RESTRICTION TRACK 2N	
1	1	8	10	DOOR CLOSE RIGHT TK 2	
1	1	9	11	DOOR CLOSE LEFT TK 2	
1	1	10	12	TRAIN READY TRACK 2	
1	1	11	13	TRAIN BERTHED TRACK 2	

1 1 12 14 TRAIN MOTION TRACK 2  
 1 1 13 15 DOOR OPEN MANUAL TK 2  
 COMMON N28G

LATCHING CARD

LEGEND:

E = ENERGIZE/ACTIVATE PRE-WIRED POINT.

SHEET F06 – S3

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

STATUS FRAMES

F	W	BT	BT	FUNCTION	LOCATION
1	2	0	2	A BLK OCCP TK 1 [SPARE]	(F1-211)
1	2	1	3	A BLK OCCP TK 1 [SPARE]	(F1-205)
1	2	2	4	A BLK OCCP TK 1 [SPARE]	(F1-204)
1	2	3	5	M BLK OCCP TK 1 [SPARE]	(F1-198)[(F1-205)]
1	2	4	6	M BLK OCCP TK 1	(F1-192)[(F1-198)]
1	2	5	7	M INT LKG BLK OCCP TK 1	(F06-1AT)[(F1-192)]
1	2	6	8	M INT LKG BLK OCCP TK 1	(F06-3AT)[(F06-1AT)]
1	2	7	9	M BLK OCCP TK 1 [INT LKG]	(F1-188)[(F06-3AT)]
1	2	8	10	M BLK OCCP TK 1	(F1-185,182)[(F1-188)]
1	2	9	11	M BLK OCCP TK 1	(F1-178)[(F1-185,182)]
1	2	10	12	M BLK OCCP TK 1	(F1-170)[(F1-178)]
1	2	11	13	M BLK OCCP TK 1	(F1-155)[(F1-170)]
1	2	12	14	M BLK OCCP TK 1	(F1-145)[(F1-155)]
1	2	13	15	M BLK OCCP TK 1	(F2-160)[(F1-145)]
				COMMON N28G	

NON-LATCHING CARD

F	W	BT	BT	FUNCTION	LOCATION
1	3	0	2	M BLK OCCP TK 2	(F2-170)[(F2-160)]
1	3	1	3	M BLK OCCP TK 2	(F2-176)[(F2-170)]
1	3	2	4	M BLK OCCP TK 2	(F2-179)[(F2-176)]
1	3	3	5	M BLK OCCP TK 2	(F2-182,185)[(F2-179)]
1	3	4	6	M BLK OCCP TK 2	(F2-188)[(F2-182,185)]
1	3	5	7	M INT LKG BLK OCCP TK 2	(F06-1BT)[(F2-188)]
1	3	6	8	M INT LKG BLK OCCP TK 2	(F06-3BT)[(F06-1BT)]
1	3	7	9	M BLK OCCP TK 2 [INT LKG]	(F2-192)[(F06-3BT)]
1	3	8	10	M BLK OCCP TK 2	(F2-198)[(F2-192)]
1	3	9	11	A BLK OCCP TK 2	(F2-204)[(F2-198)]
1	3	10	12	A BLK OCCP TK 2 [SPARE]	(F2-205)
1	3	11	13	A BLK OCCP TK 2 [SPARE]	*(F2-211)
1	3	12	14	A BLK OCCP TK 2 [SPARE]	(F2-217)
1	3	13	15	X-OVER BLK OCCP	(F06-1-3T)
				COMMON N28G	

NON-LATCHING CARD

LEGEND:

A = ADD WIRED POINT.

M = MOVED HERE.

\* = TRACK CIRCUIT NOMENCLATURE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY.  
CONTRACTOR SHALL PROVIDE NECESSARY NUMBER OF NEW TRACK CIRCUIT(S) AND  
APPROPRIATE NOMENCLATURE.

SHEET F06 – S4

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

STATUS FRAMES

F	W	BT	BT	FUNCTION	LOCATION
2	0	0	2	D SPARE [TRAIN LENGTH, TAIL TRACK 1 MSB]	
2	0	1	3	D SPARE [TRAIN LENGTH, TAIL TRACK 1]	
2	0	2	4	D SPARE [TRAIN LENGTH, TAIL TRACK 1]	
2	0	3	5	D SPARE [TRAIN LENGTH, TAIL TRACK 1 LSB]	
2	0	4	6	D SPARE [TRAIN LENGTH, TAIL TRACK 1]	
2	0	5	7	D SPARE [TRAIN LENGTH, TAIL TRACK 2 MSB]	
2	0	6	8	D SPARE [TRAIN LENGTH, TAIL TRACK 2]	
2	0	7	9	D SPARE [TRAIN LENGTH, TAIL TRACK 2]	
2	0	8	10	D SPARE [TRAIN LENGTH, TAIL TRACK 2 LSB]	
2	0	9	11	D SPARE [TRAIN LENGTH, TAIL TRACK 2]	
2	0	10	12	SPARE	
2	0	11	13	SPARE	
2	0	12	14	SPARE	
2	0	13	15	SPARE	

COMMON N28G

SPARE LATCHING CARD

F	W	BT	BT	FUNCTION	LOCATION
2	1	0	2	LOCAL IN CONTROL	
2	1	1	3	CENTRAL IN CONTROL	
2	1	2	4	LOCAL CONTROL REQUEST	
2	1	3	5	SPARE	
2	1	4	6	SPARE	
2	1	5	7	SPARE	
2	1	6	8	E TRAFFIC DIRECTION NORMAL TK 1R	
2	1	7	9	E TRAFFIC DIRECTION REVERSE TK 1R	
2	1	8	10	TRAFFIC DIRECTION NORMAL TK 1N	
2	1	9	11	TRAFFIC DIRECTION REVERSE TK 1N	
2	1	10	12	TRAFFIC DIRECTION NORMAL TK 2R	
2	1	11	13	TRAFFIC DIRECTION REVERSE TK 2R	
2	1	12	14	E TRAFFIC DIRECTION NORMAL TK 2N	
2	1	13	15	E TRAFFIC DIRECTION REVERSE TK 2N	

COMMON N28G

NON-LATCHING CARD

LEGEND:

D = DELETE WIRED POINT AFTER CUTOVER.

E = ENERGIZE/ACTIVATE PRE-WIRED POINT.

