Washington
Metropolitan
Area
Transit
Authority

# Request For Proposal

**[Federal]**

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# Mechanical Construction Services Multiple Award Task Order Contract (MATOC)

## RFP NO. FQ14114/MDG

**Date: December 16, 2014**

**Book 3 of 5**
**Technical Specifications – Seed Project**

**SECTION 00012**

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END OF SECTION

# SECTION 02220
# DEMOLITION

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for demolition work.

1.2 RELATED REQUIREMENTS

1. Clearing, grubbing, removal and protection of trees and shrubs: Section 02230.

2. Removal of concrete and masonry walls and foundations 12 inches below existing grade: Section 02320.

3. Removal and restoration of miscellaneous facilities: Section 02205.

1.3 DEFINITIONS

A. Demolition: Complete removal and disposal of existing facilities from areas to be cleared and grubbed and from other areas shown.

B. Existing facilities include, but are not restricted to, buildings, sheds, streetcar tracks, pavements, sidewalks, curbs and gutters, signs, posts, fences, drainage, concrete foundations, walls, sewage and other utility facilities, including underground and overhead utility appurtenances, located in the area to be cleared and grubbed.

C. Salvage: Section 02205.

1.4 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each:

1. Certification

a. Submit copy of request to utility companies owning or agency controlling services and appurtenances affected by demolition work for discontinuance of services along with certificates of severance.

2. Documentation

a. Demolition permit from the jurisdictional agency or owner.

b. Traffic permit from the jurisdictional agency for transport of debris.

c. Permits and releases from each owner of property where demolition debris will be deposited absolving the Authority of responsibility in connection with such disposal.

1.5 QUALITY ASSURANCE

A. Comply with codes and regulations of the Jurisdictional Authorities.

B. Obtain special permits and licenses and give notices required for performance and completion of the demolition and removal work, hauling, and disposal of debris.

1.6 SITE CONDITIONS

A. The Authority assumes no responsibility for the condition of the existing structures to be demolished.

B. Buildings

1. Demolish buildings in place.

C. Street and Road Closures

1. Make arrangements with appropriate jurisdictional agency for temporary closing of public streets or highways to traffic as necessary.

2. Arrange with the appropriate agency for the rerouting of traffic and comply with its regulations.

3. Furnish and maintain temporary signs, barricades, flashing lights, and flag persons necessitated by the Work and remove same upon completion of Work.

D. Maintenance and Control of Traffic

1. Incorporate arrangements for maintenance and control of traffic as required for demolition work including road closures and hauling of debris. Execute Traffic Control Plan and perform other measures as required to maintain and control traffic.

2. Construct, maintain and remove on completion of work, temporary canopies and other structures for protection of the public in accordance with applicable codes to ensure continuous safety of traffic.

3. Bridge cuts in traffic areas with steel plates or by other approved means.

4. Keep traffic areas free from debris and spillage of materials.

5. When demolition work interferes with bus loading facilities, provide and maintain surfaced areas at alternative locations or arrange rerouting with appropriate authorities for duration of work.

E. Protection and Restoration

1. Prevent damage to pipes, conduits, wires, cables and structures above and below ground which are not designated for removal. Repair or replace damaged items. The proposed method of repair or replacement shall be submitted for review and approval.

2. Provide safe passageways for the public around the demolition area and conduct operations to prevent injury to the public and damage to adjacent buildings, structures, or other facilities.

3. Protect sidewalks, utilities, streets, and facilities adjacent to the work from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by demolition operations. Do not leave sidewalks, utilities, streets, and facilities adjacent to the work area in a dangerous condition as a result of the demolition operation.

F. Utilities

1. Arrange with the appropriate utility owner for removal, rerouting, or capping of utility and comply with its regulations.

**PART 2 – PRODUCTS**

Not Used.

## PART 3 – EXECUTION

3.1 GENERAL

A. Do not remove, relocate, or disturb survey markers and monuments found within the demolition area without prior written approval. Demolition Plan shall show survey markers needing relocation.

B. Disconnect, cut, and cap utility services to facilities to be removed or demolished. Cap and plug pipe and other conduits abandoned due to the demolition, with approved type caps and plugs as required by the utility owners.

C. In-place abandoned utilities shall be disconnected, cut, and capped with an approved cap as approved and coordinated with the utility owner. Outside of WMATA's right-of-way, the utility shall be filled as required by the Authority Having Jurisdiction.

3.2 PRESERVATION OF REFERENCES

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

3.3 BUILDING DEMOLITION

A. Undertake rodent control and extermination program in demolition areas.

B. Take possession of building materials, fixtures and equipment in, attached to or belonging to, buildings and structures.

C. Proceed with demolition of building or structure and appurtenances.

D. Party Walls

1. Where building wall being demolished is a party wall with another building not to be demolished, prevent damage to other building and avoid interference with its occupants.

2. Restore and waterproof exposed party walls in accordance with applicable building code for exterior walls of particular type of construction involved.

3. Should party wall become unsafe or dangerous because of demolition, effect remedial measures for anchoring, bracing, or buttressing. If such work does not correct unsafe or dangerous conditions, remove and replace wall and perform necessary work to properly enclose structure that is to remain standing, at no cost to the owner of such property.

E. Cellars and Foundation Walls

1. Break concrete and masonry cellar floors into pieces not exceeding 4 cubic feet in volume, or where approved, punch holes of not less than 1 square foot area through full thickness of floor approximately at 10-foot centers.

2. Remove wooden cellar floors.

3. Remove foundation and cellar walls 12 inches minimum below final grade.

4. After breaking or removing cellar floors, fill cellar spaces with durable free-draining fill material, consisting of particles none of which exceeds 8 inches in its greatest dimension. Use masonry rubble obtained from demolition work if it meets this requirement. Place fill material in layers each of 12-inch maximum thickness, compact each layer, and fill voids in each lift with approved coarse sand.

5. Correct subsidence in filled areas by placing and compacting additional fill.

6. The Contracting Officer Representative may waive the requirement to fill cellar voids where cellar structures will be subsequently excavated for construction.

3.4 REMOVAL OF STREETCAR TRACKS, PAVEMENTS, SIDEWALK, CURBS AND GUTTERS

A. Removal of Streetcar Tracks

1. Regardless of depth, totally remove and dispose of rails, slot rails, yokes, switches, turnouts, ties, manholes, concrete and masonry encasements, cables, insulators and other related parts and accessories of track installation located within boundaries drawn two feet outside outer rails.

2. Remove materials within such boundaries horizontally and from existing street grade to yoke encasement subgrade, vertically. In double track installations, remove materials in intervening space between inner rails of each track.

3. Known locations of streetcar tracks are shown.

4. Remove streetcar tracks as necessitated by the Work and as directed, whether tracks are shown or encountered during excavation.

5. Transport from the Site removed or excavated track accessories or parts thereof, which will become the property of the Contractor.

6. Methods of removal and disposal shall be at the Contractor's option, subject to approval and meeting the requirements of the Construction Sequence and Maintenance of Traffic Schedule.

B. Demolish pavement, sidewalks, curbs, and gutters within demolition area shown to underside of pavement and dispose of resulting debris. Remove and salvage stone curbing where shown. Dispose of 6-inch granite curb.

C. Fill resulting excavations, holes, and depressions to existing grade or alternative grade as shown, using fill material conforming to requirements of Section 02320.

D. Adequately drain resulting surfaces.

3.5 DISPOSAL

A. Remove debris resulting from demolition work to locations outside Authority's right-of-way in accordance with applicable laws and ordinances and as prescribed by Authorities Having Jurisdiction.

B. Dispose of debris off site only with permission of property owner where such debris is to be deposited and in accordance with codes and regulations of the Jurisdictional Authorities.

C. Do not burn or bury debris at demolition site.

D. Provide copies of permits or licenses showing compliance to state and local requirements for disposing.

END OF SECTION

# SECTION 03371

# REPAIR OF STRUCTURAL CONCRETE

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for repairing structural concrete and as follows:

1. Repair cracks by epoxy injection and spalls in the station concrete platforms discovered during replacement of the platform pavers.

1.2 REFERENCES

A. Codes and regulations of the Jurisdictional Authorities.

B. ACI: Unless otherwise specified, ACI requirements govern the performance of the Work.

C. FS TT-P-86.

1.3 DEFINITIONS

A. Repair: Repair consists of patching concrete spalls and delaminations by epoxy injection grouting.

1.4 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each.

B. Submit for approval, no less than 21 calendar days prior to execution of the Work

1. Product Data: Manufacture's technical data on all materials for use in the Work.

a. Submit product data with Shop Drawings and working drawings as applicable.

2. Provide description of epoxy grout injection equipment to be used.

3. The proposed work platform to be used during the performance of work.

C. Samples

1. Two quarts of epoxy resin.

D. Certification

1. Certify that materials furnished meet specified requirements and are compatible with existing materials.

1.5 QUALITY ASSURANCE

A. Qualification of Contractor

1. Epoxy injection work shall be performed by licensed applicators or companies whose injection process has been successfully used on similar structural repair projects.

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver products to the job site in their original unopened containers clearly labeled with manufacturer's names, product name, batch number and date, referenced specification number, type, and class as applicable. Store in WMATA approved area meeting manufacturer's temperature requirements.

1.7 SITE CONDITIONS

A. Fabricate barricades in accordance with the plans submitted and approved as required by the General Requirements.

B. Erect barricades around work areas in accordance with the approved plans and specified safety requirements.

C. All work times shall be coordinated with the Contracting Officer Representative. All work specified for this Contract shall be done during hours as specified.

D. Dust Control: Implement dust control procedures at all times during the rehabilitation of the concrete structures. All excess dust and debris outside of the work area shall be cleared and cleaned and kept clear at all times. Track right-of-way shall be kept clear of all equipment and debris during revenue hours.

E. Protection and Restoration

1. Prevent damage to pipes, conduits, wires, cables, and structures, which are not designated for removal. Repair or replace damaged items.

F. Cracks, spalls, and delaminated concrete encountered that, in the opinion of the Contractor require repair, shall be brought to the attention of the Contracting Officer Representative and repaired if directed.

G. Contractor shall be responsible for ensuring that surface condition and the atmospheric and surface temperature ranges are suitable for the specified material. Follow manufacturer's instructions for weather condition and temperature ranges.

H. Remove debris resulting from demolition work to locations outside Authority's right-of-way.

I. Dispose of debris off site only with permission of property owner where such debris is to be deposited in accordance with codes and regulations of the Jurisdictional Authorities.

J. Do not burn debris at demolition site.

**PART 2 – PRODUCTS**

2.1 MATERIALS

A. Epoxy bond coat for spall repair shall be Sika Armatec 110 or approved equal.

B. Concrete injection material for non-leaking concrete crack repair shall be Nitobond ULV 300 by FOSROC, Inc., or Sikadur 35, Hi-Mod LV LPL, or approved equal to be used for cracks greater than 1/16 inch wide and less than 1/4 inch wide.

C. Concrete epoxy or polymer mortar for vertical and overhead shallow spalls less than 1-1/2 inches deep or cracks greater than 1/4 inch wide shall be Nitomortar HB, Sika Repair 223, or approved equal.

D. Concrete epoxy or polymer mortar for vertical and overhead deep spalls greater than 1-1/2 inches deep shall be Nitomortar HB, Sika Repair SHA, or approved equal.

2.2 PRESSURE WASHING EQUIPMENT

A. The equipment used to clean the concrete surfaces shall be a High Pressure water jet system manufactured by Jetstream, Flow International, Butterwort, or approved equal. It shall:

1. Be capable of delivering water pressures from 3500 psi to 20,000 psi. Limit applied pressure to avoid damaging sound concrete.

2. Provide for the collection and filtration of the cleaning debris. No cleaning debris shall be allowed to enter the track drainage system, public storm drains, or streams. All particulates shall be disposed of at a site and in a manner approved by the Jurisdictional Authorities.

2.3 METERING, MIXING, AND INJECTION EQUIPMENT

A. The equipment used to meter and mix the two injection adhesive components and inject the mixed material into the crack shall be portable, positive displacement type pumps with an interlock to provide positive ration control of exact proportions of the two components at the nozzle. The pumps shall be electric or air powered and shall provide in-line mixing and metering systems.

B. The injection equipment shall have the capability of discharging the mixed material at pressure up to 100 psi and maintaining that pressure.

C. A pressure test of the system shall be performed as required by the Contracting Officer Representative before the start of epoxy injection.

D. The equipment shall have the capability of maintaining the volume ratio for the injection system prescribed by the manufacturer of the material within a tolerance of plus or minus 5 percent by volume at any discharge pressure up to 100 psi.

**PART 3 – EXECUTION**

3.1 CLEAN CONCRETE

A. The surface of the concrete shall be cleaned to remove calcite deposits, epoxy from previous repair efforts, rust, and water stains prior to repair. Surface preparation may be accomplished by pressure washing, mechanical means, or cleaning agent approved by the Contracting Officer Representative.

3.2 EPOXY INJECTION SYSTEM FOR CONCRETE CRACK REPAIR

A. General: Use for repairing non-leaking cracks greater than 0.06 inches in width.

B. Preparation

1. Clean surfaces adjacent to cracks of dirt, grease, oil, efflorescence, or other foreign matter detrimental to bond of epoxy injection surface seal system. Acids and corrosives will not be permitted.

2. Before application of epoxy grout, cracks shall be sealed at the surface using Sika 31, Hi Mod GelXV, or approved equal.

3. Place the surface seal material over the cracks to be pressure injected and around each injection port. Allow sufficient time as recommended by product manufacturer to set before pressure injecting.

C. Installation

1. Entry ports in the surface seal shall be established along the crack at a distance of 6 to 12 inches apart.

2. The injection of the epoxy resin into each crack shall begin at the entry port at the lowest elevation. Maximum injection pressure shall be 100 psi. Injection shall continue at the first port until the injection material begins to flow out of the port at the next highest elevation. The second port shall be plugged and injection shall continue at the first port as long as possible. When the material no longer flows, the first port shall be plugged and injection shall begin at second port. The entire crack shall be injected with the same sequence.

3. After the injection material has cured, the surface seal and injection packers shall be removed. The face of the crack shall be finished flush with the adjacent concrete. There shall be no indentations, discoloration, or protrusions caused by placement of entry ports.

D. Pump Ratio Test

1. The mixing head of the injection equipment shall be disconnected and the two components shall be pumped simultaneously into separate calibrated containers. The amounts discharged into the calibrated containers simultaneously during the same time period shall be compared to determine the correct volume. Frequency of the pump ratio test will be determined by the Contracting Officer Representative.

3.3 CONCRETE SPALL REPAIRS

A. Surface Preparation

1. Remove defective concrete with chipping hammers or other approved equipment.

2. Prepare exposed concrete surface by pressure washing clean and allowing drying thoroughly. Surface drying may be accomplished by air jet. Ensure that compressed air used in cleaning and drying is free from oil or other contaminating materials.

3. Apply materials only when the surface condition and the atmospheric and surface temperature ranges are suitable for the specified material. Contractor shall be responsible for cleaning area to be repaired and removing excess water from spall. Follow manufacturer's instruction for weather conditions and temperature ranges.

4. Maintain concrete surface in sufficient depth at temperature of 65 degrees F minimum during first 4 hours after placement of epoxy bond coat. Preheating may be done with radiant heaters or other approved means. Do not preheat concrete in excess of 200 degrees F with final surface temperature below 105 degrees F at time of placing epoxy materials.

B. Application of Epoxy Bonding Agents

1. Prepare epoxy bonding agent in accordance with manufacturer=s recommendations.

2. Apply epoxy bonding agent to prepared dry concrete and steel surface at coverage of 80 square feet per gallon maximum or as recommended by manufacturer.

3. Epoxy bonding agent may be applied by any convenient and safe method, which will yield effective coverage, such as squeegees, brushes, or rollers.

4. During application of epoxy boding agent, ensure that material is confined to area being bonded; avoid contamination of adjacent surfaces. Extend epoxy bond coat slightly beyond edges of repair area.

C. Application of Epoxy or Polymer Mortar

1. Mix specified components in accordance with manufacturer's recommendations.

2. Mix specified components with slow-speed mechanical device.

3. Prepare mortar in small batches so that each batch can be completely mixed and placed within approximately 30 minutes.

4. Do not add thinners or dilutants to mortar mixture.

5. Immediately after application of bonding agent, place, tamp, flatten, and smooth mortar. Scrub repair mortar into the prepared surface.

6. Mortar shall be flush with surrounding concrete surface.

7. Steel-trowel finish. Trowels may be heated to facilitate finishing.

D. Curing

1. Cure mortar repairs immediately after completion at 40 degrees F minimum until mortar is hard.

2. Do not subject specified mortar to moisture until after specified post-curing has been completed.

END OF SECTION

**SECTION 03640**

**CONCRETE CRACK SEALING WITH INJECTED WATER-REACTIVE POLYMER GROUT**

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for furnishing and installing a concrete wall crack sealing system with a single component injected water-reactive non-shrink polyurethane grout for sealing leaking joints, cracks, fractures and holes in concrete, and the repair of contraction joints prior to the application of the test section coatings and as directed by the Contracting Officer Representative and as shown on the Concrete Drawings.

B. Furnish, at no cost to the Authority, the services of a manufacturer=s technical field representative to ensure proper injection of the water-reactive polyurethane grout.

C. This Section describes the injection of a crack or joint with infiltrating water with a polymer grout.

1.2 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each.

B. Submit for approval, no less than 21 calendar days prior to execution of the Work:

1. Product Data: Manufacturer=s technical data on all materials for use in the Work.

a. Submit product data with Shop Drawings and working drawings, as applicable.

2. Provide description of polymer grout injection equipment and procedures to be used.

3. Provide a certificate of compliance stating that the repair material meets the specified requirements. Provide the manufacturer=s current printed literature on the specified product.

C. Samples

1. Two quarts of chemical grout.

1.3 QUALITY ASSURANCE

A. The manufacturer of the specified product shall have an established training program for, certifying, Contractor=s for application of the materials.

B. The Contractor shall be an Approved Contractor by the manufacturer of the specified product, and have completed a program of instruction in the use of the specified repair material, and can provide certification proof from the manufacturer attesting to it's Approved Contractor status. The Contractor shall be able to demonstrate past performance on jobs of similar scope and size.

C. Make all arrangements and pay all costs to have manufacturer's authorized representative on the job at the beginning of all major phases of the Work, including joint preparation and installation of polyurethane grout, to advise installer of the proper procedures and quality control techniques.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver the specified product in original, unopened containers clearly labeled with the manufacturer's name, labels, product identification, and batch numbers.

B. Store the specified product as recommended by the manufacturer.

C. Store chemical grout dry at 50 to 90 degrees F. Material shall be 65 to 85 degrees F before using. Protect against freezing. Discard frozen material.

1.5 SITE CONDITIONS

A. Protection: Precautions shall be taken to avoid damage to any surface or utilities such as water pipes, conduits, acoustical tiles, and rail systems near the work zone due to mixing and handling the specified repair material.

B. If additional leakage at cracks or joints (not indicated in the Contract Drawings) is encountered that, in the opinion of the Contractor, require repair, bring these locations to the attention of the Contracting Officer Representative, and repair if directed.

**PART 2 – PRODUCTS**

2.1 POLYURETHANE WATER-REACTIVE CHEMICAL GROUT

A. The grouting material shall be one component low viscosity hydrophilic polyurethane liquid as manufactured by DeNeef Construction Chemicals 18314 Mathis Road Waller, TX, 77484-1219- tel: 800-732-0166. The grout shall be a water reactive single component polyurethane grout, developed to stop highly active leaks. The grout shall be nontoxic after curing. The polyurethane liquid shall react only with water to foam and expand to form a flexible, tough, rubber type gasket that stops water.

B. Product Properties of Uncured Chemical Grout

| | Property | Standards | Results |
|---|---|---|---|
| 1. | Solids Content | ASTM D1010 | 82-88% |
| 2. | Viscosity | ASTM D1638 at 70°F | 300-600cps |
| 3. | Color | Visual | Amber |
| 4. | Weight per gallon | ASTM D1638 | 91.5 Lbs. |
| 5. | Flash Point (Pensky Martens) | | 225 deg. F. |
| 6. | Corrosiveness | | Noncorrosive |
| 7. | Toxicity | | Toxic in liquid form |

C. Product Properties of the Cured Polyurethane Chemical Grout

| | Property | Standards | Results |
|---|---|---|---|
| 1. | Density | ASTM D3574 | 14 lbs/ft3 |
| 2. | Tensile Strength | ASTM D3574 | 80-90 psi |
| 3. | Elongation | ASTM D3574 | 700- 800% |
| 4. | Shrinkage | ASTM D756 | 18% linear |
| 5. | Toxicity | ASTM 1042 | Cured material is non-toxic |

D. Packers are required for injection. Packers for injection shall be supplied from the manufacturer.

E. Hoses: Moisture-impermeable hoses are required for use where grout material is being pumped.

## PART 3 – EXECUTION

### 3.1 SURFACE PREPARATION

A. The cracks, holes, cold joints, and fractures shall be clean. Remove dust, laitance, grease, curing compounds, waxes, impregnations, foreign particles, coatings, efflorescence, rust stains, and disintegrated materials from the defects by wire brushing and scraping or mechanical means as approved by the manufacturer. All cracks, fractures, holes, and joints shall be thoroughly flushed with clean water to remove dirt, dust, and other contaminants. If joints or cracks that are being sealed are dry, water shall be pumped into the cold joint or crack before injecting grout.

B. Repair cracks and cold joints by drilling offset test holes at a distance from the defect of 1/2 the depth of the concrete, at an angle sufficient to intersect the defect at approximately half the distance of the concrete thickness. Injection hole spacing is normally 6 inches or up to 24 inches apart depending upon the width of the defect. Generally, the wider the defect, the greater the distance of grout travel; therefore the injection holes will be farther apart. The purpose of the test holes is to pump water into the crack or cold joint to determine spacing for injectors along the crack. Drill the holes to intersect the crack or cold joint midway through the substrate. Install the injection packers in holes and tighten. If the defect to be injected is 1/2 inch or greater at surface, use oil-free oakum saturated with grout and mixed with water. Hold oakum for 2 to 3 minutes to allow foaming and insert oakum into defect, hole, or cold joint. Water shall be sprayed into area before inserting activated oakum.

C. For thin concrete walls of 6 inches or less, the injection holes shall be drilled directly into the defect itself to prevent damage to the concrete.

### 3.2 APPLICATION

A. Installation Procedure Crack Injection

1. This specified polyurethane water reactive grout requires no mixing.

2. The injection equipment shall be used to meter the polyurethane chemical grout and dispense the product into the prepared crack, whole or joint. The unit shall be portable and be equipped with positive displacement type pumps with interlock to provide positive control of the polyurethane chemical grout at the nozzle. The pumps shall be air powered or electric and shall provide an in-line metering system with gages at eh injection nozzle and the pump, and shall contain drain-back plugs.

3. Follow manufacturer's recommendations for the use of safety equipment required for the handling and storage of the polyurethane grout.

B. Injection of Grout

1. Basic steps for crack or joint repair are as follows:

a. Clean area to be grouted.

b. Drill holes for grout injection.

c. Flush defect with water.

d. Grout injection.

e. Remove injectors.

f. Patch injector holes.

g. Remove excess surface grout.

h. Apply a surface sealer to defect surfaces.

2. Flush the crack to be injected with clean potable water prior to the installation of the grout. Observe the return of the water from the surface of the crack prior to the moving to the next injection port for water flushing. The entire crack must be flushed prior to the injection of polyurethane grout.

3. Pump polyurethane chemical grout for 45 seconds at a pressure not to exceed 250 psi and then pause to allow the material to flow into all of the cracks and crevices. Watch for material flow and water movement to appear on the concrete surface. When the surface movement stops, begin injection into the next packer. When sealing vertical cracks, begin injecting at the bottom of the crack and work vertically. If faster reaction time is needed, or if grout is being pumped at cold temperature, an accelerant may be added to the base material. Consult manufacturer before adding an Accelerator. If leakage is observed, re-inject to assure that all voids are properly sealed.

## 3.3 CLEAN UP

A. Completely flush pump and hoses with polyurethane chemical grout pump flush. Use sharp-sided tool such as putty knife or trowel to remove excess material from walls, and floors. Wait for material to cure before removing. May be sanded off if necessary. All solvent and cured grout shall be removed from the Work site and disposed of in accordance with all regulatory requirements.

B. The uncured polyurethane chemical grout can be cleaned from tools with an approved solvent. The cured polyurethane chemical grout can only be removed mechanically.

C. Leave finished work and work area in a neat, clean condition without evidence of spillovers onto adjacent areas.

D. The grout shall not be allowed to seal the High Pressure Relief (HPR) ports. If grout fills the HPR ports, the Contractor shall clean out the sealed HPR as directed by the Contracting Officer Representative.

END OF SECTION

**SECTION 07841**

**FIRESTOPPING**

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for perimeter fire containment systems and specifies through-penetration firestop systems for penetrations through the following fire-resistance-rated assemblies:

1. Floors.
2. Roofs.
3. Walls and partitions.
4. Construction enclosing compartmentalized areas.
5. Smoke barriers.

1.2 RELATED REQUIREMENTS

A. Section 03300.

B. Division 15 Sections specifying duct and piping penetrations.

C. Division 16 Sections specifying cable and conduit penetrations.

1.3 REFERENCES

A. Comply with codes and regulations of the Jurisdictional Authorities.

B. ASTM E 84, E 814.

C. UL - 1479.

1.4 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each.

B. Product Data: For each type of through-penetration firestop system product indicated.

C. Shop Drawings: For each through-penetration firestop system, show each kind of construction condition penetrated, relationships to adjoining construction, and kind of penetrating item. Include firestop design designation of testing and inspecting agency acceptable to Authorities Having Jurisdiction that evidences compliance with requirements for each condition indicated.

1. Submit documentation, including illustrations, from a qualified testing and inspecting agency that is applicable to each through-penetration firestop system configuration for construction and penetrating items.

D. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

E. Certification: Signed by manufacturers of through-penetration firestop system products certifying that products furnished comply with requirements.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who has completed through-penetration firestop systems similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.Source Limitations: Obtain through-penetration firestop systems, for each kind of penetration and construction condition indicated, from a single manufacturer.

C. Fire-Test-Response Characteristics: Provide through-penetration firestop systems that comply with the following requirements and those specified in "Performance Requirements" Article:

1. Through-penetration firestop systems are identical to those tested in accordance with ASTM E 814. Provide rated systems complying with the following requirements:

a. Through-penetration firestop system products bear classification marking of qualified testing and inspecting agency.

b. Through-penetration firestop systems correspond to UL in Fire Resistance Directory reference to through-penetration firestop system.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver through-penetration firestop system products to Project site in original, unopened containers or packages with intact and legible manufacturers' labels identifying product and manufacturer; date of manufacture; lot number; shelf life, if applicable; qualified testing and inspecting agency's classification marking applicable to Project; curing time; and mixing instructions for multicomponent materials.

B. Store and handle materials for through-penetration firestop systems to prevent their deterioration or damage due to moisture, temperature changes, contaminants, or other causes.

**PART 2 – PRODUCTS**

2.1 PERFORMANCE REQUIREMENTS

A. General: For the following constructions, provide through-penetration firestop systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of assembly penetrated.

1. Fire-resistance-rated non-load-bearing walls, including partitions, with fire-protection-rated openings.

2. Fire-resistance-rated floor assemblies

3. Fire-resistance-rated roof assemblies.

B. F-Rated Systems: Provide through-penetration firestop systems with F-ratings indicated, as determined in accordance with ASTM E 814, but not less than that equaling or exceeding fire-resistance rating of constructions penetrated.

C. T-Rated Systems: For the following conditions, provide through-penetration firestop systems with T-ratings indicated, as well as F-ratings, as determined in accordance with ASTM E 814, where systems protect penetrating items exposed to potential contact with adjacent materials in occupiable floor areas.

1. Penetrations located outside wall cavities.

2. Penetrations located in construction containing fire-protection-rated openings.

D. For through-penetration firestop systems exposed to view, traffic, moisture, and physical damage, provide products that after curing do not deteriorate when exposed to these conditions both during and after construction.

1. For piping penetrations provide moisture-resistant through-penetration firestop systems.

2. For floor penetrations with annular spaces exceeding 4 inches in width and exposed to possible loading and traffic, provide firestop systems capable of supporting floor loads involved either by installing floor plates or by other means.

E. For through-penetration firestop systems exposed to view, provide products with flame-spread ratings of less than 25 and smoke-developed ratings of less than 450, as determined per ASTM E 84.

2.2 SITE CONDITIONS

A. Environmental Limitations: Do not install through-penetration firestop systems when ambient or substrate temperatures are outside limits permitted by through-penetration firestop system manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.

B. Ventilate through-penetration firestop systems in accordance with manufacturer's written instructions by natural means or where this is inadequate, forced-air circulation.