SHEET F06 – S5

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

STATUS FRAMES

F	W	BT	BT	FUNCTION	LOCATION
2	2	0	2	RTE LKD TK 1	
2	2	1	3	RTE LKD TK 2	
2	2	2	4	CENTRAL LOCKED OUT	(SIG 2,4,6,8)
2	2	3	5	SWITCH 1 CALLED NORMAL	
2	2	4	6	SWITCH 1 CALLED REVERSE	
2	2	5	7	SWITCH 1 NORMAL	
2	2	6	8	SWITCH 1 REVERSE	
2	2	7	9	SWITCH 3 CALLED NORMAL	
2	2	8	10	SWITCH 3 CALLED REVERSE	
2	2	9	11	SWITCH 3 NORMAL	
2	2	10	12	SWITCH 3 REVERSE	
2	2	11	13	SIG CLEAR TK 1 SIG 2	
2	2	12	14	ENT RECV TK 1 SIG 2	
2	2	13	15	APPR LKD TK 1 SIG 2	
				COMMON N28G	

NON-LATCHING CARD

F	W	BT	BT	FUNCTION	LOCATION
2	3	0	2	FLEETED TK 1 SIG 2	
2	3	1	3	D SPARE [AUTO RTE IN EFFECT SIG 2]	
2	3	2	4	SIG CLEAR TK 1 SIG 4	
2	3	3	5	ENT RECV TK 1 SIG 4	
2	3	4	6	APPR LKD TK 1 SIG 4	
2	3	5	7	FLEETED TK 1 SIG 4	
2	3	6	8	SIG CLEAR TK 2 SIG 6	
2	3	7	9	ENT RECV TK 2 SIG 6	
2	3	8	10	APPR LKD TK 2 SIG 6	
2	3	9	11	FLEETED TK 2 SIG 6	
2	3	10	12	D SPARE [AUTO RTE IN EFFECT SIG 6]	
2	3	11	13	SIG CLEAR TK 2 SIG 8	
2	3	12	14	ENT RECV TK 2 SIG 8	
2	3	13	15	APPR LKD TK 2 SIG 8	
				COMMON N28G	

NON-LATCHING CARD

LEGEND:

D = DELETE WIRED POINT AFTER CUTOVER.

SHEET F06 – S6

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

STATUS FRAMES

F	W	BT	BT	FUNCTION	LOCATION
3	0	0	2	FLEETED TK 2 SIG 8	
3	0	1	3	D SPARE [AUTO RTE IN EFFECT SIG 8]	

3	0	2	4	E	SIG CLEAR TK 1 SIG 10
3	0	3	5	E	ENT RECV TK 1 SIG 10
3	0	4	6	E	FLEETED TK 1 SIG 10
3	0	5	7	E	SIG CLEAR TK 2 SIG 14
3	0	6	8	E	ENT RECV TK 2 SIG 14
3	0	7	9	E	FLEETED TK 2 SIG 14
3	0	8	10	E	SIG CLEAR TK 1 SIG 20
3	0	9	11	E	ENT RECV TK 1 SIG 20
3	0	10	12	E	FLEETED TK 1 SIG 20
3	0	11	13	E	SIG CLEAR TK 2 SIG 24
3	0	12	14	E	ENT RECV TK 2 SIG 24
3	0	13	15	E	FLEETED TK 2 SIG 24

COMMON N28G

NON-LATCHING CARD

F	W	BT	BT	FUNCTION	LOCATION
3	1	0	2	SPARE	
3	1	1	3	SPARE	
3	1	2	4	SPARE	
3	1	3	5	SPARE	
3	1	4	6	SPARE	
3	1	5	7	SPARE	
3	1	6	8	SPARE	
3	1	7	9	SPARE	
3	1	8	10	SPARE	
3	1	9	11	SPARE	
3	1	10	12	SPARE	
3	1	11	13	SPARE	
3	1	12	14	SPARE	
3	1	13	15	SPARE	

COMMON N28G

NON-LATCHING CARD

LEGEND:

D = DELETE WIRED POINT AFTER CUTOVER.  
E = ENERGIZE/ACTIVATE PRE-WIRED POINT.

SHEET F06 – S7

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

STATUS FRAMES

F	W	BT	BT	FUNCTION	LOCATION
3	2	0	2	D SPARE [AUTO OPER MODE 1]	
3	2	1	3	D SPARE [AUTO OPER MODE 2]	
3	2	2	4	D SPARE [AUTO OPER MODE 3]	
3	2	3	5	SPARE	
3	2	4	6	SPARE	
3	2	5	7	SPARE	
3	2	6	8	SPARE	
3	2	7	9	SPARE	
3	2	8	10	SPARE	

3	2	9	11	SPARE
3	2	10	12	SPARE
3	2	11	13	SPARE
3	2	12	14	SPARE
3	2	13	15	SPARE
COMMON N28G				

NON-LATCHING SPARE CARD

F	W	BT	BT	FUNCTION	LOCATION
3	3	0	2	SPARE	
3	3	1	3	SPARE	
3	3	2	4	SPARE	
3	3	3	5	SPARE	
3	3	4	6	SPARE	
3	3	5	7	SPARE	
3	3	6	8	SPARE	
3	3	7	9	SPARE	
3	3	8	10	SPARE	
3	3	9	11	SPARE	
3	3	10	12	SPARE	
3	3	11	13	SPARE	
3	3	12	14	SPARE	
3	3	13	15	SPARE	
COMMON N28G					

NO CARD

LEGEND:

D = DELETE WIRED POINT AFTER CUTOVER.

SHEET F06 – S8

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

STATUS FRAMES

F	W	BT	BT	FUNCTION	LOCATION
4	0	0	2	DC PWR AC INC LINE BRK 01 CLOSED	(SS)
4	0	1	3	DC PWR AC INC LINE BRK 01 TRIP	(SS)
4	0	2	4	DC PWR AC INC LINE BRK 02 CLOSED	(SS)
4	0	3	5	DC PWR AC INC LINE BRK 02 TRIP	(SS)
4	0	4	6	DC PWR AC TIE BRK 03 CLOSED	(SS)
4	0	5	7	DC PWR AC TIE BRK 03 TRIP	(SS)
4	0	6	8	DC PWR AC RECT TRANS FDR BRK (INIT) 11 CLOSED	(SS)
4	0	7	9	DC PWR AC RECT TRANS FDR BRK (INIT) 11 TRIP	(SS)
4	0	8	10	DC PWR AC RECT TRANS FDR BRK (INIT) 12 CLOSED	(SS)
4	0	9	11	DC PWR AC RECT TRANS FDR BRK (INIT) 12 TRIP	(SS)
4	0	10	12	DC PWR AC RECT TRANS FDR BRK (FUTU) 13 CLOSED	(SS)
4	0	11	13	DC PWR AC RECT TRANS FDR BRK (FUTU) 13 TRIP	(SS)
4	0	12	14	DC PWR AC RECT TRANS FDR BRK (FUTU) 14 CLOSED	(SS)
4	0	13	15	DC PWR AC RECT TRANS FDR BRK (FUTU) 14 TRIP	(SS)
COMMON N28G					