2.3 COORDINATION

A. Coordinate construction of openings and penetrating items to ensure that through-penetration firestop systems are installed according to specified requirements.

B. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate through-penetration firestop systems.Do not cover up through-penetration firestop system installations that will become concealed behind other construction until the Contracting Officer Representative has examined each installation.

**PART 3 – EXECUTION**

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Cleaning: Clean out openings immediately before installing through-penetration firestop systems to comply with written recommendations of firestop system manufacturer and the following requirements:

1. Remove from surfaces of opening substrates and from penetrating items foreign materials that could interfere with adhesion of through-penetration firestop systems.

2. Clean opening substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with through-penetration firestop systems. Remove loose particles remaining from cleaning operation.

3. Remove laitance and form-release agents from concrete.

B. Priming: Prime substrates where recommended in writing by through-penetration firestop system manufacturer using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.

C. Masking Tape: Use masking tape to prevent through-penetration firestop systems from contacting adjoining surfaces that will remain exposed on completion of Work and that would otherwise be permanently stained or damaged by such contact or by cleaning methods used to remove smears from firestop system materials. Remove tape as soon as possible without disturbing firestop system's seal with substrates.

3.3 THROUGH-PENETRATION FIRESTOP SYSTEM INSTALLATION

A. General: Install through-penetration firestop systems to comply with "Performance Requirements" Article and firestop system manufacturer's written installation instructions and published drawings for products and applications indicated.

B. Install forming/damming/backing materials and other accessories of types required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire ratings indicated.

C. Install fill materials for firestop systems by proven techniques to produce the following results:

1. Fill voids and cavities formed by openings, forming materials, accessories, and penetrating items as required achieving fire-resistance ratings indicated.

2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.

3. For fill materials that will remain exposed after completing Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

3.4 FIELD QUALITY CONTROL

A. Where deficiencies are found, repair or replace through-penetration firestop systems so they comply with requirements.

3.5 IDENTIFICATION

A. In areas not exposed to public view, identify through-penetration firestop systems with pressure-sensitive, self-adhesive, preprinted vinyl labels. Attach labels permanently to surfaces of penetrated construction on both sides of each firestop system installation where labels will be visible to anyone seeking to remove penetrating items or firestop systems. Include the following information on labels:

1. The words: "Warning--Through-Penetration Firestop System--Do Not Disturb."

3.6 CLEANING AND PROTECTION

A. Clean off excess fill materials adjacent to openings as Work progresses by methods and with cleaning materials that are approved in writing by through-penetration firestop system manufacturers and that do not damage materials in which openings occur.

B. Provide final protection and maintain conditions during and after installation that ensure through-penetration firestop systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated through-penetration firestop systems immediately and install new materials to produce through-penetration firestop systems complying with specified requirements.

3.7 THROUGH-PENETRATION FIRESTOP SYSTEM SCHEDULE

A. Where UL-classified systems are indicated, they refer to the alpha-alpha-numeric designations listed in UL's "Fire Resistance Directory" under product Category XHEZ.

B. Firestop Systems for Metallic and Non-metallic Conduit, Tubing, Sleeves, Cable Trays and Cables:

1. UL-1479: Fire rated for 3 hours.

2. Type of fill materials: One or more of the following:

a. Silicone sealant.

b. Intumescent putty.

c. Silicone foam.

C. Firestop Systems for Ductwork: Comply with the following:

1. UL- 1479: WJ7007.

1. Type of Fill Materials: Intumescent sealant.

END OF SECTION

# SECTION 08110

# HOLLOW METAL DOORS AND FRAMES

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for providing hollow metal doors and frames.

1.2 RELATED REQUIREMENTS

A. Finish hardware: Section 08710, FINISH HARDWARE.

B. Glass and glazing: Section 08800.

C. Field painting: Section 09920.

1.3 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each.

1. Shop Drawings

a. Details of construction, connections, anchors, schedules, setting diagrams and interface with work of other trades.

b. Schedule of doors and frames using the same reference numbers for details and openings as those on the Contract Documents.

2. Certification.

1.4 REFERENCES

A. Comply with codes and regulations of the Jurisdictional Authorities.

B. NFPA: 80 (Standard for Fire Doors and Fire Windows).

C. UL: Building Materials Directory.

D. NAAMM: Standards HMMA 861 and 862.

E. SDI: 100.

F. FS: TT-F-322.

G. ASTM: A153, A366, A526, A569, A780, C236, C976.

H. DHI (Door and Hardware Institute): A115, Recommended Locations for Builder's Hardware.

I. ADA (Americans with Disabilities Act).

J. Fire-Rated Assemblies: Where UL-listing, UL-label or UL Building Materials Directory is specified, another testing and inspection agency acceptable to the Contracting Officer Representative and to Authorities Having Jurisdiction may be used.

1.5 PRODUCT, DELIVERY, STORAGE AND HANDLING

A. Deliver products to the jobsite in original unopened containers or wrappings clearly labeled with manufacturer's name and brand designation, door schedule number, referenced specification number, type, class, and rating as applicable.

B. Store products in an approved dry area, protect from contact with soil and from exposure to the elements.

C. Handle products so as to prevent breakage of containers and damage to products.

**PART 2 – PRODUCTS**

2.1 MATERIALS

A. Hot-Rolled Steel Sheets and Strip: Commercial quality carbon steel pickled and oiled, complying with ASTM A569, free of scale, pitting or surface defects.

B. Cold-Rolled Steel Sheets: Commercial quality, level, carbon steel, complying with ASTM A366.

C. Galvanized Steel Sheets: Zinc-coated carbon steel sheets of commercial quality, complying with ASTM A526, G60 zinc coating, mill phosphatized.

D. Shop-Applied Primer: Rust-inhibitive baked-on primer, suitable as base for specified finish paint systems.

E. Finish Paint Systems: Section 09920.

F. Supports and Anchors: Sheet steel, gauge in accordance with HMMA reference standards, unless specified otherwise. After fabricating, galvanize units to be built into or attached to exterior walls, wet areas such as doors to toilet rooms and janitor’s room, or attached to slabs on grade; complying with ASTM A153, Class B.

G. Inserts, Bolts and Fasteners: Manufacturer’s standard units unless specified otherwise. Hot-dip galvanized items to be used in exterior walls, wet areas such as doors to toilet rooms and janitor’s rooms, or attached to slabs on grade; complying with ASTM A153, Class C or D as applicable.

H. Metallic Filler: FS TT-F-322.

I. Galvanizing Repair Compound: Stick form, melting point 600 degrees F to 650 degrees F, GALVABAR or approved equal.

2.2 FABRICATION

A. GENERAL

1. Fabricate hollow metal door and frame units to be rigid, neat in appearance, and free from defects, warp or buckle. Wherever practicable, fit and assemble units in manufacturer’s plant. Clearly identify work that cannot be permanently factory-assembled before shipment, to ensure proper assembly at project site.

2. Galvanize exterior door and frame assemblies, and wet area door and frame assemblies such as at toilet room and janitor’s room; including but not limited to face sheets, reinforcements, closures, dust covers, mortar shields, glazing and louver beads, clips, anchor bolts, screws, rivets and welds.

3. Exposed fasteners are not allowed on door frames and door faces; elsewhere, provide countersunk flat Philips heads for exposed screws and bolts.

4. Door Hardware Preparation

   a. Prepare and reinforce doors and frames to receive mortised and concealed hardware in accordance with final Hardware Schedule and templates provided by hardware supplier. Comply with applicable requirements of DHI A115-series, Steel Door Prep Standards, for door and frame preparation for hardware.

   b. Reinforce doors and frames to receive surface-applied hardware. Drilling and tapping for surface-applied hardware may be done at project site.

   c. Locate hardware as indicated on approved shop drawings or, if not indicated, in accordance with ADA requirements pertaining to operating hardware locations, and the Recommended Locations for Builder's Hardware, published by the DHI.

5. Shop Painting

   a. Clean, treat and paint exposed surfaces of steel door and frame units, including galvanized surfaces.

   b. Chemically clean steel surfaces of mill scale, rust, oil, grease, dirt and other foreign materials before application of paint.

   c. Apply phosphate conversion pretreatment coating.

   d. Apply shop coat of prime paint of even consistency to provide a uniformly finished surface ready to receive finish paint. Apply primer immediately after surface preparation and pretreatment.

6. Insulated Metal Assemblies: Where schedules, provide doors and frames fabricated as thermal-insulating assemblies and tested according to ASTM C236 or ASTM C976.

## 2.3 FRAMES

A. General

1. Fabricate frames to uniform profile as shown of full-welded unit construction, with corners mitered and reinforced. Continuously weld full depth and width of frame, except for knock-down frames.

2. Mullions and Transom Bars: Provide closed or tubular mullions and transom bars where indicated.

   a. Fasten mullions and transom bars at crossings and to jambs by butt welding, except for knock-down frames.

   b. Reinforce joints between frame members with concealed clip angles or sleeves of the same metal and thickness as frame.

3. Jamb anchors: Provide in accordance with NAAMM Standards HMMA 861 and 862:

   a. Provide T-type anchors or strap-and-stirrup type anchors at new masonry.

   b. Provide Z-type anchors at metal stud partitions.

   c. Provide bolt-type anchors with pipe spacers at in-place construction.

4. Floor anchors: Provide floor anchors for each jamb and mullion that extends to floor, formed of galvanized steel sheet, as follows:

    a. Monolithic concrete slabs: Clip-type anchors, with two holes to receive fasteners, welded to bottom of jambs and mullions.

    b. Separate topping concrete slabs: Adjustable type with extension clips, allowing not less than 2-inch height adjustment. Terminate bottom of frames at finish floor surface.

5. Head anchors: Provide two anchors at head of frames exceeding 42 inches wide for frames mounted in steel stud walls.

6. Head strut supports

    a. Provide 3/8-inch by 2-inch vertical steel struts extending from top of frame at each jamb to supporting construction above, unless frame is anchored to masonry or to other structural support at each jamb.

    b. Bend top of struts to provide flush contact for securing to supporting construction above.

    c. Provide adjustable bolted anchorage to frame jamb members.

7. Structural reinforcing members: Provide structural reinforcing members as a part of frame assembly, where indicated at mullions, transoms or other locations, which are to be built into frame.

8. Spreader bars: Across bottom of welded frames, provide removable spreader bar, tack welded to jambs and mullions.

9. Door silencers

    a. Drill stop to receive three silencers on single door frames and two silencers on double door frames.

    b. Install plastic plugs to keep holes clear during construction.

10. Plaster guards: Provide 18-gauge steel plaster guards or dust-cover boxes (galvanized at exterior locations), welded to frame, at back of hardware cutouts, where mortar or other materials might obstruct hardware installation or operation and to close off interior of openings.

B. Interior Hollow Metal Frames: NAAMM Standard HMMA 861, Guide Specifications for Commercial Hollow Metal Doors and Frames except as follows:

1. Openings over 4 feet wide: 12-gauge.

2. Cart-storage rooms and other doors as indicated: Use security hollow metal frames specified below.

3. Knock-down frames may be used in drywall construction as specified below.

C. Exterior and Security Hollow Metal Frames: NAAMM Standard HMMA 862, Guide Specifications for Security Hollow Metal Doors and Frames, except as follows:

1. Use for exterior doors and for indicated security doors including cart-storage room.

2. Cart-storage-room frame anchors: Hot-dip galvanized anchor bolts, not less than 1/2 inch by 6 inches, inaccessible from the safety walk, eight per frame.

D. Interior Knock-Down Hollow Metal Frames: SDI 100, and as follows:

1. Knock-down frames may be used only in interior drywall construction.

2. Openings 4 feet wide or less: 16-gauge.

3. Openings over 4 feet wide: 12-gauge.

2.4 DOORS

A. Thermal Insulation: Provide exterior doors and panels with internal thermal insulation of extruded polystyrene. Aged R-value of door or panel is to be 5.0 or greater.

B. Interior Hollow Metal Doors: NAAMM Standard HMMA 861, Guide Specifications for Commercial Hollow Metal Doors and Frames except for cart-storage room and other doors as indicated.

C. Exterior and Security Hollow metal Doors: NAAMM Standard HMMA 862, Guide Specifications for Security Hollow Metal Doors and Frames.

1. Use for exterior doors and for indicated security doors including cart-storage room.

2.5 FIRE-DOOR ASSEMBLIES

A. Where fire-rated door and frame assemblies are required for code compliance, or are otherwise indicated, provide door, frame and hardware assemblies in compliance with NFPA 80, which are labeled and listed by UL.

B. Fabrication and assembly requirements necessary to obtain labels will take precedence over requirements shown or specified, except where requirements shown or specified exceed sizes or gauges required for labeling.

C. Where oversized fire doors are required, furnish manufacturer's certification that assembly has been constructed with materials and methods equivalent to labeled construction.

D. Louvers: Equip louvers in fire-rated doors with UL-listed self-closing fire dampers with fusible links.

E. Identify each fire door and frame with permanent UL labels, indicating the applicable fire rating of both the door and the frame. Secure labels to vertical edge of doors and frames where readily visible. Protect labels from painting operations.

2.6 TRANSOM ASSEMBLIES

A. Removable Transom Bar: Formed as shown of same material as frame, with manufacturer's standard bolted connection.

B. Removable Transom Panel: Formed as shown of the same construction as the door or doors below, through-bolted to frame eight inches on-center maximum.

**PART 3 – EXECUTION**

3.1 INSTALLATION

A. Deliver work, ready to set up and erect in place as rapidly as general construction work permits. Set work in place in accordance with approved Shop Drawings, plumb and level, strongly secured against displacement and with built-in anchors. In masonry construction, set frames in advance of masonry work. Limit field-cutting, drilling, and punching to minimum necessary.

B. Anchor metal frames in accordance with NAAMM Standards HMMA 861 and 862.

C. Anchor fire-door assemblies in accordance with NFPA 80.

D. Install doors after masonry work has been completed; accurately fit and adjust to work properly.

E. Maintain installation clearances and tolerances in accordance with NAAMM Standards HMMA 861 and 862.

F. Coat field welds and repair damage to zinc-coated surfaces in accordance with ASTM A780 and as follows:

1. Wire-brush welds and other repair areas to bright metal.

2. Apply galvanizing repair compound at rate of 2 ounces per square foot.

G. Touch-up shop applied primer as recommended by manufacturer for compatibility with finish paint system.

H. Application of finish hardware: Section 08710, FINISH HARDWARE.

I. Glazing materials and installation: Section 08800.

3.2 CLEAN UP

A. Upon completion of installation, clean surfaces of doors and frames as recommended by door manufacturer.

B. Remove from the site rubbish and debris caused by this work.

C. Leave areas surrounding openings in broom-clean condition.

END OF SECTION

# SECTION 08710
# FINISH HARDWARE

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for providing finish hardware.