NON-LATCHING CARD

F	W	BT	BT	FUNCTION	LOCATION
4	1	0	2	DC PWR AC FDR BRK, AUX PWR TRANS 1 CLOSED	(SS)
4	1	1	3	DC PWR AC FDR BRK, AUX PWR TRANS 1 TRIP	(SS)
4	1	2	4	DC PWR AC FDR BRK, AUX PWR TRANS 2 CLOSED	(SS)
4	1	3	5	DC PWR AC FDR BRK, AUX PWR TRANS 2 TRIP	(SS)
4	1	4	6	DC PWR DC RECT BRK (INIT) 21 CLOSED	(SS)
4	1	5	7	DC PWR DC RECT BRK (INIT) 21 TRIP	(SS)
4	1	6	8	DC PWR DC RECT BRK (INIT) 22 CLOSED	(SS)
4	1	7	9	DC PWR DC RECT BRK (INIT) 22 TRIP	(SS)
4	1	8	10	DC PWR DC RECT BRK (FUTU) 23 CLOSED	(SS)
4	1	9	11	DC PWR DC RECT BRK (FUTU) 23 TRIP	(SS)
4	1	10	12	DC PWR DC RECT BRK (FUTU) 24 CLOSED	(SS)
4	1	11	13	DC PWR DC RECT BRK (FUTU) 24 TRIP	(SS)
4	1	12	14	SPARE	
4	1	13	15	SPARE	
				COMMON N28G	

NON-LATCHING CARD

SHEET F06 – S9

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

STATUS FRAMES

F	W	BT	BT	FUNCTION	LOCATION
4	2	0	2	DC PWR DC FDR TIE BRK 31 CLOSED	(SS)
4	2	1	3	DC PWR DC FDR TIE BRK 31 TRIP	(SS)
4	2	2	4	DC PWR DC FDR TIE BRK 32 CLOSED	(SS)
4	2	3	5	DC PWR DC FDR TIE BRK 32 TRIP	(SS)
4	2	4	6	DC PWR DC FDR TIE BRK 33 CLOSED	(SS)
4	2	5	7	DC PWR DC FDR TIE BRK 33 TRIP	(SS)
4	2	6	8	DC PWR DC FDR TIE BRK 34 CLOSED	(SS)
4	2	7	9	DC PWR DC FDR TIE BRK 34 TRIP	(SS)
4	2	8	10	DC PWR DC FDR TIE BRK 36 CLOSED	(SS)
4	2	9	11	DC PWR DC FDR TIE BRK 36 TRIP	(SS)
4	2	10	12	R SPARE [DC PWR DC FDR TIE BRK 41 CLOSED	(FUT TBS)]
4	2	11	13	R SPARE [DC PWR DC FDR TIE BRK 41 TRIP	(FUT TBS)]
4	2	12	14	R SPARE [DC PWR DC FDR TIE BRK 42 CLOSED	(FUT TBS)]
4	2	13	15	R SPARE [DC PWR DC FDR TIE BRK 42 TRIP	(FUT TBS)]
				COMMON N28G	

NON-LATCHING CARD

F	W	BT	BT	FUNCTION	LOCATION
4	3	0	2	R SPARE [DC PWR DC FDR TIE BRK 43 CLOSED	(FUT TBS)]
4	3	1	3	R SPARE [DC PWR DC FDR TIE BRK 43 TRIP	(FUT TBS)]
4	3	2	4	R SPARE [DC PWR DC FDR TIE BRK 44 CLOSED	(FUT TBS)]
4	3	3	5	R SPARE [DC PWR DC FDR TIE BRK 44 TRIP	(FUT TBS)]
4	3	4	6	SPARE	
4	3	5	7	SPARE	
4	3	6	8	SPARE	
4	3	7	9	SPARE	

4	3	8	10	SPARE
4	3	9	11	SPARE
4	3	10	12	SPARE
4	3	11	13	SPARE
4	3	12	14	SPARE
4	3	13	15	SPARE

COMMON N28G

NON-LATCHING CARD

LEGEND:

R = CONTRACTOR SHALL REMOVE WIRED POINT  
AND UPDATE SCAN SHEET AND DRAWINGS.

SHEET F06 – S10

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

STATUS FRAMES

F	W	BT	BT	FUNCTION	LOCATION
5	0	0	2	DC PWR TRANS OVER TEMP (INIT) 1 NOR/OFF	(SS)
5	0	1	3	DC PWR TRANS OVER TEMP (INIT) 1 ABN/ON	(SS)
5	0	2	4	DC PWR TRANS OVER TEMP (INIT) 2 NOR/OFF	(SS)
5	0	3	5	DC PWR TRANS OVER TEMP (INIT) 2 ABN/ON	(SS)
5	0	4	6	DC PWR TRANS OVER TEMP (FUTU) 3 NOR/OFF	(SS)
5	0	5	7	DC PWR TRANS OVER TEMP (FUTU) 3 ABN/ON	(SS)
5	0	6	8	DC PWR TRANS OVER TEMP (FUTU) 4 NOR/OFF	(SS)
5	0	7	9	DC PWR TRANS OVER TEMP (FUTU) 4 ABN/ON	(SS)
5	0	8	10	DC PWR RECT OVER TEMP (INIT) 1 NOR/OFF	(SS)
5	0	9	11	DC PWR RECT OVER TEMP (INIT) 1 ABN/ON	(SS)
5	0	10	12	DC PWR RECT OVER TEMP (INIT) 2 NOR/OFF	(SS)
5	0	11	13	DC PWR RECT OVER TEMP (INIT) 2 ABN/ON	(SS)
5	0	12	14	DC PWR RECT OVER TEMP (FUTU) 3 NOR/OFF	(SS)
5	0	13	15	DC PWR RECT OVER TEMP (FUTU) 3 ABN/OPN	(SS)

COMMON N28G

NON-LATCHING CARD

F	W	BT	BT	FUNCTION	LOCATION
5	1	0	2	DC PWR RECT OVER TEMP (FUTU) 4 NOR/OFF	(SS)
5	1	1	3	DC PWR RECT OVER TEMP (FUTU) 4 ABN/ON	(SS)
5	1	2	4	DC PWR RECT TRANS LOCKOUT (INIT) 1 NOR/OFF	(SS)
5	1	3	5	DC PWR RECT TRANS LOCKOUT (INIT) 1 ABN/ON	(SS)
5	1	4	6	DC PWR RECT TRANS LOCKOUT (INIT) 2 NOR/OFF	(SS)
5	1	5	7	DC PWR RECT TRANS LOCKOUT (INIT) 2 ABN/ON	(SS)
5	1	6	8	DC PWR RECT TRANS LOCKOUT (FUTU) 3 NOR/OFF	(SS)
5	1	7	9	DC PWR RECT TRANS LOCKOUT (FUTU) 3 ABN/ON	(SS)
5	1	8	10	DC PWR RECT TRANS LOCKOUT (FUTU) 4 NOR/OFF	(SS)
5	1	9	11	DC PWR RECT TRANS LOCKOUT (FUTU) 4 ABN/ON	(SS)
5	1	10	12	DC PWR AC INC LINE VOLTS 1 NOR/OFF	(SS)
5	1	11	13	DC PWR AC INC LINE VOLTS 1 ABN/ON	(SS)
5	1	12	14	DC PWR AC INC LINE VOLTS 2 NOR/OFF	(SS)
5	1	13	15	DC PWR AC INC LINE VOLTS 2 ABN/ON	(SS)