1.2 RELATED REQUIREMENTS

A. Access Doors and Frames including locks and cylinders: Section 08305.

B. Overhead Coiling Doors: Section 08331.

C. Overhead Coiling Grilles: Section 08334.

D. Cremone bolt to receive lock and chain provided under this section: Section 02877.

E. Hollow Metal Doors and Frames: Section 08110.

F. Aluminum Entrances and Storefronts: Section 08410.

G. Metal Concave Mandoors: Section 08481.

1.3 REFERENCES

A. Comply with codes and regulation of the Jurisdictional Authorities.

B. ANSI/BHMA: A156-Series Standards for Builders Hardware.

C. ASTM: A413

D. FS: *T*T-S-001657.

E. ADA: ADAAG.

F. NFPA: 80, *101, 130.*

G. DHI: Recommended Locations for Builders Hardware for Standard Steel Doors and Frames, Recommended Locations for Builders Hardware for Custom Steel Doors and Frames.

1.4 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each.

1. Shop Drawings

a. Product Data: Manufacturers' technical literature and catalog cuts, edited as necessary to indicate each item of hardware, model, selected options, finish, installation instructions, maintenance of operating parts and finish, and other information necessary to show compliance with requirements. Make coordinated submittal packages complete with all supporting data.

b. Hardware Schedule: Hardware schedule coordinated with doors, frames, gates, and related work to ensure proper size, thickness, hand, function, design, and finish of hardware. Base Hardware Schedule on hardware sets indicated in PART 3 herein.

Indicate complete designations of each item required for each door or opening, including the following information:

(1) Explanation of each abbreviation, symbol, and code contained in hardware schedule. Schedules with unidentified notations will be rejected without review.

(2) Door and frame number, size, and materials.

(3) Type, style, function, size, and finish of each hardware item. Include lockset functions, angle of closer operation, lever and handle designs, lengths of flush bolts, types of stops, sizes of armor and kick plates, and other such data.

(4) Name and manufacturer of each item.

(5) Fastenings and other pertinent information.

(6) Location of each hardware set cross-referenced to indications on Contract Drawings, both on floor plans and in door schedule.

(7) Mounting locations for hardware.

(8) Keying information.

c. Submittal sequence: Submit hardware schedule at earliest possible date particularly where acceptance of hardware schedule must precede fabrication of other work that is critical in the Project construction schedule. Include with hardware schedule the product data, samples, Shop Drawings of work affected by finish hardware, and other information essential to a coordinated review of hardware schedule.

d. Templates: Transmit hardware templates directly to trades fabricating related work specified to be prepared for the installation of finish hardware under this Section. Submit record copy of these transmittals to the Contracting Officer Representative.

e. Coordinating hardware preparation by other trades: Check Shop Drawings of other trades to ensure that correct provisions from transmitted templates are made for locating and installing finish hardware to comply with indicated requirements.

2. Samples

a. Finishes: Two, minimum 4-inch squares of each finish to be furnished. Submit with Shop Drawings.

b. Hardware units: Each type of exposed hardware unit in approved finish and tagged with full description for coordination with hardware schedule. Submit unit samples prior to submission of final hardware schedule.

(1) When requested, samples will be returned to the Supplier. Accepted units that remain undamaged through the Submittal, review, and field-comparison process may, after final check of operation, be used in the Work, within limitations of keying coordination requirements. Submit the following:

(a) One sample of a lockset including, trim, escutcheon, strike box, lever, cylinder, and key.

(b) One sample of hinge.

(c) One sample of each miscellaneous item of finish hardware.

(d) Provide finishes so that color and surface finish or polish of various items of the same designated finish match throughout the Work. Hardware with non-matching finishes will be rejected.

c. The Authority reserves the right to require samples of each specific item to be furnished

3. Certification.

4. Documentation

a. Construction keying schedule.

1.5 QUALITY ASSURANCE

A. Hardware Supplier Qualifications: A recognized architectural finish hardware supplier, with warehousing facilities in the Project's vicinity, that has a record of successful in-service performance for supplying finish hardware similar in quantity, type, and quality to that indicated for this Project and that employs an experienced architectural hardware consultant (AHC) who is available to the Contracting Officer Representative and Contractor, at reasonable times during the course of the Work for consultation.

1. Require supplier to have its AHC develop the hardware schedule.

2. Require supplier's AHC to meet with the Contracting Officer Representative to discuss and finalize lock-functions and keying requirements.

B. Fire-Rated Openings: Provide hardware for fire-rated openings that complies with NFPA 80 and requirements of Authorities Having Jurisdiction. Provide only items of hardware that are listed and are identical to products tested by UL, Warnock Hersey, FM, or other testing and inspecting organization acceptable to authorities having jurisdiction for use on types and sizes of doors indicated in compliance with requirements of fire-rated door and door frame labels.

1. Equip labeled doors with hinges of steel or stainless steel base metal, closers, and automatic latching devices in addition to the hardware requirements in the specified hardware sets.

2. If a conflict appears between this paragraph and the hardware sets scheduled, the requirements of this paragraph shall govern.

C. Americans With Disabilities Act (ADA): Comply with the ADA Accessibility Guidelines (ADAAG).

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver products to jobsite in original unopened packages, clearly labeled with manufacturer's name, brand, specification identification data and identification as shown on approved hardware schedule.

B. Store products in an approved dry area, protect from contact with soil and from exposure to the elements. Keep products dry.

C. Handle products so as to prevent breakage of containers and damage to products.

1.7 MAINTENANCE TOOLS AND INSTRUCTIONS

A. Furnish a complete set of specialized tools and maintenance instructions as needed for the Authority's continued adjustment, maintenance, removal and replacement of hardware.

## PART 2 – PRODUCTS

2.1 HARDWARE TYPES

A. General

1. Hardware grade: Provide only Grade 1 hardware in accordance with ANSI/BHMA A156-Series Standards and with the additional requirements specified in this Section, except where otherwise specified or approved in writing by the Contracting Officer Representative for each specific door number.

2. Fire-rated hardware: Where applied to fire-rated labeled doors and frames, provide fire-rated listed hardware, tested by a fire-rating testing agency acceptable to Authorities Having Jurisdiction.

3. Finishes: Finish designations are ANSI/BHMA A156.18 standards and are subject to approval for color, texture, and appearance.

a. Finish 630 (Formerly US 32D): Except where otherwise indicated, provide finish 630, satin-polish stainless steel on stainless steel base metal, matching sample on file with the Contracting Officer Representative.

b. Finish 626 (Formerly US 26D): Where indicated, provide finish 626, satin-polish chromium plated over nickel on brass or bronze base metal, matching finish 630 as specified above.

c. Finish 628 (Formerly US 28): Where indicated, provide finish 628, satin-polish aluminum clear anodized over aluminum base metal.

d. Finish 652 (Formerly US 26D): Where indicated, provide finish 652, satin-polish chromium plated over nickel on steel base metal, matching finish 630 as specified above.

e. Finish 719 (Formerly US27): Mill finish aluminum uncoated.

f. Finish 613 (Formerly US10B): Where indicated, provide finish 613, satin-finish statuary bronze.

g. Finish 630 may be substituted for Finish 626 or Finish 652 at no additional cost to the Authority.

4. Single Source: Obtain each type of hardware from a single manufacturer.

B. Hinges: ANSI/BHMA A156.1, full mortise butt hinges, anti-friction bearings, button tips (not flush), unless otherwise specified for each specific door number. Extruded butts may be used in lieu of wrought butts.

1. Quantity required per door leaf

a. Doors 61 inches to 90 inches in height: 1-1/2 pairs.

b. Doors 91 inches to 120 inches in height: Two pairs.

2. Types

a. Exterior doors, doors from public passageways, and doors to wet areas such as showers: Stainless steel butts, Type A5111, finish 630.

b. Interior, non-public doors: Steel butts, Type A811*1* (Grade *1*), Finish 652.

c. Doors with reverse-bevel swing (out-swinging) having locks: fit butts with non-removable pins effective when door is in closed position.

C. Locksets

D. Hollow metal doors: ANSI/BHMA A156.13, full mortise, adjustable armored front, 3/4-inch-throw anti-friction latch bolt, one-inch-throw stainless steel deadbolt, Finish 630, Function as scheduled.

1. Trim design

a. Cast lever handles, recurving to within 1/2 inch of door face, equal in appearance and dimensions to one of the following unless otherwise scheduled:

| Series | Design | Producer |
|---|---|---|
| ML2200 Series | Newport NSA | Corbin/Russwin |
| 8200 Series | KD rose, L lever | Sargent |
| 8700 Series | PB lever, YK rose | Yale |

b. Finish: 630 unless otherwise scheduled.

c. Roses: Concealed screw or screwless, 2-1/4-inch diameter.

d. Cylinder trim: Equip with flush or security-beveled solid cylinder collar as appropriate for flush or projecting cylinder.

2. Aluminum doors in Yard Buildings

a. Finish: 630 unless otherwise scheduled.

E. Cylinders and Keying for all doors except aluminum doors in Parking Structures: Match the Authority's existing keying and interchangeable core system as follows and at no additional cost to the Authority.

1. Cylinders: Finish 630.

a. For locksets: ANSI/BHMA A156.5, interchangeable-core type, designed to accept the Authority's existing Russwin Recore System. One core furnished for each lock, stamped with visual key control.

b. High security: Interlocking-pin type, Emhart High-Security Locking System or approved equal.

c. Construction cores: Provide construction cylinders until final cylinders and keying is approved and installed.

2. Keys and keying

a. Keys: Stamped with the inscription TRANSIT AUTHORITY-DO NOT DUPLICATE and with visual key-control data.

b. Quantity: Three keys for each core plus blanks equal to 10 percent of total keys furnished.

3. Key tags and holders: ANSI/BHMA A156.5, inscribed with key-change number and key-control symbol.

F. Push Plates and Door Pulls: ANSI/BHMA A156.6, Finish 630, with the following additional requirements:

1. Push plate: 3/16 inch by 10 inches by 20 inches unless otherwise shown, with edges beveled.

2. Door pull: 3/4-inch round bar, 8 inches center-to-center, concealed fasteners; escutcheon plate same as push plate.

G. Door Closers: ANSI/BHMA A156.4, Type C02xx1 (xx - indicates top-of-door-mounted, on interior side), Finish 630.

1. Surface-mounted.

2. Sweep period: Adjusted so that from an open position of 70 degrees, the door will take at least 3 seconds to move to a point 3 inches from the latch, measured to the leading edge of the door.

3. Cover plate: Full metal cover, Finish 630.

4. Parallel arms and drop brackets: Provide as necessary for mounting on interior side unless otherwise noted. Where hold-open feature is specified for closers, use type that permits doors to open 140 degrees, other conditions permitting.

5. Maximum force for pushing or pulling open a door with closer (measured with a push-pull scale applied perpendicular to the door at the door opener or 30 inches from the hinged side, whichever is farther from the hinge):

a. Fire doors: Minimum opening force allowable by the Jurisdictional Authorities.

b. Interior hinged doors: 5 lbf.

H. Stops

1. Overhead-type: ANSI/BHMA A156.8, Type C54511 holder/stop; holder deactivated on labeled doors, Finish 630.

2. Wall-type: ANSI/BHMA A156.16, Type L02101, with vandal-resistant concealed fasteners, Finish 630. Use floor-type where wall-type is not practicable.

3. Floor-type: ANSI/BHMA A156.16, Type L02141 or L02161 as necessary, with matching extender if necessary to properly engage door bottom, Finish 630.

I. Flush Extension Bolts: ANSI/BHMA A156.8, Type L04081, Finish 630.

1. Dustproof strikes, Type L04021, provided for bolts located at bottom of door leaf, except where metal thresholds are specified. Cut opening to suit bolt.

2. Operating mechanism located approximately six feet from floor for top bolts and approximately 12 inches from floor for bottom bolts.

3. Bolts located in edge of inactive leaf of pair of doors.

4. Automatic Flush Bolts: Listed for 1-1/2-hour, B-labeled, Finish 630; Ives No. 559 or approved equal with strikes; with coordinator where recommended by manufacturer.

J. Silencers: ANSI/BHMA A156.16, Type L03011. Provide silencers for each door.

1. Three for each single door.

2. Two for each pair of doors.

K. Exit Devices: ANSI/BHMA A156.3; complying with NFPA 80, listed and labeled by a testing and inspecting agency acceptable to Authorities Having Jurisdiction; lever trim as required for locksets; Finish 630.

1. Single door: Function F03 (mortise); latch bolt by push on crossbar inside and by key from outside; operation from outside is by lever.

2. Double door: Active leaf Function F03 as above, inactive leaf (manual flush bolts) without outside trim.

3. Maximum pushing force to operate exit device

a. Fire doors: Minimum opening force allowable by the jurisdictional authorities.

b. Interior hinged doors: 5 lbf.

4. Coordinators: ANSI/BHMA A156.3.

L. Metal Thresholds: ANSI/BHMA A156.21; profiles as shown for each location; ADA compliant; metal thickness 0.125 inch; maximum height 5/16 inch; with countersunk matching screws.

1. Public passageways and mezzanines: Finish 630, stainless steel with abrasive finish or Finish 613, satin-finish statuary bronze.

2. Other locations: Finish 719, mill finish aluminum with grooves.

M. Weather Stripping/Smoke *Seals*: ANSI/BHMA A156.22, Finish 628 (satin aluminum clear anodized) with stainless steel sheet-metal screws and as follows:

1. Head and jamb: Head and jamb type, stop-applied; National Guard *A626* or equal. Provide nylon brush gasketing or approved equal.

2. Sill: Drip strip at sill; National Guard 15 or approved equal.

3. Sweep: Door sweep type, surface mounted at bottom of door; National Guard D608 nylon brush gasketing or approved equal. Provide sweep in addition to drip strip where scheduled.

4. Astragals: Provide nylon brush overlapping type: National Guard 600 or approved equal.

N. Chain: ASTM A413, Class PT, case-hardened, carbon-steel security chain, 3/8-inch diameter.

O. Padlock: Interchangeable-core type padlock, designed to accept the Authority's existing Russwin Recore System.

1. One core furnished for each lock, stamped with visual key control; with two keys, keyed and master-keyed as directed.

2. Body: Solid extruded brass.

3. Five-pin tumblers.

4. Shackle: Hardened steel, zinc-plated, 1-3/4 inch opening height, self-locking spring-type.

P. Deadlock: ANSI/BHMA A156.5 mortise dead lock, Grade 2 (1/2-inch minimum throw) with interchangeable-core cylinder; operation as scheduled.

Q. Authority-Furnished Property:

1. Cross-bar lock: High-security locking bar with surface-mounted keepers, inside knob and high-security cylinder.

2.2 FASTENINGS

A. Provide hardware complete with screws, through-bolts and other fasteners of suitable type for secure anchorage to construction materials.

B. Screws, through-bolts and other fasteners having spanner-type heads: As approved.

C. Provide fasteners that harmonize in material, color and texture with finished appearance of hardware items.

D. Provide concealed fastenings with door pull, flush pulls, wall door stops and other such items.

E. Provide spanner-head through-bolts and hex bolts as applicable for surface-mounted hardware.

F. Sheet-metal screws and self-tapping screws are prohibited except where specified.

2.3 TEMPLATES

A. Furnish templates of hardware to other trades, so that doors, frames, and gates can be cut, reinforced and otherwise prepared in the shop for installation of finish hardware.

2.4 THRESHOLD SEALANT

A. Butyl: Polymerized butyl rubber and inert fillers (pigments), solvent-based with minimum 75 percent solids, non-sag consistency, tack-free time of 24 hours or less, paintable, non-staining, and complying with FS TT-S-001657.

**PART 3 – EXECUTION**

3.1 INSTALLATION

A. General

1. Coordinate work of this Section with work of other trades.

2. Install each hardware item in compliance with the manufacturer's instructions and recommendations.

3. Apply finish hardware in a neat and workmanlike manner. Set units level, plumb, and true to line and location. Adjust and reinforce the attachment substrate as necessary for proper installation and operation.

4. Cut mortises neat, clean and of proper net size. Drill and countersink units that are not factory prepared for anchorage fasteners. Space fasteners and anchors in accordance with industry standards.

5. Where cutting and fitting is required to install hardware onto or into surfaces that are later to be painted or finished in another way, coordinate removal, storage, and reinstallation or application of surface protection with finishing work specified in other Sections. Do not install surface-mounted items until finishes have been completed on the substrates involved.

6. Provide keying in accordance with keying schedule prepared by and for the Contractor in accordance with the Authority’s keying system. Deliver keying schedule and keys to the Contracting Officer Representative prior to Final Acceptance.

B. Mounting Heights: Mount hardware units at heights indicated in the following publications, except as specifically indicated or required to comply with governing regulations and except as otherwise directed by the Contracting Officer Representative:

1. Recommended Locations for Builders Hardware for Standard Steel Doors and Frames by DHI.

2. Recommended Locations for Builders Hardware for Custom Steel Doors and Frames by DHI.

3. ADA Accessibility Guidelines (ADAAG).

C. Exterior Thresholds: Set thresholds for exterior doors in full bed of specified butyl sealant.

D. Weatherstripping/Smoke Seals: Install weatherstripping around entire perimeter of door frame to form a complete seal and in accordance with manufacturer's instructions.

1. Position and install head and jamb weatherstripping so that door closes snugly against seal but does not inhibit latching of lockset.

2. Position and install sill weatherstripping to seal snugly against threshold without inhibiting latching of lockset.

3. Note that at fire-rated doors, lockset is to latch by closer operation only, without manual assistance.

E. Adjustment: Adjust hardware to operate as designed and replace hardware that is missing, scratched, marred, or otherwise damaged.

1. Adjust and check each operating item of hardware and each door to ensure proper operation or function of every unit. Replace units that cannot be adjusted to operate freely and smoothly or as intended for the application made.

2. Where door hardware is installed more than one month prior to acceptance or occupancy of a space or area, return to the installation during the week prior to acceptance or occupancy and make final check and adjustment of hardware items in such space or area. Clean operating items as necessary to restore proper function and finish of hardware and doors. Adjust door control devices to compensate for final operation of heating and ventilating equipment.

3. Clean adjacent surfaces soiled by hardware installation.

F. Instruction: At a time prescribed by the Contracting Officer Representative, have the hardware installer or knowledgeable operating-hardware-manufacturers' representatives instruct the Authority's personnel in the proper adjustment and maintenance of hardware and hardware finishes.

3.2 CLEAN-UP

A. Remove from the site rubbish and debris caused by this work.

B. Leave areas surrounding doors in broom-clean condition.

3.3 HARDWARE SETS

A. Hardware Sets

1. Provide hardware sets in accordance with door schedule and the following set schedule.

2. Provide the number of pairs of butt hinges in accordance with previously specified requirements.

3. Designations used to describe hardware items by using a manufacturer's product name and number are for the purpose of describing a general level of quality and function. Products that are equal, complying with the requirements specified in this section may be used.

| **SET NO. 1** | |
|---|---|
| **Quantity** | **Hardware** |
| Previously Specified | Butt Hinges, 4-1/2 by 4-1/2 |
| 1 Each | Lockset, Function F09 |
| 1 Each | Door Closer |
| 1 Each | Wall-Type Stop |
| 1 Each | Metal Threshold |

| **SET NO. 2** | |
|---|---|
| **Quantity** | **Hardware** |
| Previously Specified | Butt Hinges, 4-1/2 by 4-1/2 |
| 1 Each | Lockset, Function F07 |
| 1 Each | Door Closer |
| 1 Each | Wall-Type Stop |

| **SET NO. 3** | |
|---|---|
| **Quantity** | **Hardware** |
| As Necessary | Lock Cylinders (Provide proper cam to engage lock mechanism by other trade.) |

| **SET NO. 4** | |
|---|---|
| **Quantity** | **Hardware** |
| 1 Each | Deadlock, E06082 |

| SET NO. 5 | |
|---|---|
| **Quantity** | **Hardware** |
| Previously Specified | Butt Hinges, 4-1/2 by 4-1/2 |
| 1 Each | Latchset, Function F01 |
| 1 Each | Door Closer |
| 1 Each | Wall-Type Stop |

| SET NO. 6 | |
|---|---|
| **Quantity** | **Hardware** |
| Previously Specified | Butt Hinges, 4-1/2 by 4-1/2 |
| 1 Each | Exit Device, Function F03 |
| 1 Each | Door Closer |
| 1 Each | Wall-Type Stop |

| SET NO.7 | |
|---|---|
| **Quantity** | **Hardware** |
| Previously Specified | Butt Hinges, 4-1/2 by 4-1/2 |
| 1 Each | Lockset, Function F13 |
| 1 Each | Door Closer with Hold-Open |
| 1 Each | Wall-Type Stop |
| 1 Each | Cross-Bar Lock |

| SET NO. 8 | |
|---|---|
| **Quantity** | **Hardware** |
| Previously Specified | Butt Hinges, 4-1/2 by 4-1/2 |
| 1 Each | Lockset, Function F07 |
| 2 Each | Door Closer |
| 2 Each | Wall-Type or Floor-Type Stop |
| 2 Each | Automatic Flush Bolt |
| 1 Each | Coordinator |

| SET NO. 9 | |
|---|---|
| **Quantity** | **Hardware** |
| Previously Specified | Butt Hinges, 4-1/2 by 4-1/2 |
| 1 Each | Lockset, Function F07 |
| 2 Each | Door Closer |
| 2 Each | Overhead-Type Stop |
| 1 Each | Metal Threshold |
| 2 Each | Automatic Flush Bolt |
| 1 Each | Coordinator |
| 1 Set | Weatherstripping |

| SET NO. 10 | |
|---|---|
| **Quantity** | **Hardware** |
| Previously Specified | Butt Hinges, 4-1/2 by 4-1/2 |
| 2 Each | Door Pulls |
| 2 Each | Door Closer with Hold-Open |
| 2 Each | Wall-Type or Floor-Type Stop, As Necessary |

| SET NO. 11 | |
|---|---|
| **Quantity** | **Hardware** |
| Previously Specified | Butt Hinges, 4-1/2 by 4-1/2 |
| 1 Each | Lockset, Function F09 |
| 2 Each | Door Closer |
| 1 Each | Wall-Type Stop |
| 1 Each | Metal Threshold |
| 2 Each | Automatic Flush Bolt |
| 1 Each | Coordinator |

| SET NO. 12 | |
|---|---|
| **Quantity** | **Hardware** |
| Previously Specified | Butt Hinges, 4-1/2 by 4-1/2 |
| 1 Each | Lockset, Function F07 |
| 1 Each | Door Closer |
| 1 Each | Overhead-Type Stop |
| 1 Each | Metal Threshold |
| 1 Set | Weatherstripping |

| SET NO. 13 | |
|---|---|
| **Quantity** | **Hardware** |
| Previously Specified | Butt Hinges, 4-1/2 by 4-1/2 |
| 1 Each | Lockset, Function F14 |
| 1 Each | Door Closer |
| 1 Each | Overhead-Type Stop |
| 1 Each | Metal Threshold |
| 1 Set | Weatherstripping |

END OF SECTION

# SECTION 10200

# METAL LOUVERS

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for providing fixed, extruded aluminum, and formed-metal louvers, blank-off panels, and accessories.

1.2 RELATED REQUIREMENTS

A. Seals and Sealants: Section 07900.

B. Metal Doors and Frames: Section 08110.

C. Field Painting: Section 09920.

1.3 REFERENCES

A. Codes and regulations of the Jurisdictional Authorities.

B. AAMA: 603.8, 605.2, 607.1.

C. AMCA: 500, 501.

D. ASTM: A653, a780, B26, B209, B221, C612, D1187.

E. AWS: D1.2, D1.3.

F. NAAMM: Metal Finishes Manual for Architectural and Metal Products.

G. SMACNA: Architectural Sheet Metal Manual.

H. SSPC: Paint 12.Codes, Regulations, Reference Standards and Specifications:

1.4 DEFINITIONS

A. Louver Terminology: Definitions of terms for metal louvers contained in AMCA 501 apply to this Section, unless otherwise defined in this Section or in referenced standards.

B. Standard Free Area: Free area of a louver 48 inches wide by 48 inches high, identical to that provided.Maximum Standard Airflow: Airflow at point of beginning water penetration through a louver 48 inches wide by 48 inches high, identical to that provided.Drainable-Blade Louver: Louver designed to collect and drain water to exterior at sill by means of gutters in front edges of blades and channels in jambs and mullions.

1.5 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each.

1. Product Data: For each type of product specified provides manufacturer's printed product information.

2. Shop Drawings: For louver units and accessories. Include plans; elevations; sections; and details showing profiles, angles, and spacing of louver blades. Show unit dimensions related to wall openings and construction; free area for each size indicated; profiles of frames at jambs, heads, and sills; and anchorage details and locations.

a. For installed louvers and vents indicated to comply with design loadings, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

3. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for units with factory-applied color finishes.

4. Samples for Verification: Of each type of metal finish required, prepared on Samples of same thickness and material indicated for final Work. Where finishes involve normal color and texture variations, include Sample sets showing the full range of variations expected.

5. Product Certificates: Signed by manufacturers of louvers certifying that the products furnished comply with requirements and are licensed to bear the AMCA seal based on tests made according to AMCA 500 and complying with AMCA's Certified Ratings Program.

1.6 QUALITY ASSURANCE

A. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of kind indicated. Engineering services are defined as those performed for installations of louvers that are similar to those indicated for this Project in material, design, and extent.

B. Source Limitations: Obtain louvers and vents through one source from a single manufacturer where alike in one or more respects regarding type, design, or factory-applied color finish. Welding Standards: As follows:

1. Comply with AWS D1.2, "Structural Welding Code--Aluminum."

2. Comply with AWS D1.3, “Structural Welding Code–Sheet Steel.” Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone re-certification.

C. SMACNA Standard: Comply with SMACNA's "Architectural Sheet Metal Manual" recommendations for fabrication, construction details, and installation procedures.

1.7 SITE CONDITIONS

A. Field Measurements: Verify louver openings by field measurements before fabrication and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.

1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish opening dimensions and proceed with fabricating louvers without field measurements. Coordinate construction to ensure that actual opening dimensions correspond to established dimensions.

**PART 2 – PRODUCTS**

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance: Provide exterior metal louvers capable of withstanding the effects of loads and stresses from wind and normal thermal movement without evidencing permanent deformation of louver components including blades, frames, and supports; noise or metal fatigue caused by louver blade rattle or flutter; or permanent damage to fasteners and anchors.

1. Wind Load: Uniform pressure (velocity pressure) of 20 lbf/sqft., acting inward or outward.

2. Thermal Movements: Provide louvers that allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, and other detrimental effects:

B. Temperature Change (Range): 120 degrees F, ambient; 180 degrees F, material surfaces. Air-Performance, Water-Penetration, and Air-Leakage Ratings: Provide louvers complying with performance requirements indicated, as demonstrated by testing manufacturer's stock units 48 inches wide by 48 inches high. Test units according to AMCA 500.

1. Perform testing on unpainted, cleaned, degreased units.

2. Perform water-penetration testing on louvers without screens.

2.2 MATERIALS

A. Aluminum Extrusions: ASTM B221, alloy 6063-T5 or T-52

B. Aluminum Sheet: ASTM B209, alloy 3003 or 5005 with temper as required for forming, or as otherwise recommended by metal producer for required finish

C. Aluminum Castings: ASTM B26/B26M, alloy 319.

D. Galvanized Sheet Steel: ASTM A653/A653M, G90 zinc coating, mill phosphatized.

E. Fasteners: Of same basic metal and alloy as fastened metal or 300 series stainless steel, unless otherwise indicated. Do not use metals that are incompatible with joined materials.

1. Use types and sizes to suit unit installation conditions.

2. Use Phillips flat-head screws for exposed fasteners, unless otherwise indicated.

F. Anchors and Inserts: Of type, size, and material required for loading and installation indicated. Use nonferrous metal or hot-dip galvanized anchors and inserts for exterior installations and elsewhere as needed for corrosion resistance. Use toothed steel or expansion bolt devices for drilled-in-place anchors.

G. Bituminous Paint: Cold-applied asphalt mastic complying with SSPC-Paint 12 but containing no asbestos fibers, or cold-applied asphalt emulsion complying with ASTM D1187.

2.3 FABRICATION

A. Assemble louvers in factory to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

B. Continuous Vertical Assemblies: Where height of louver units exceeds fabrication and handling limitations, fabricate units to permit field-bolted assembly with close-fitting joints in jambs and mullions, reinforced with splice plates and without interrupting blade-spacing pattern. Maintain equal louver blade spacing to produce uniform appearance.

C. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining materials' tolerances, and perimeter sealant joints.