COMMON N28G

NON-LATCHING CARD

SHEET F06 – S11

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

STATUS FRAMES

F	W	BT	BT	FUNCTION	LOCATION
5	2	0	2	DC PWR AC SUPPLY 3 TO SWGR FAIL NOR/OFF	(SS)
5	2	1	3	DC PWR AC SUPPLY 3 TO SWGR FAIL ABN/ON	(SS)
5	2	2	4 R	SPARE [DC PWR AC SUP 4 TO SWGR FAIL NOR/OFF	(F TBS)]
5	2	3	5 R	SPARE [DC PWR AC SUP 4 TO SWGR FAIL ABN/ON	(F TBS)]
5	2	4	6	DC PWR AUX PWR TRANSFER SW 3 NOR/OFF	(SS)
5	2	5	7	DC PWR AUX PWR TRANSFER SW 3 ABN/ON	(SS)
5	2	6	8 R	SPARE [DC PWR AUX PWR TRANSFER SW 4 NOR/OFF	(F TBS)]
5	2	7	9 R	SPARE [DC PWR AUX PWR TRANSFER SW 4 ABN/ON	(F TBS)]
5	2	8	10	DC PWR BAT CHARGE RLY 3 NOR/OFF	(SS)
5	2	9	11	DC PWR BAT CHARGE RLY 3 ABN/ON	(SS)
5	2	10	12 R	SPARE [DC PWR BAT CHARGE RLY 4 NOR/OFF	(FUTU TBS)]
5	2	11	13 R	SPARE [DC PWR BAT CHARGE RLY 4 ABN/ON	(FUTU TBS)]
5	2	12	14	SPARE	
5	2	13	15	SPARE	

COMMON N28G

NON-LATCHING CARD

F	W	BT	BT	FUNCTION	LOCATION
5	3	0	2	AC INC LINE BRK 1 CLOSED	(AC SERV RM NEAR)
5	3	1	3	AC INC LINE BRK 1 TRIP	(AC SERV RM NEAR)
5	3	2	4	AC INC LINE BRK 2 CLOSED	(AC SERV RM FAR)
5	3	3	5	AC INC LINE BRK 2 TRIP	(AC SERV RM FAR)
5	3	4	6	AC SEC TIE BRK 1 CLOSED	(AC SERV RM NEAR)
5	3	5	7	AC SEC TIE BRK 1 TRIP	(AC SERV RM NEAR)
5	3	6	8	AC SEC TIE BRK 2 CLOSED	(AC SERV RM FAR)
5	3	7	9	AC SEC TIE BRK 2 TRIP	(AC SERV RM FAR)
5	3	8	10	AC SEC MAIN BRK 1 CLOSED	(AC SERV RM NEAR)
5	3	9	11	AC SEC MAIN BRK 1 TRIP	(AC SERV RM NEAR)
5	3	10	12	AC SEC MAIN BRK 2 CLOSED	(AC SERV RM FAR)
5	3	11	13	AC SEC MAIN BRK 2 TRIP	(AC SERV RM FAR)
5	3	12	14	SPARE	
5	3	13	15	SPARE	

COMMON N28G

NON-LATCHING CARD

LEGEND:

R = CONTRACTOR SHALL REMOVE WIRED POINT  
AND UPDATE SCAN SHEET AND DRAWINGS.

SHEET F06 – S12

R.T.U. SCAN SHEET – EXAMPLE LOCATION

## ANACOSTIA RTU (F06)

## STATUS FRAMES

F	W	BT	BT	FUNCTION	LOCATION
6	0	0	2	AC TRANS OVER TEMP 1 NOR/OFF	(AC SERV RM NEAR)
6	0	1	3	AC TRANS OVER TEMP 1 ABN/ON	(AC SERV RM NEAR)
6	0	2	4	AC TRANS OVER TEMP 2 NOR/OFF	(AC SERV RM FAR)
6	0	3	5	AC TRANS OVER TEMP 2 ABN/ON	(AC SERV RM FAR)
6	0	4	6	BATTERY ROOM EXHAUST FAN 1 NOR/OFF	(AC S.R.NEAR)
6	0	5	7	BATTERY ROOM EXHAUST FAN 1 ABN/ON	(AC S.R.NEAR)
6	0	6	8	BATTERY ROOM EXHAUST FAN 2 NOR/OFF	(AC S.R. FAR)
6	0	7	9	BATTERY ROOM EXHAUST FAN 2 ABN/ON	(AC S.R. FAR)
6	0	8	10	AC EMERG TRANSFER SW 1 NOR/OFF	(AC SERV RM NEAR)
6	0	9	11	AC EMERG TRANSFER SW 1 ABN/ON	(AC SERV RM NEAR)
6	0	10	12	AC EMERG TRANSFER SW 2 NOR/OFF	(AC SERV RM FAR)
6	0	11	13	AC EMERG TRANSFER SW 2 ABN/ON	(AC SERV RM FAR)
6	0	12	14	SPARE	
6	0	13	15	SPARE	
COMMON N28G					

NON-LATCHING CARD

F	W	BT	BT	FUNCTION	LOCATION
6	1	0	2	AC BAT CHARGE RELAY 1 NOR/OFF	(AC SERV RM NEAR)
6	1	1	3	AC BAT CHARGE RELAY 1 ABN/ON	(AC SERV RM NEAR)
6	1	2	4	AC BAT CHARGE RELAY 2 NOR/OFF	(AC SERV RM FAR)
6	1	3	5	AC BAT CHARGE RELAY 2 ABN/ON	(AC SERV RM FAR)
6	1	4	6	INVERTER OUTPUT 1 NOR/OFF	(AC SERV RM NEAR)
6	1	5	7	INVERTER OUTPUT 1 ABN/ON	(AC SERV RM NEAR)
6	1	6	8	INVERTER OUTPUT 2 NOR/OFF	(AC SERV RM FAR)
6	1	7	9	INVERTER OUTPUT 2 ABN/ON	(AC SERV RM FAR)
6	1	8	10	INVERTER OUTPUT 3 NOR/OFF	(SS)
6	1	9	11	INVERTER OUTPUT 3 ABN/ON	(SS)
6	1	10	12	R SPARE [INVERTER OUTPUT 4 NOR/OFF	(FUTURE TBS)]
6	1	11	13	R SPARE [INVERTER OUTPUT 4 ABN/ON	(FUTURE TBS)]
6	1	12	14	SPARE	
6	1	13	15	SPARE	
COMMON N28G					

NON-LATCHING CARD

## LEGEND:

R = CONTRACTOR SHALL REMOVE WIRED POINT  
AND UPDATE SCAN SHEET AND DRAWINGS.

SHEET F06 – S13

R.T.U. SCAN SHEET – EXAMPLE LOCATION

## ANACOSTIA RTU (F06)

## STATUS FRAMES

F	W	BT	BT	FUNCTION	LOCATION
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6	2	0	2	FANS 1 EMERGENCY OFF	(NEAR)
6	2	1	3	FANS 1 EMERGENCY ON	(NEAR)
6	2	2	4	FANS 2 EMERGENCY OFF	(FAR)
6	2	3	5	FANS 2 EMERGENCY ON	(FAR)
6	2	4	6	FANS 3 EMERGENCY OFF	(DOME NEAR)
6	2	5	7	FANS 3 EMERGENCY ON	(DOME NEAR)
6	2	6	8	FANS 4 EMERGENCY OFF	(DOME FAR)
6	2	7	9	FANS 4 EMERGENCY ON	(DOME FAR)
6	2	8	10	FANS 5 EMERGENCY OFF	(FS-F06)
6	2	9	11	FANS 5 EMERGENCY ON	(FS-F06)
6	2	10	12	R SPARE [CHLR WATER PUMP EMERGENCY OFF	(CHP-F02)]
6	2	11	13	R SPARE [CHLR WATER PUMP OFF	(CHP-F02)]
6	2	12	14	SPARE	
6	2	13	15	SPARE	

COMMON N28G

NON-LATCHING CARD

F	W	BT	BT	FUNCTION	LOCATION
6	3	0	2	SPARE	
6	3	1	3	SPARE	
6	3	2	4	SPARE	
6	3	3	5	SPARE	
6	3	4	6	SPARE	
6	3	5	7	SPARE	
6	3	6	8	SPARE	
6	3	7	9	SPARE	
6	3	8	10	SPARE	
6	3	9	11	SPARE	
6	3	10	12	SPARE	
6	3	11	13	SPARE	
6	3	12	14	SPARE	
6	3	13	15	SPARE	

COMMON N28G

NON-LATCHING SPARE CARD

LEGEND:

R = CONTRACTOR SHALL REMOVE WIRED POINT AND UPDATE SCAN SHEET AND DRAWINGS.

SHEET F06 – S14

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

STATUS FRAMES

F	W	BT	BT	FUNCTION	LOCATION
7	0	0	2	FIRE ALARM 1 ACTIVE/ON	(STA/VS-10,11/SEJ-5/TC/C)
7	0	1	3	FIRE ALARM 3 ACTIVE/ON	(SS)
7	0	2	4	R SPARE [FIRE ALARM 4 ACTIVE/ON	(FUTURE TBS)]
7	0	3	5	SPARE	
7	0	4	6	FIRE ALARM 11 ACTIVE/ON	(FS-F06)

7	0	5	7	FIRE ALARM 16 ACTIVE/ON	(VS-F12)
7	0	6	8	FIRE ALARM 20 ACTIVE/ON	(CHP-F02)
7	0	7	9	FIRE ALARM 21 ACTIVE/ON	(DPS-F05)
7	0	8	10	FIRE ALARM 26 ACTIVE/ON	(EE-F01)
7	0	9	11	D SPARE [FIRE ALARM 27 ACTIVE/ON]	[(TAIL TK1)]
7	0	10	12	D SPARE [FIRE ALARM 28 ACTIVE/ON]	[(TAIL TK2)]
7	0	11	13	UNAUTHORIZED ENTRANCE 1 ABN/ON	(STA/ETC)
7	0	12	14	UNAUTHORIZED ENTRANCE 3 ABN/ON	(SS)
7	0	13	15	R SPARE [UNAUTHORIZED ENT 4 ABN/ON COMMON N28G	(FUTURE TBS)]

NON-LATCHING CARD

F	W	BT	BT	FUNCTION	LOCATION
7	1	0	2	UNAUTHORIZED ENTRANCE 10 ABN/ON	(FARE)
7	1	1	3	UNAUTHORIZED ENTRANCE 11 ABN/ON	(FS-F06)
7	1	2	4	UNAUTHORIZED ENTRANCE 16 ABN/ON	(VS-F12)
7	1	3	5	UNAUTHORIZED ENTRANCE 20 ABN/ON	(CHP-F02)
7	1	4	6	UNAUTHORIZED ENTRANCE 21 ABN/ON	(DPS-F05)
7	1	5	7	UNAUTHORIZED ENTRANCE 26 ABN/ON	(EE-F01)
7	1	6	8	ACU FAN 4 ABN/ON	(FAR)
7	1	7	9	HIGH WATER LEVEL DETECTOR 3 ACTIVE/ON	(SS)
7	1	8	10	SUBWAY DPS 1 ABN/ON	(DPS-F05)
7	1	9	11	SEWAGE PUMP 1 AIR ABN/ON	(SEJ-F05)
7	1	10	12	STATION AMBIENT TEMP ABN/ON	(FAR)
7	1	11	13	ACU FAN 1 ABN/ON	(NEAR)
7	1	12	14	ACU FAN 2 ABN/ON	(FAR)
7	1	13	15	ACU FAN 3 ABN/ON COMMON N28G	(NEAR)

NON-LATCHING CARD

LEGEND:

D = DELETE WIRED POINT AT APPROPRIATE TIME.

R = CONTRACTOR SHALL REMOVE WIRED POINT AND UPDATE SCAN SHEET AND DRAWINGS.