D. Include supports, anchorages, and accessories required for complete assembly. Provide vertical mullions of type and at spacings indicated, but not more than recommended by manufacturer, or 72 inches o.c., whichever is less. At horizontal joints between louver units, provide horizontal mullions, unless continuous vertical assemblies are indicated. Provide sill extensions and loose sills made of same material as louvers where indicated or required for drainage to exterior and to prevent water penetrating to interior. Join frame members to one another and to fixed louver blades with fillet

welds, threaded fasteners, or both, as standard with louver manufacturer, concealed from view; unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.

2.4 FIXED, EXTRUDED-ALUMINUM LOUVERS

A. Louver Construction: Provide fixed-blade louvers with extruded-aluminum frames and blades. Horizontal Louvers: Either drainable- or non-drainable-blade (as indicated) type complying with the following:

1. Louver Depth: As indicated.

2. Frame Thickness: 0.125 inches, or as indicated.

3. Blade Thickness: 0.125 inches, or as indicated.

4. Performance Requirements: As indicated.

5. AMCA Seal: Mark units with AMCA Certified Ratings Seal.

B. Continuous, Horizontal, Drainable-Blade Louvers: Fabricated with close-fitting, field-made splice joints in blades designed to permit expansion and contraction without deforming blades or framework and with mullions recessed from front edges of blades so blades have continuous appearance.

1. Louver Depth: As indicated.

2. Frame Thickness: 0.125 inches, or as indicated.

3. Blade Thickness: 0.125 inches, or as indicated.

4. Blade Profile: As indicated.

5. Blade Angle and Spacing: As indicated.

2.5 FIXED, FORMED-METAL LOUVERS

A. Louver Construction: Provide fixed-blade louvers with frames and blades formed from metal sheet of metal indicated.

B. Horizontal Louvers: Either drainable- or non-drainable-blade type (as indicated) complying with the following

1. Louver Depth: As indicated.

2. Frame and Blade Material: Galvanized steel sheet, 0.052 inch.

3. Performance Requirements: As indicated.LOUVER SCREENS

A. Provide each exterior louver with louver screens complying with the following requirements:

1. Screen Location for Fixed Louvers: Interior face.

2. Screening Type: Bird screening, unless otherwise indicated.

3. Screening Type: Insect screening, as indicated.

B. Secure screens to louver frames with stainless-steel machine screws, spaced a maximum of 6 inches from each corner and at 12 inches o.c.

C. Louver Screen Frames: Fabricate screen frames with mitered corners to louver sizes indicated and to comply with the following requirements:

1. Metal: Same kind and form of metal as indicated for louver to which screens are attached.

a. Reinforce extruded-aluminum screen frames at corners with clips.

2. Finish: Same finish as louver frames to which louver screens are attached.

D. Type: Rewirable frames with a driven spline or insert for securing screen mesh. Louver Screening for Aluminum Louvers: As follows:

1. Bird Screening: Aluminum, 1/2-inch-square mesh, 0.063-inch wire

2. Insect Screening: Aluminum, 18-by-16 mesh, 0.012-inch wire.

E. Louver Screening for Galvanized Steel Louvers: As follows:

1. Bird Screening: Galvanized steel, 1/2-inch square mesh, 0.047-inch wire.

2. Insect Screening: Galvanized steel, 18-by-14 mesh, 0.011-inch wire. Insect Screening: Aluminum, 18-by-16 mesh, 0.012-inch wire.

F. Louver Screening for Galvanized Steel Louvers: As follows:

1. Bird Screening: Galvanized steel, 1/2-inch-square mesh, 0.047-inch wire.

2. Insect Screening: Galvanized steel, 18-by-14 mesh, 0.011-inch wire.

2.7 BLANK-OFF PANELS

A. Fabricate blank-off panels from materials and to sizes indicated and comply with the following requirements:

1. Finish: Same as finish applied to louvers.

2. Attach blank-off panels to back of louver frames with clips.

B. Insulated, Blank-off Panels: Laminated metal-faced panels consisting of insulating core surfaced on back and front with metal sheets, complying with the following requirements:

1. Thickness: 1 inch.

2. Metal Facing Sheets: Aluminum sheet, 0.032 inch thick.

3. Insulating Core: Unfaced, rigid, glass-fiberboard insulation complying with ASTM C612, Classes 1 and 2.

4. Edge Treatment: Trim perimeter edges of blank-off panels with louver manufacturer's standard extruded-aluminum-channel frames 0.081 inch thick, with corners mitered and with same finish as panels.FINISHES

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Finish louvers after assembly.

2.9 ALUMINUM FINISHES

A. Finish designations prefixed by AA comply with system established by the Aluminum Association for designating aluminum finishes.

B. Class II, Clear Anodic Finish: AA-M12C22A31 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class II, clear coating 0.010 mm or thicker) complying with AAMA 607.1.

C. Baked-Enamel Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; Organic Coating: as specified below). Apply baked enamel complying with paint manufacturer's specifications for cleaning, conversion coating, and painting.

1. Organic Coating: Thermosetting, modified-acrylic enamel primer/topcoat system complying with AAMA 603.8, except with a minimum dry film thickness of 1.5 mils, medium gloss.

2. Color: As selected by the Contracting Officer Representative from manufacturer's full range of colors.

D. High-Performance Organic Coating Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; Organic Coating: as specified below). Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

1. Fluoropolymer Three-Coat Coating System: Manufacturer's standard three-coat, thermo cured system consisting of specially formulated inhibitive primer, fluoropolymer color coat, and clear fluoropolymer topcoat, with both color coat and clear topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight; complying with AAMA 605.2.

a. Color and Gloss: As selected by the Contracting Officer Representative from manufacturer's full range of colors and glosses.

2.10 GALVANIZED STEEL SHEET FINISHES

A. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A780. Apply a conversion coating of type suited to organic coating applied over it.Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-enamel finish consisting of prime coat and thermosetting topcoat, with not less than 1.0-mil dry film thickness for topcoat. Comply with paint manufacturer's written instructions for applying and baking to achieve a minimum dry film thickness of 2.0 mils.

1. Color and Gloss: As selected by the Contracting Officer Representative from manufacturer's full range of colors and glosses.

**PART 3 – EXECUTION**

3.1 PREPARATION

A. Coordinate Setting Drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

3.2 INSTALLATION

A. Locate and place louver units' level, plumb, and at indicated alignment with adjacent work.

B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.

C. Form closely fitted joints with exposed connections accurately located and secured.

D. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated

E. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

F. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

G. Install concealed gaskets, flashings, joint fillers, and insulation, as louver installation progresses, where weathertight louver joints are required. Comply with Section 07900 for sealants applied during louver installation.

3.3 ADJUSTING, CLEANING, AND PROTECTING

A. Test operation of adjustable louvers and adjust as needed to produce fully functioning units that comply with requirements.

B. Periodically clean exposed surfaces of louvers and vents that are not protected by temporary covering to remove fingerprints and soil during construction period. Do not let soil accumulate until final cleaning.

C. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.

D. Protect louvers and vents from damage during construction. Use temporary protective coverings where needed and approved by louver manufacturer. Remove protective covering at the time of Substantial Completion.

E. Restore louvers and vents damaged during installation and construction so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Contracting Officer Representative, remove damaged units and replace with new units.

F. Clean and touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.

END OF SECTION

# SECTION 13110

# STRAY CURRENT AND CATHODIC PROTECTION

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for providing and connecting stray-current and cathodic-protection equipment.

1.2 RELATED REQUIREMENTS

A. Grading, excavation and backfilling: Section (02320).

B. Corrosion control system testing: Section (13115).

C. Grounding and bonding: Section 16060, GROUNDING AND BONDING.

D. Wire, cable and busways: Section 16120, WIRE, CABLE, AND BUSWAYS.

E. Wire connection accessories: Section 16125, WIRE CONNECTION ACCESSORIES.

F. Raceways, boxes and cabinets: Section 16130, RACEWAYS, BOXES, AND CABINETS.

1.3 REFERENCES

A. Comply with codes and regulations of Jurisdictional Authorities.

B. ASTM: B418 Standard Specification for Cast and Wrought Galvanic Zinc Anodes

C. ASTM D570 Standard Test Method for Water Absorption of Plastics

D. ASTM D638 Standard Test Method for Tensile Properties of Plastics

E. ASTM D1248 Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable

F. ASTM E11 Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves.

G. MS: MIL-A-18001 Military Specification: Anodes, Sacrificial Zinc Alloy

1.4 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each.

1. Shop Drawings

a. Show utility locations

b. Show equipment or installation protection

2. Certification

a. Certified test reports of field quality-control testing.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Mark each item with manufacturer's name, brand designation, referenced standard, type, class, and rating, as applicable.

B. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.

C. Store equipment in secure and dry storage facility.

**PART 2 – PRODUCTS**

2.1 PRODUCTS AND MATERIALS

A. Cast-Iron Anodes

1. Size and type: As shown.

2. Chemical composition:

| Element | Percent |
|---|---|
| Silicon | 14.33 |
| Chromium | 4.5 |
| Carbon | 0.85 |
| Manganese | 0.65 |
| Iron | Remainder |

3. Physical properties

a. Tensile strength: 15,000 psi.

b. Compressive strength: 100,000 psi.

c. Brinell hardness: 520.

d. Density: 7.0 grams per cubic centimeter.

e. Melting point: 2,300 degrees F.

f. Specific resistance: 72 microhms per centimeter cube at 20 degrees C.

g. Coefficient of expansion: $7.33 \times 10^{-6}$ per degree F from 32 degrees F to 212 degrees F.

4. Lead wire: Single-conductor insulated cable, 8AWG minimum, factory-connected to anode with connection sealed with cast epoxy-resin encapsulation.

5. Anode packaged as follows:

a. Stove pipe: Galvanized steel, 30-gauge minimum, in accordance with the one of the following:

(1) Diameter: Eight inches; Length: Eight feet.

(2) Diameter: Five inches; Length: Six feet.

b. Ends of pipe crimped to end seal of 1/2-inch interior-grade plywood.

c. Containing compacted backfill of coke breeze of graded coal or recalcined petroleum coke, with the following additional requirements:

(1) Resistivity on dry basis: 60 ohms per centimeter cube, maximum.

(2) Chemical composition:

| Material | Percent |
|---|---|
| Fixed carbon | 78.22 - 78.40 |
| Ash | 18.6 maximum |
| Moisture | 9.50 - 14.70 |
| Volatile matter | 3.00 - 3.14 |
| Sulphur | 1.2 maximum |

(3) Gradation

(a) Sieve size in accordance with ASTM E11.

(b) Requirements:

| Percent Passing | Sieve Size |
|---|---|
| 1/2 inch | 100 |
| 3/8 inch | 85 |
| No. 6 | 65 |

B. Magnesium Anodes

1. Packaged anodes, type and size as shown.

2. Chemical composition for high-potential type anodes:

| Element | Percent |
|---|---|
| Aluminum | 0.010 maximum |
| Manganese | 0.50 - 1.30 |
| Zinc | 0.050 maximum |
| Silicon | 0.050 maximum |
| Copper | 0.020 maximum |
| Nickel | 0.001 maximum |
| Iron | 0.030 maximum |
| Other metallic elements | 0.050 each or 0.300 maximum total |
| Magnesium | Remainder |

3. Lead wire: Single-conductor insulated cable, 12AWG minimum, factory-connected to anode with connection sealed with cast epoxy-resin encapsulation.

4. Anode packaged in permeable cloth sack containing compacted backfill of mixture with the following requirements:

| Material | Percent |
|---|---|
| Gypsum | 75 |
| Bentonite | 20 |
| Sodium sulphate | 5 |

C. Zinc Anodes: MS MIL-A-18001, bare-ribbon 5/8 by 7/8-inch section or packaged anode, type and size as shown, with the following additional requirements:

1. Lead wire: Single-conductor insulated cable, 12AWG minimum, factory-connected to the anode with connection sealed with cast epoxy-resin encapsulation.

2. Anode packaged in permeable cloth sack containing compacted backfill of mixture consisting of 50-percent hydrated gypsum and 50-percent bentonite.

D. Reference Electrode: ASTM B418, Type II, one galvanized-steel rod, factory-connected to electrode and equipped with two bolted connectors suitable for 12AWG single-conductor insulated cable.

E. Test Boxes

1. Cathodic-protection test boxes: Plastic, each 5 inches inside diameter by 18 inches long, with cast-iron lid, collar and terminal board.

2. Stray-current test boxes: Six inches cubical, galvanized cast-iron box with watertight cover.

F. Wire and Cable

1. Header cable, bond wire and cast-iron anode lead wire in accordance with the following:

a. Single-conductor.

b. Size: As shown.

c. Insulation: HMWPE, 600 volt, in accordance with the following: ASTM D1248, Type I, Class C, Grade 5.

2. Magnesium or zinc anode lead and test wire

a. Single-conductor.

b. Size: 12AWG unless otherwise shown.

c. Color: As shown; anodes lead as furnished.

d. Insulation: TW, 600-volt, moisture-resistant thermoplastic in accordance with UL 83.

G. Pipeline-Casing Spacers

1. Virgin polyethylene, molded.

2. Runner height: Sufficient to provide ½-inch clearance between pipe, couplings and hubs as well as internal casing wall.

3. Color: Natural.

4. In accordance with the following:

| Characteristic | Reference | Requirement |
|---|---|---|
| Compressive strength | - | 3,200 psi |
| Tensile strength | ASTM D638 | 3,100 - 5,500 psi |
| Impact strength | - | 1.5 - 2.0 foot-pound per inch notch |
| Water absorption | ASTM D570 | 0.1 percent |
| Temperature | - | 180 degrees F (80C) maximum |

5. Bolts
    a. Steel, cadmium-plated.
    b. Sizes: As standard with the manufacturer.
6. Nuts
    a. Steel, cadmium-plated, square.
    b. Sizes: To match bolts.

H. Pipeline-Casing End Seals
1. Type L
    a. Modular mechanical-type.
    b. Consisting of interlocking synthetic-rubber links with cadmium-plated steel nuts and bolts.
    c. Depth limitations: As shown on Contract Drawings.
2. Type H
    a. Compression-ring seals.
    b. Nonconductive sleeve: Fiberglass reinforced epoxy (FRE), with cadmium-plated steel nuts and bolts.
    c. Depth limitations: As shown on Contract Drawings.

I. Insulating Gasket
1. Non-asbestos, all-temperature.
2. Full-face.
3. Thickness: 1/8 inch.
4. Basis of Design: Johns-Manville 71.

J. Insulating Sleeves and Washers
1. Up to 300 degrees F
    a. Sleeve: Mylar tube, 1/32 inch thick.
    b. Washer: Phenolic, 1/8 inch thick.

2. 300 degrees F and above

   a. Sleeve Basis of Design: Klinger, 1/32 inch thick.

   b. Washer Basis of Design: Johns-Manville 71, Teflon.

**PART 3 – EXECUTION**

3.1 INSTALLATION

A. Bury anodes or electrodes of type and at location shown. Excavate and backfill holes in accordance with Section 02320, with the following additional requirements:

   1. Wet packaged anode thoroughly before backfilling hole.

   2. Use fine clay soil, free from stones and bricks, for backfilling.

B. Install header cable of size and at location shown, in accordance with Section 16120, WIRE, CABLE AND BUSWAYS.

C. Install test boxes of type and at location shown.

D. Connect anode lead wires to header cable or test boxes as shown.

E. Isolate pipes of different metals and Authority pipes from utility-company pipes using insulated union, compression insulating couplings, or insulated flange and bolt connections. Connect each side of insulated joints to test box using conductors as shown.

F. Where Authority pipes cross utility-company pipes, connect Authority pipes to test boxes using two 12AWG and one 4AWG conductors as shown.

G. Bond joints in buried metallic pipe and structure in accordance with Section 16060, GROUNDING AND BONDING. Connect buried metallic pipe and structure to test boxes using single-conductor insulated cable of size shown.

H. Install conduit of type shown, in accordance with Section 16130, RACEWAY, BOXES AND CABINETS FOR ELECTRICAL SYSTEMS.

I. Install single-conductor insulated cable in accordance with Section 16120, WIRE, CABLE AND BUSWAYS. Leave one foot of slack in test boxes.

J. Use exothermic weld sealed with cast epoxy-resin encapsulation for splices made in direct-burial cable.

K. Use compression-type connectors in accordance with Section 16125, WIRE CONNECTION ACCESSORIES.

L. Install casing spacers in accordance with manufacturer's recommendation, except maximum spacer distance not to exceed 10 feet.

3.2 IDENTIFICATION

A. Identify wire and cable in each test box using nonmetallic fiberboard or plastic tags or pressure-sensitive labels.

3.3 FIELD QUALITY CONTROL

A. Provide necessary equipment and perform testing in the presence of the Contracting Officer Representative in accordance with Section 13115 (Corrosion Control System Testing).

END OF SECTION

# SECTION 15070
# VIBRATION ISOLATION

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for providing vibration isolation for mechanical equipment and piping.

1.2 RELATED REQUIREMENTS

A. Section 05500

B. Section 03100

C. Section 03200

D. Section 03300

1.3 REFERENCES

A. Comply with codes and regulations of the Jurisdictional Authorities

B. ASTM: A123.

1.4 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each.

1. Shop Drawings

a. Include tabulation of design data on isolators including actual deflection; outside diameter; free, operating. and solid heights of isolators; method of attachment; bolt sizes; and type and sizes of anchor plates.

B. Certification.

## PART 2 – PRODUCTS

2.1 EQUIPMENT

A. General Requirements

1. Vibration isolators selected to produce uniform loading and deflection even when equipment weight is not evenly distributed; steel components hot-dip galvanized after fabrication in accordance with ASTM A123.

a. Types of vibration isolators

b. For equipment

(1) Floor-mounted: Spring isolators.

(2) Ceiling-suspended: Suspension-type isolators.

2. Spring isolators for floor-mounted equipment

   a. Free-standing, laterally stable without housing, complete with minimum 1/4-inch thick neoprene, acoustical friction pad in series with spring element.

   b. Leveling bolts and adequate facilities for bolting to equipment and supporting structure using isolation washers.

   c. Coil outside diameter: Not less than 0.8 of operating height of spring.

   d. Horizontal stiffness: Not less than 0.8 of vertical stiffness.

   e. Springs designed to have additional 50-percent capacity beyond rated load.

   f. Springs designed so that ends remain parallel during and after spring deflection to operating height.

   g. Vibration isolators selected for lowest operating speed of equipment.

   h. Built-in adjustable limit stops with isolators provided for equipment of operating weight different from installed weights, to prevent rising of equipment when weight is removed and for equipment exposed to wind. Limit stops not to be in contact during normal operating conditions.

   i. Welding of springs to load-plate assembly for vibration isolators with capacities of 6,000 pounds or less is prohibited.

   j. Vibration isolators with capacities of 6,000 pounds or less are permitted use of cups or other positive means for restraining springs.

3. Suspension-type isolation hangers for ceiling-suspended equipment

   a. Combination of spring and neoprene in series.

   b. Spring made of stable steel.

   c. Encased in structurally stable steel bracket.

   d. Spring diameter large enough to permit 15-degree angular misalignment of rod connecting hanger to equipment without rubbing on box

   e. Designed to provide complete support for suspended units upon failure or rupture of isolator.

B. Isolation-Unit Types and Deflection

1. Fans, ventilating units, evaporation units and air-conditioning units: Floor-mounted and ceiling-suspended.

   a. Spring isolators designed for a minimum of 1.5 inches deflection.

**PART 3 – EXECUTION**

3.1 INSTALLATION

A. Install vibration isolators where shown as recommended by the equipment manufacturer.

B. Mount mechanical equipment on vibration isolators to isolate equipment from structure.

C. Jack bases and equipment into position and wedge or block before vibration isolators are loaded.

D. Use isolator leveling bolts for final leveling of equipment after equipment is in operation.

E. Springs installed so that ends remain parallel during and after deflection to operating height.

END OF SECTION

# SECTION 15075

# IDENTIFICATION OF MECHANICAL EQUIPMENT AND PIPING

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for providing identification of mechanical equipment and piping.

1.2 RELATED REQUIRMENTS

A. Section 09920

1.3 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each.

1. Samples

a. Labels and tags in each size.

2. Documentation

a. Charts for valves; include valve identification number, location and purpose.

## PART 2 – PRODUCTS

2.1 EQUIPMENT

A. Nameplates: Laminated plastic.

B. Tags: 18-gauge stainless steel.

C. Identification Plates: Bronze, Authority-furnished.

D. Snap-Around Pipe Markers: comply with ASME (ANSI) A13.1 Standard

## PART 3 – EXECUTION

3.1 INSTALLATION

A. Cement nameplates with permanent adhesive on equipment and apparatus.

B. Affix labels to surface of control and switch boxes by means of machine screws with vibration proof nuts and neoprene washers. Cement labels to surface with permanent adhesive when screws cannot be used.

C. Fasten tags securely to valves with brass jack chain, so as to permit easy reading.

D. Mount valve charts in aluminum frames with clear Lucite front cover in locations as directed.

3.2 IDENTIFICATION

A. Equipment and Apparatus

1. Label equipment, devices, and apparatus with black engraved letters on white background laminated-plastic nameplates securely fastened to metal panels, showing function and unit number of item.

B. Piping

1. Snap-Around Pipe Marker size, legend, and color coding on piping showing service and direction of flow as follows:

a. Soil and waste lines - White color field with Black letter S

b. Vent lines - Grey & White band color field with Black letter V

c. Storm water lines - White color field with Black letters ST-W

d. Size of letters:

(1) Pipe 3/4 inch to 1-1/4 inches: 1/2-inch letters, 8-inch color field

(2) Pipe 1-1/2 inches to 2-1/2 inches: 3/4-inch letters, 8-inch color field

(3) Pipe 3 inches to 6 inches: 1-1/4-inch letters, 12-inch color field

(4) Pipe 7 to 10 inches: 2-1/2-inch letters, 24-inch color field

(5) Over 10 inches: 3-1/2-inch letters, 32-inch color field

2. Color coding of exposed piping and terminations of piping is specified as follows:

a. General Requirements

(1) Color coding is required for accessible piping systems, except associated supports, brackets, hangers and similar accessories.

(2) Identify piping systems to be color coded as specified above.

b. Location of Snap-Around Pipe Markers

(1) Locate at points where pipes enter and leave rooms or spaces, at junction points and points of distribution, close to valves and equipment, at changes of direction, and at intervals of maximum 50 feet along each run of piping. Reduce intervals to 25 feet in congested areas of piping.

C. Valves

1. Identify valves with 1-1/2 inch diameter, 18-gauge stainless-steel tags.

2. Designate appropriate service on each tag with 1/4-inch stamped black-filled letters and valve number with 1/2-inch stamped black-filled numbers.

END OF SECTION

# SECTION 15135

# SUMP PUMPS

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for providing sump pumps, complete with motor drives and controls.

1.2 RELATED REQUIREMENTS

A. Piping systems: Section 15205, PIPING SYSTEMS

B. Raceways, boxes and cabinets: Section 16130, RACEWAYS, BOXES, AND CABINETS

C. Wire, cable and busways: Section 16120, WIRE, CABLE, AND BUSWAYS

D. Motors: Section 16225, MOTORS

1.3 REFERENCES

A. Comply with codes and regulations of the Jurisdictional Authorities.

B. UL and NEMA compliance, provide electric motors and components which are listed and labeled by Underwriters Laboratories (UL 778) and comply with NEMA standards.

1.4 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements specified for each:

1. Shop Drawings: Manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and method of assembly of components.

2. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to plumbing pumps.

3. Product Data: Submit manufacturer's pump specifications, installation and start-up instructions, and current accurate pump characteristic performance curve with selection points clearly indicated.

4. Operation and Maintenance Manuals: Include shop drawings, wiring diagrams, product data, along with trouble shooting maintenance guide and parts list for pump and control equipment.

1.5 QUALITY ASSURANCE

A. Source Quality Control

1. Select pumps based on capacity, total dynamic head and electrical characteristics shown.

2. Test pumps at 1-1/2 times working pressure.

3. Balance impeller statically, dynamically, and hydraulically.

## PART 2 – PRODUCTS

2.1 EQUIPMENT

A. General Requirements

1. In design and purchase of equipment, provide for interchangeability of subassemblies, parts, motors, starters, and relays.

B. Submersible Sump Pump

1. Type: Automatic, electric-motor-driven, centrifugal, wet-pit, close-coupled.

2. To include single-phase, hermetically sealed, capacitor-start motor with built-in overload protection, upper and lower bearing factory-sealed, grease-lubricated ball-type, common shaft of stainless steel, Type 316, and sealed pump cable with neoprene cover and flexible armor. Motors to have cooling characteristics permitting continuous operation in totally submerged, and partially submerged conditions.

3. Casing: Close-grain cast iron, volute-type.

4. Impeller: Cast iron or bronze, enclosed or semi-open, with vanes and back shroud, dynamically balanced.

5. Intake protected with slotted cast-iron or perforated steel intake strainer with effective free area sufficient to prevent cavitation and poor efficiency.

6. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Zoeller

b. Stancor

c. Goulds

C. Controls

1. Duplex submersible, single-phase unit. Completely independent, designed for direct switching of two single-phase pumps. Primary control to be ultrasonic with pump alteration lead/lag pump control capability and discharge totalizing capability. Secondary/back up control to consist of a two float configuration. Manual pump operation to be by local switches on control enclosure.

2. Ultrasonic level pump controller consisting of a microprocessor based level controller and an ultrasonic transducer.

a. Enclosure: NEMA 4X

b. Operating Temp: minus 5 degrees F to 140 degrees F

c. Power supply: 100 to 230 VAC @50/60Hz

d. Display: Multi-field backlit LCD

e. Output: Six relay contacts 0/4 to 20mA

f. Input: One 0/4mA from alternative device scalable (other than transducer)

g. Communication: Digital communication with built-in Modbus RTU via RS-485.

h. Transducer Range: 1 to 50 feet.

i. Control Functions: Provide pump control with manual on-spring return to off as well as alternate pumps on each successive cycle of operation.

j. Alarm capability based on various set points.

3. Float switch mechanically activated Single Pole Double Throw (SPDT) and mercury free. Shell to be leak-proof, shockproof, and impact-resistant.

a. Electrical Rating: 10A, 120/230VAC

b. Actuation angle: 5 degrees above and 5 degrees below horizontal.

D. Wiring

1. Wiring Identification: All wires to be identified with heat shrink machine labeled sleeves.

2. Wiring and conduit: Sections 16130, RACEWAYS, BOXES, AND CABINETS, and Section 16120, WIRE, CABLE, AND BUSWAYS.

E. Nameplates

1. Securely attach equipment ID nameplate to each pump, power receptacle, and control panel.

2. Pump to have manufacturer's nameplate with model number, serial number, electrical, and operating characteristics.

**PART 3 – EXECUTION**

3.1 INSTALLATION

A. Fit equipment and appurtenances within space provided and make readily serviceable. Provide access space around pumps for service as indicated ensure recommendation by manufacturer is maintained.

B. Duplex pumps to be installed so that one pump can be isolated for service or replacement and the second pump can remain operational. Provide piping, valves, accessories, gauges, supports, and flexible connections as indicated.

C. Provide hangers and anchor bolts required for proper installation of equipment as recommended by manufacturer and as indicated on Contract Drawings.

D. Install in accordance with manufacturer's instructions.

3.2 FIELD QUALITY CONTROL

A. Ensure that connections are secure and watertight.

B. Test system through five complete operating cycles.

C. Ensure that pump and motor operate without noticeable vibration.

END OF SECTION

# SECTION 15205
# PIPING SYSTEMS

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for providing piping, fittings, valves, drains, specialties and supporting devices.

1.2 RELATED REQUIREMENTS

A. Firestopping: Section 07841, FIRESTOPPING.

B. Field painting: Section 09920.

C. Identification of mechanical equipment and piping: Section 15075, IDENTIFICATION OF MECHANICAL EQUIPMENT AND PIPING.

D. Grounding and bonding: Section 16060, GROUNDING AND BONDING.

1.3 REFERENCES

A. Comply with codes and regulations of the Jurisdictional Authorities.

B. The Model Plumbing Code.

C. ASSE Standards.

D. AWWA Standards.

E. ASME Code for Unfired Pressure Vessels.

F. ANSI/ASME: A21.15/C115, B16.1, B16.3, B16.5, B16.9, B16.11, B16.18, B16.22, B16.39, B31.1, Z21.22.

G. ANSI/AWS: A5.8, E8016, E8018.

H. CISPI: HSN 85.

I. FS: A-A-1192, SS-C-153C, WW-P-51F, WW-P-460D, WW-P-501, WW-U-516B, WW-U-531, WW-V-51F.

J. MSS: SP-58, SP-67, SP-70, SP-80, SP-110.

K. PDI: WH-201.

L. ASTM: A53, A74, A105, A126, A234, A276, A395, A536, B32, B61, B62, B88, B150, B280, B306, F709.

1.4 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each.