SHEET F06 - S15

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

STATUS FRAMES

F	W	BT	BT	FUNCTION	LOCATION
7	2	0	2	FANS 1 OPERATION ABN/ON	(AC SERV RM NEAR)
7	2	1	3	FANS 2 OPERATION ABN/ON	(AC SERV RM FAR)
7	2	2	4	FANS 3 OPERATION ABN/ON	(AC SERV RM NEAR)
7	2	3	5	FANS 4 OPERATION ABN/ON	(AC SERV RM FAR)
7	2	4	6	FANS 5 OPERATION ABN/ON	(FS-F06)
7	2	5	7	FANS 1 SUPPLY	(AC SERV RM NEAR)
7	2	6	8	FANS 2 SUPPLY	(AC SERV RM FAR)
7	2	7	9	FANS 3 SUPPLY	(AC SERV RM NEAR)
7	2	8	10	FANS 4 SUPPLY	(AC SERV RM FAR)

7	2	9	11	FANS 5 SUPPLY	(FS-F06)
7	2	10	12	FANS 1 REMOTE CONTROL ABN/ON	(AC SERV RM NEAR)
7	2	11	13	FANS 2 REMOTE CONTROL ABN/ON	(AC SERV RM FAR)
7	2	12	14	FANS 3 REMOTE CONTROL ABN/ON	(AC SERV RM NEAR)
7	2	13	15	FANS 4 REMOTE CONTROL ABN/ON	(AC SERV RM FAR)
				COMMON N28G	

NON-LATCHING CARD

F	W	BT	BT	FUNCTION	LOCATION
7	3	0	2	FANS 5 REMOTE CONTROL ABN/ON	(FS-F06)
7	3	1	3	VENT SHAFT DAMPER 1 ABN/ON	(VS-F10)
7	3	2	4	VENT SHAFT DAMPER 2 ABN/ON	(VS-F11)
7	3	3	5	VENT SHAFT DAMPER 3 ABN/ON	(VS-F12)
7	3	4	6	TUNNEL TEMP 5 HIGH ABN/ON	(FS-F06)
7	3	5	7	TUNNEL TEMP 5 LOW ABN/ON	(FS-F06)
7	3	6	8	SPARE	
7	3	7	9	SPARE	
7	3	8	10	SPARE	
7	3	9	11	SPARE	
7	3	10	12	SPARE	
7	3	11	13	SPARE	
7	3	12	14	SPARE	
7	3	13	15	SPARE	
				COMMON N28G	

NON-LATCHING CARD

SHEET F06 – S16

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

STATUS FRAMES

F	W	BT	BT	FUNCTION	LOCATION
8	0	0	2 R	SPARE [CHP SPACE TEMP ABN/ON	(CHP-F02)]
8	0	1	3 R	SPARE [REFG CONTROL AIR PRES ABN/ON	(CHP-F02)]
8	0	2	4 R	SPARE [IN/OUT COND WATER PRES 1 ABN/ON	(CHP-F02)]
8	0	3	5 R	SPARE [ENTER COND WATER PRES 1 ABN/ON	(CHP-F02)]
8	0	4	6 R	SPARE [LEAVE COND WATER PRES 1 ABN/ON	(CHP-F02)]
8	0	5	7 R	SPARE [REFG OIL TEMP 1 ABN/ON	(CHP-F02)]
8	0	6	8 R	SPARE [REFG PURGE AIR PRES 1 ABN/ON	(CHP-F02)]
8	0	7	9 R	SPARE [CHLR MOTOR NO. 1 OFF	(CHP-F02)]
8	0	8	10 R	SPARE [CHLR AC SERVICE ABN/ON	(CHP-F02)]
8	0	9	11	FANS 5 AUTOMATIC	(FS-F06)
8	0	10	12	FANS 5 EXHAUST	(FS-F06)
8	0	11	13	FAN SHAFT DAMPER 5 ABN/ON	(FS-F06)
8	0	12	14	SPARE	
8	0	13	15	SPARE	
				COMMON N28G	

NON-LATCHING SPARE CARD

F	W	BT	BT	FUNCTION	LOCATION
8	1	0	2	SPARE	
8	1	1	3	SPARE	
8	1	2	4	SPARE	
8	1	3	5	SPARE	
8	1	4	6	SPARE	
8	1	5	7	SPARE	
8	1	6	8	SPARE	
8	1	7	9	SPARE	
8	1	8	10	SPARE	
8	1	9	11	SPARE	
8	1	10	12	SPARE	
8	1	11	13	SPARE	
8	1	12	14	SPARE	
8	1	13	15	SPARE	
COMMON N28G					

NON-LATCHING SPARE CARD

LEGEND:

R = CONTRACTOR SHALL REMOVE WIRED POINT AND UPDATE SCAN SHEET AND DRAWINGS.

SHEET F06 – S17

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

STATUS FRAMES

F	W	BT	BT	FUNCTION	LOCATION
8	2	0	2	SPARE	
8	2	1	3 R	SPARE [DC PWR SUBSTA LOAD MSB	(SS)]
8	2	2	4 R	SPARE [DC PWR SUBSTA LOAD	(SS)]
8	2	3	5 R	SPARE [DC PWR SUBSTA LOAD BINARY	(SS)]
8	2	4	6 R	SPARE [DC PWR SUBSTA LOAD	(SS)]
8	2	5	7 R	SPARE [DC PWR SUBSTA LOAD	(SS)]
8	2	6	8 R	SPARE [DC PWR SUBSTA LOAD LSB	(SS)]
8	2	7	9	SPARE	
8	2	8	10	SPARE	
8	2	9	11	SPARE	
8	2	10	12	SPARE	
8	2	11	13	SPARE	
8	2	12	14	SPARE	
8	2	13	15	SPARE	
COMMON N28G					

NON-LATCHING SPARE CARD

F	W	BT	BT	FUNCTION	LOCATION
8	3	0	2 R	SPARE [ENTER COLD WATER TEMP MSB	(CHP-F02)]
8	3	1	3 R	SPARE [ENTER COLD WATER TEMP	(CHP-F02)]

8	3	2	4	R	SPARE [ENTER COLD WATER TEMP	(CHP-F02))
8	3	3	5	R	SPARE [ENTER COLD WATER TEMP	(CHP-F02))
8	3	4	6	R	SPARE [ENTER COLD WATER TEMP	(CHP-F02))
8	3	5	7	R	SPARE [ENTER COLD WATER TEMP	(CHP-F02))
8	3	6	8	R	SPARE [ENTER COLD WATER TEMP LSB	(CHP-F02))
8	3	7	9	R	SPARE [LEAVE COLD WATER TEMP MSB	(CHP-F02))
8	3	8	10	R	SPARE [LEAVE COLD WATER TEMP	(CHP-F02))
8	3	9	11	R	SPARE [LEAVE COLD WATER TEMP	(CHP-F02))
8	3	10	12	R	SPARE [LEAVE COLD WATER TEMP	(CHP-F02))
8	3	11	13	R	SPARE [LEAVE COLD WATER TEMP	(CHP-F02))
8	3	12	14	R	SPARE [LEAVE COLD WATER TEMP	(CHP-F02))
8	3	13	15	R	SPARE [LEAVE COLD WATER TEMP LSB	(CHP-F02))
COMMON N28G						

NON-LATCHING SPARE CARD

LEGEND:

R = CONTRACTOR SHALL REMOVE WIRED POINT  
AND UPDATE SCAN SHEET AND DRAWINGS.

SHEET F06 – S18

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

STATUS FRAMES

F	W	BT	BT		FUNCTION	LOCATION
9	0	0	2	R	SPARE [COLD WATER FLOW, GPM MSB	(CHP-F02))
9	0	1	3	R	SPARE [COLD WATER FLOW, GPM	(CHP-F02))
9	0	2	4	R	SPARE [COLD WATER FLOW, GPM	(CHP-F02))
9	0	3	5	R	SPARE [COLD WATER FLOW, GPM	(CHP-F02))
9	0	4	6	R	SPARE [COLD WATER FLOW, GPM	(CHP-F02))
9	0	5	7	R	SPARE [COLD WATER FLOW, GPM	(CHP-F02))
9	0	6	8	R	SPARE [COLD WATER FLOW, GPM LSB	(CHP-F02))
9	0	7	9	R	SPARE [REFG EVAP PRES MSB	(CHP-F02))
9	0	8	10	R	SPARE [REFG EVAP PRES	(CHP-F02))
9	0	9	11	R	SPARE [REFG EVAP PRES	(CHP-F02))
9	0	10	12	R	SPARE [REFG EVAP PRES	(CHP-F02))
9	0	11	13	R	SPARE [REFG EVAP PRES	(CHP-F02))
9	0	12	14	R	SPARE [REFG EVAP PRES	(CHP-F02))
9	0	13	15	R	SPARE [REFG EVAP PRES LSB	(CHP-F02))
COMMON N28G						

NON-LATCHING SPARE CARD

F	W	BT	BT		FUNCTION	LOCATION
9	1	0	2	R	SPARE [REFG COND PRES MSB	(CHP-F02))
9	1	1	3	R	SPARE [REFG COND PRES	(CHP-F02))
9	1	2	4	R	SPARE [REFG COND PRES	(CHP-F02))
9	1	3	5	R	SPARE [REFG COND PRES	(CHP-F02))
9	1	4	6	R	SPARE [REFG COND PRES	(CHP-F02))
9	1	5	7	R	SPARE [REFG COND PRES	(CHP-F02))
9	1	6	8	R	SPARE [REFG COND PRES LSB	(CHP-F02))

9	1	7	9	SPARE
9	1	8	10	SPARE
9	1	9	11	SPARE
9	1	10	12	SPARE
9	1	11	13	SPARE
9	1	12	14	SPARE
9	1	13	15	SPARE

COMMON N28G

NON-LATCHING SPARE CARD

LEGEND:

R = CONTRACTOR SHALL REMOVE WIRED POINT  
AND UPDATE SCAN SHEET AND DRAWINGS.

SHEET F06 – S19

R.T.U. SCAN SHEET – EXAMPLE LOCATION

ANACOSTIA RTU (F06)

STATUS FRAMES

F	W	BT	BT	FUNCTION	LOCATION
9	2	0	2	VACANT	
9	2	1	3	VACANT	
9	2	2	4	VACANT	
9	2	3	5	VACANT	
9	2	4	6	VACANT	
9	2	5	7	VACANT	
9	2	6	8	VACANT	
9	2	7	9	VACANT	
9	2	8	10	VACANT	
9	2	9	11	VACANT	
9	2	10	12	VACANT	
9	2	11	13	VACANT	
9	2	12	14	VACANT	
9	2	13	15	VACANT	

VACANT SLOT

F	W	BT	BT	FUNCTION	LOCATION
9	3	0	2	VACANT	
9	3	1	3	VACANT	
9	3	2	4	VACANT	
9	3	3	5	VACANT	
9	3	4	6	VACANT	
9	3	5	7	VACANT	
9	3	6	8	VACANT	
9	3	7	9	VACANT	
9	3	8	10	VACANT	
9	3	9	11	VACANT	
9	3	10	12	VACANT	

9	3	11	13	VACANT
9	3	12	14	VACANT
9	3	13	15	VACANT

VACANT SLOT

SHEET F06 – S20\*

**PART 2- PRODUCTS**  
NOT USED

**PART 3 - EXECUTION**  
NOT USED

**END OF SECTION**

## SECTION 16998

### ATC APPENDIX "CD" CORRECTION OF ATC DEFICIENCIES

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. Definitions: As used in this Section
- B. General Conditions
- C. Deficiencies of Tested ATC Materials, Equipment, Systems or Subsystems
- D. Pre-Acceptance Recognition of Deficiencies in ATC Materials, Equipment, Systems or Subsystems
- E. Time for Performance, Contract Price
- F. Transportation Charges
- G. Failure to Correct
- H. Correction of Deficient Replacements and Reperformances
- I. Disassembly/Reassembly Expense
- J. Warranties

##### 1.02 RELATED SECTIONS

- A. All 16900-Series Sections

##### 1.03 DEFINITIONS: AS USED IN THIS SECTION

- A. Deficiency:
  - 1. ATC materials and equipment, will be regarded as having a deficiency if a type of material or equipment, in like service accumulates a failure rate greater than five percent during a period starting with initial Factory Testing of the applicable material and/or, equipment, and ending 24 months following final acceptance by the Authority.
  - 2. ATC systems or subsystems will be regarded as having a deficiency if they exhibit any condition or characteristics which are not in compliance with the requirements and intent of this Contract anytime during a period starting with initial Factory Testing of the applicable system and/or subsystem, and extending for 24 months following final acceptance by the Authority.
- B. Correction
  - 1. Correction of ATC materials or equipment exhibiting a failure rate greater than five percent means taking of any and all actions necessary to correct the deficiencies, including removal and replacement of all pieces of material or equipment in like service in a manner satisfactory to the designated Resident Engineer.
  - 2. Correction of ATC systems or subsystems exhibiting one or more deficiencies means taking any and all actions to eliminate any and all deficiencies in a manner satisfactory to the designated Resident Engineer.

#### **1.04 GENERAL CONDITIONS**

- A. The rights and remedies of the Authority provided in this Section: Shall not be affected in any way by any other provisions under this Contract concerning the conclusiveness of inspections and acceptance, and;
  - 1. Are in addition to and do not limit any rights afforded to the Authority by any other Section of this Contract.
  - 2. This Section shall apply only to those deficiencies discovered by either the Authority or the Contractor within a period commencing with the initial Factory Testing of the applicable material, equipment, system and/or subsystem and extending for 24 months after acceptance by the Authority.
- B. The Contractor shall not be responsible under this Section for the correction of deficiencies in Authority-furnished property, except for deficiencies in installation, unless the Contractor performs or is obligated to perform any modifications or other work on such property. In that event, the Contractor shall be responsible for correction of deficiencies to the extent of such modifications or other work.
- C. The Contractor will not be responsible under this Section for the correction of deficiencies caused by the Authority.

#### **1.05 DEFICIENCIES IN ATC MATERIALS, EQUIPMENT, SYSTEMS AND/OR SUBSYSTEMS**

- A. Notice of Deficiency to Contractor: If the Contracting Officer determines that a deficiency exists in any of the ATC materials, equipment, systems or subsystems provided to the Authority under this Contract, he will promptly (within 30 days) notify the Contractor of the deficiency, in writing,.
- B. Recommendation for Correction: Upon timely notification of the existence of such a deficiency, or if the Contractor independently discovers a deficiency in Factory Tested ATC materials, equipment, systems or subsystems, the Contractor shall promptly submit to the Contracting Officer his recommendation for corrective actions, together with supporting information in sufficient detail for the Contracting Officer to determine what corrective action, if any, shall be taken. The recommendation shall be submitted to the Contracting Officer within 15 working days of notice of the deficiency.
- C. Direction to Contractor Concerning Correction of ATC Deficiencies : Within 30 days after receipt of the Contractor's recommendations for corrective action and adequate supporting information, the Contracting Officer, at his sole discretion, will give the Contractor written notice not to correct the subject deficiency, or to correct or partially correct the subject deficiency within a reasonable time and at a specified location.
- D. Correction of ATC Deficiencies by Contractor: The Contractor shall promptly comply with any timely direction by the Contracting Officer to correct or partially correct an ATC deficiency, at no increase in the Contract price. The Contractor shall also prepare and furnish to the Authority data and reports applicable to any correction required under this Section (including revision and updating of all other affected data called for under this Contract) at no increase in the Contract price.
- E. Schedule of Deficiency Corrections: The Contractor shall prepare a Schedule of Deficiency Corrections and deliver it to the Authority for approval within 15 working days of discovery of an ATC deficiency by the Authority or the Contractor.
- F. Modification of Contract with respect to Uncorrected ATC Deficiencies: In the event of timely notice of a decision not to correct, or only to partially correct an ATC deficiency, the Contractor shall submit within 15 working days, a technical and cost proposal to amend the

Contract to permit acceptance of the affected materials, equipment, systems or subsystems in accordance with the revised requirements, and an equitable reduction in Contract price shall promptly be negotiated by the parties and stated in a modification to this Contract.

**1.06 PRE-ACCEPTANCE RECOGNITION OF DEFICIENCIES IN ATC MATERIALS, EQUIPMENT, SYSTEMS OR SUBSYSTEMS**

- A. The Contractor shall maintain a log of all ATC material, equipment, system and subsystem failures starting at the time of initial Factory Testing of each type of item, and make this log available to the Designated Resident Engineer. If the Contractor becomes aware at any time before acceptance by the Authority (whether before or after tender to the Authority) that a deficiency exists in any ATC materials, equipment, system or subsystems, he shall promptly correct the deficiency, or, if he elects to invoke the procedures specified in Part 1.05, he shall promptly communicate information concerning the deficiency to the Contracting Officer in writing, together with his detailed recommendation for corrective action.

**1.07 TIME FOR PERFORMANCE; CONTRACT PRICE**

- A. In no event will the Authority be responsible for extension or delays in the scheduled deliveries or periods of performance under this Contract as a result of the Contractor's obligations to correct ATC deficiencies, nor shall there be any adjustment of the delivery schedule or period of performance as a result of such correction of deficiencies, except as may be agreed to by the Authority in a supplemental agreement with adequate consideration.
- B. It is hereby specifically recognized and agreed by the parties hereto that this Section shall not be construed as obligating the Authority to increase the Contract price of this Contract.

**1.08 TRANSPORTATION CHARGES**

- A. When the Authority returns supplies to the Contractor for correction or replacement pursuant to this Section, the Contractor shall be liable for transportation charges up to an amount equal to the cost of transportation by the usual commercial method of shipment from the designated destination point under this Contract to the Contractor's plant, in addition to any charges specified in Part 1.08.B. The Contractor shall also bear the responsibility for the supplies while in transit.
- B. When compliance with the terms of this Section by the Contractor involves shipment of corrected or replacement supplies from the Contractor to the Authority, the Contractor shall be liable for transportation charges up to an amount equal to the cost of transportation by the usual commercial method of shipment from the Contractor's plant to the designated destination point under this Contract, in addition to any charges specified in Part 1.08.A. The Contractor shall also bear the responsibility for the supplies while in transit.

**1.09 FAILURE TO CORRECT**

- A. If the Contractor fails or refuses to present a detailed recommendation for corrective action in accordance with Part 1.05, correct deficiencies in accordance with Part 1.05 C. or, prepare and furnish data reports in accordance with Part 1.05 D.,
  - 1. The Contracting Officer will give the Contractor written notice specifying the failure or refusal and setting a period after receipt of the notice within which it must be corrected.
- B. If the failure or refusal is not corrected within the specified period, the Contracting Officer may, by contract or otherwise, as required:
  - 1. Obtain detailed recommendations for corrective action;

2. Correct the materials, equipment, systems or subsystems, or;
3. Replace the materials, equipment, systems or subsystems, and if the Contractor fails to furnish timely disposition instructions, the Contracting Officer may dispose of non-conforming materials, equipment, systems or subsystems for the Contractor's account in a reasonable manner, in which the Authority is entitled to reimbursement from the Contractor or from the proceeds for the reasonable expense of care and disposition, as well as for excess costs incurred or to be incurred, and;
4. Obtain applicable data and reports; and charge to the Contractor the cost occasioned to the Authority thereby.

#### **1.10 CORRECTION OF DEFICIENT REPLACEMENTS AND REPERFORMANCES**

- A. Any ATC materials or equipment corrected or furnished in replacement, and any ATC systems or subsystems revised pursuant to this Section shall also be subject to all the provisions of the Contract to the same extent as ATC materials, equipment, systems or subsystems previously tested, and/or initially accepted, i.e., for a new 24-month period.

#### **1.11 DISASSEMBLY/REASSEMBLY EXPENSE**

- A. The Contractor shall be liable for reasonable cost of disassembly/reassembly of larger items necessary to remove the materials or equipment to be inspected and/or returned for correction or replacement.

#### **1.12 WARRANTIES**

- A. All ATC materials and equipment provided under this Contract shall be warranted for proper operation for a period of 24 months beginning with final acceptance by the Authority.
- B. All subcontractors', manufactures', and suppliers' warranties and guarantees, expressed or implied, respecting any part of the ATC work, and any materials or equipment used therein shall be deemed obtained and shall be enforced by the Contractor as the agent and for the benefit of the Authority without the necessity of separate transfer or assignment thereof. Furthermore, if directed by the Contracting Officer, the Contractor shall require such subcontractors, manufacturers and suppliers to execute such warranties and guarantees in writing to the Authority.

#### **PART 2 - PRODUCTS (NOT USED)**

#### **PART 3 - EXECUTION (NOT USED)**

**END OF SECTION**