1. Shop Drawings

a. Complete catalog information and Shop Drawings for material and equipment.

b. Submittals include, but are not limited to, the following:

(1) Pipes and piping layout, including locations of hangers and supports.

(2) Pipe hangers and supports.

(3) Valves.

(4) Cleanout deck plates and wall plates.

(5) Escutcheons.

(6) Gauges.

(7) Expansion joints, guides and anchors.

(8) Pipe sleeves.

(9) Drains.

2. Certification

a. Certificates from manufacturers verifying the following:

(1) That pipe-joint gaskets and lubricants are satisfactory for use with pipe and fittings specified.

(2) That expansion joints are designed and tested as specified.

1.5 QUALITY ASSURANCE

A. Qualifications of Welder: Section 05120.

1.6 SITE CONDITIONS

A. Do not perform welding when the temperature of base metal is less than zero degrees F.

B. Do not perform welding when surfaces are wet from rain, snow, ice, or during periods of high wind unless operator and work are properly protected.

**PART 2 – PRODUCTS**

2.1 PERFORMANCE REQUIREMENTS

A. General Requirements

1. In design and purchase of equipment, provide for interchangeability of items of piping equipment, subassemblies and parts.

2.2 EQUIPMENT

A. Piping

1. Ductile-iron pipe and fittings

a. Piping for sewage-ejector discharge, drainage-pump discharge, interim pumps and for water service from point of connection to inside of structure: ANSI/ASME A21.15/C115, 250-pound pressure class, flanged.

(1) Flanges: ANSI/ASME B16.1.

b. Pipe coated on outside with bituminous coating and lined with cement mortar of twice standard thickness specified for pipe size used.

(1) Cement-mortar lining having a seal coat of nontoxic, taste, and odor-free bituminous material.

c. Neoprene gaskets furnished for joints.

2. Copper tubing and fittings

a. Solder joints: Lead-free 95.5-percent tin, 4.0-percent copper and 0.5-percent silver with non-corrosive flux; ASTM B32.

3. Copper drainage tube (DWV) and fittings

a. Seamless tubing: ASTM B306, No. 122 for drainage, waste, and vent piping and fittings.

4. Unpolished stainless-steel drip pans

a. Provided under water, waste, or condensate-drain piping which run over transformer vaults or electric motor starters.

b. Each drip pan provided with 1-inch drain.

5. Unions

a. 1-1/2 inches and smaller: Threaded, ASME B16.39, Type A or B to match piping.

b. Two inches and larger unions: ASTM A126, Class B, flanged.

(1) Two, 2-1/2 and 3-inch union flanges: Steel, FS WW-U-531 or of cast iron, ANSI/ASME B16.1, 125-pound class.

c. Four inch and larger union: Forged steel, 150-pound class, slip-on weld-neck flanges, ANSI/ASME B16.5.

d. Nonferrous-piping unions: Brass, FS WW-U-516B.

6. Cleanouts

a. For cast-iron bell-and-spigot pipe: SVCI, ferrule caulked into cast-iron fittings and extra-heavy brass tapered screw plug with recessed head.

b. For wrought-iron pipe: Extra-heavy brass plug in drainage fitting.

c. Floor cleanouts: Cleanouts turning up through architecturally finished floors made by means of a long-sweep ell or Y and adjustable ABS housing with secured, scoriated, round satin-brass cover.

d. Wall cleanouts: Cleanout plugs furnished with solid head tapped for 1/4-inch brass machine screw to secure cover plate. Cover plate to be polished-brass round access plate secured to plug with countersunk screw.

e. For threaded pipes: Bronze, FS WW-P-460D, Class A.

f. Furnished with adjustable recessed head in floor and where shown.

g. Except for test openings, cleanout plugs for pipes up to 4 inches to be same size as pipe.

h. On pipe sizes 5 inches and larger, cleanout plugs to be of 4 inches and pipe reduced to plug size with bushing.

B. Valves

1. Globe, angle, ball, and check valves

a. Two inches and smaller

(1) WW-V-51F, Class B.

(2) Bronze with threaded ends, rough bodies and finished trim.

(3) Materials except hand wheels: ASTM B61.

(4) Globe and angle valves furnished with malleable-iron hand wheels.

2. Valves for copper piping

a. Gate valves with solder ends: MSS SP-80, Type 2, Class 150, Bronze, Type 1, Class B.

b. Gate valves with flanged ends: MSS SP-80, Type 2, Class 150, Bronze.

c. Globe, angle, ball, and check valves with solder or flanged ends: FS WW-V-51F, Bronze, Class B.

C. Supporting Devices

1. Pipe hangers and supports

a. Provide adjustable steel pipe hangers and supports as follows:

(1) Clevis and clamp, cadmium-plated or zinc-plated: MSS SP-58, Type 1 and Type 8 for steel and cast-iron piping.

(2) Space not greater than 6 feet for pipe sizes up to and including 1-1/2 inches; 10 feet for pipe sizes 2 inches through 6 inches; 16 feet for pipe sizes 8 inches and larger

b. Pipe hangers for copper tubing: Steel, copper-plated, clevis-type, spaced at maximum 5 feet for tubing sizes through 1-1/2 inches and maximum 8 feet for sizes 2 inches and larger.

c. Hanger rods minimum diameter 3/8 inch, constructed of steel, cadmium-plated, threaded full-length and diameter required by pipe size and load imposed.

d. Hanger rod nuts and washers: Steel, cadmium-plated.

e. Supported from malleable-iron, hot-dip galvanized inserts in concrete slab: MSS SP-58, Type 18.

f. Pipe hangers and supports in tunnels and shafts: MSS-SP-58, stainless steel, ASTM A276, Type 304.

2. Pipe anchors

a. Designed to withstand five times anchor load minimum.

b. Vertical pipes anchored by means of clamps welded around pipes and secured to wall or floor construction.

3. Pipe guides

   a. Factory-made cast semi-steel or heavy fabricated galvanized steel, consisting of bolted two-section outer cylinder and base with two-section guiding spider bolted or welded tight to pipe.

   b. Designed to clear pipe insulation and to prevent over-travel of spider and cylinder.

   c. Guides not less than 12 inches long and spiders not less than the following:

| Pipe size / inches | Spider length / inches |
|---|---|
| 1-1/2 and smaller | 2 |
| 2 to 3 | 2-1/2 |
| 4 | 3 |
| 5 and larger | 3-1/2 |

4. Expansion bolt anchors

   a. Consisting of bolt, expander, star lock washer, and nut.

   b. Fabricated of stainless steel, Type 303, including expander and star lock washer.

   c. Anchor assemblies: FS: A-A-1992, Group II, Type 4, Class 1.

5. Self-drilling anchors

   a. Self-drilling expansion anchors, with self-cutting annular broaching grooves.

   b. Anchor and expander plug: FS: A-A-1992, Group III, Type 1, double-plated.

6. Pipe sleeves

   a. Through interior masonry-unit walls: As shown. Sleeve shall be large enough to accommodate pipe and covering but not less than two sizes larger than pipe size.

   b. Through poured-concrete interior walls, floors and ceiling: As shown.

      (1) Sleeves minimum two sizes larger than pipe. At floors, sleeves to project 4 inches above finish floor.

   c. Through exterior structural elements: Minimum two sizes larger than pipe and as shown.

   d. Sleeves designed to allow expansion/contraction movement of pipe.

7. Escutcheon plates

   a. Polished brass or stainless steel, screw-fastened to wall or ceiling.

   b. Plate collars caulked watertight with mastic.

   c. Mastic: FS SS-C-153C, Type I.

D. Drains

1. Area drains

a. Cast iron with flashing flange and flat grate for entrance areas.

b. Outlets designed for connection to cast-iron soil pipe.

c. Drain sizes and types as shown.

d. Clamping devices: For securing membrane or flashing for drains installed in membrane-waterproofed floors and in floors not laid on ground.

2. Floor drains

a. Cast iron with flashing flanges and bottom or side outlet as required and designed for connection to cast-iron soil pipe.

b. Clamping devices: For securing membranes or flashing, for drains installed in membrane-waterproofed floors and in floors not laid on ground.

c. Reinforced-neoprene flashing: For drains installed in floors that are not membrane-waterproofed and are not laid on ground.

d. Flashing of reinforced sheet neoprene, secured to drain by clamping device and extending 12 inches minimum from drain to ensure watertight connection.

e. Area, yard and floor drains in public spaces having finished brass grates.

f. Floor-drain sizes and types as shown.

**PART 3 – EXECUTION**

3.1 INSTALLATION

A. Welding Procedure

1. Perform welding by manual metallic arc-process except for pipe sizes 4 inches and smaller where gas welding (oxyacetylene) may be used.

a. Use electrodes and rods of composition recommended for pipe by AWS.

b. Heat surface within 3 inches from point where weld will start to temperature warm to the hand before welding.

2. Weld corrosion-resistant nickel-copper alloy steel pipe by arc-process utilizing low-hydrogen electrodes of AWS E8016 or E8018 types.

3. Leave joint surfaces smooth, uniform, free from fins, tears and other defects which adversely affect proper welding.

4. After each pass of weld on multiple-pass welding, clean weld free of slag and other deposits before applying next pass.

5. Peen with light blows of blunt-nosed peening hammer.

a. Do not peen surface layers or first pass in groove welds.

6. For groove welds, have surface pass substantially centered on the seam, smooth and free from depressions.

7. Perform fillet-welds with minimum cutting back of outside pipe.
    a. Leave throat of full fillet-weld not less than 0.707 of thickness of pipe.
    b. Repair excess cutting back and undercutting of base metal in pipe adjoining weld.
    c. Fill up craters to full cross section of weld.
8. Align and position accurately joints to be welded, so that pipe will not project beyond its adjoining pipe by more than 20 percent of pipe wall thickness or 1/8-inch maximum.
9. Install welded pipe in accordance with ANSI/ASME B31.1.

B. Soil, Waste, Vent and Drainage-Piping Installation

1. Grade piping to 1/4 inch per foot and not less than that of main drain to which it is connected.
2. Use reducers to change pipe sizes on vent and drain lines.
3. Use long-sweep bends, Y-fittings, 1/8 or 1/16-bends, or combination Y and 1/8-bends to make changes in direction.
4. Join service-weight soil pipe and fittings with service-weight gaskets and extra-heavy soil pipe and fittings with extra-heavy gaskets.
    a. Designate and clearly identify service-weight and extra-heavy gaskets.
    b. Use lubricant for making joints.
    c. Make tight seal between external face of pipe and internal face of bell.
    d. Use gaskets capable of making and maintaining tight seal with deflection not exceeding 5 degrees.
    e. Assemble joints by use of tools recommended by pipe, fittings, and gasket manufacturers.
    f. Employ trained workmen experienced in installation of gasket system to install entire gasket system.
5. Install embedded cast-iron piping at angle of 90 degrees to contraction joints with end of pipe bell coinciding precisely with centerline of contraction joint.
6. Cut ends of screw-jointed pipes squarely to seat in bottom of recess of fittings and ream after cutting so waterway is not reduced in size.
7. Apply thread dope or compound to male thread only.

C. Steel-Pipe Installation

1. Install horizontal piping with minimum pitch of one inch in 40 feet and arrange for drains at low points.
2. Pipe drip pan to discharge as shown; if not shown, discharge to nearest open drain.
3. Provide flexible connections to coils, pumps, and other equipment so as to eliminate undue strains in piping and equipment.
4. Do not support embedded pipe from reinforcing bars with metallic means.

D. Pipe Anchors

1. Securely anchor piping where shown and where necessary for proper installation to force pipe expansion in proper direction.

E. Expansion-Bolt Anchors

1. Drill holes and install expansion-bolt anchors as recommended by anchor-bolt manufacturer. Do not locate less than eight inches from concrete edge.

F. Pipe Sleeves

1. Exterior walls

a. Install as shown.

b. For cathodically protected pipe, test in accordance with Section 13115.

2. Interior walls

a. Install as shown. Seal to maintain integrity of walls.

G. Bonding: In accordance with Section 16060, GROUNDING AND BONDING, and with the following additional requirements:

1. Bond mechanical joints and fittings, including valves, by exothermic-welding method.

2. Make welds in accordance with recommendations of the manufacturer. Clean and coat with coal tar epoxy.

3. Bond pipe using bonding strap welded to each side of joint not less than six inches from joint. Allow sufficient slack in conductor for expansion of pipe.

H. Firestopping: Section 07841, FIRESTOPPING.

1. Pipe penetration through fire rated partitions to be sealed with approved fireproof sealant.

3.2 FIELD QUALITY CONTROL

A. Water-Pressure Testing

1. Prior to burial or concealment, test affected piping in presence of the Contracting Officer Representative using specified procedures.

2. Test entire piping systems and test until found leak-free in presence of and to satisfaction of the Contracting Officer Representative.

3. Notify the Authority at least 36 hours in advance of making tests.

4. Test piping at following pressures:

a. Soil, waste, and vent piping: Requirements of local plumbing code but not less than equivalent to 10 feet of water.

b. Ductile-iron pipe: 150 psi or 1-1/2 times maximum working pressure, whichever is greater, at lowest point in system.

B. Test Procedures

1. Soil, waste, and vent piping

a. Water test to include entire system from lowest point to highest point.

b. After filling system, shut off water supply and allow it to stand 2 hours without loss or leakage.

c. Conduct final test by smoke test or peppermint test as prescribed by Jurisdictional Authority.

C. Repair of Leaks

1. Do not repair by mechanical caulking leaks in threads or welds occurring while pipeline is under test or in service.

2. Introduction into piping system of material intended to stop leakage is prohibited.

3. Repair leaks in threaded piping by breaking joint, cutting new threads on pipe, and installing new pipe fitting.

4. Remove defective welds by chipping or gas gouging from one or both sides of joint.

a. Re-weld chipped-out places.

b. When base metals of fillet-weld are cut back or throat of weld is less than specified, repair defect by adding additional weld metal.

3.3 CLEANING AND PROTECTION

A. Adjust and Clean

1. Flush entire hot and cold-water piping and other piping and equipment connected downstream from the domestic-water inlet main shutoff valve with water to remove sediment after completion of tests, replacements or repairs.

a. Use chlorine for disinfection in form of hypochlorite solution or in form of compressed gas applied through approved chlorinator.

b. Operate valves and equipment during chlorination to ensure that chlorine reaches entire system.

c. Feed water and chlorination agent into system at rate providing for 50 ppm of chlorine and allow standing 24 hours before flushing.

d. Residual chlorine at end of 24-hour retention period: Two-ppm minimum.

2. Flush treated water from system completely after disinfection.

3. Continue flushing until samples show that quality of water delivered is comparable with public water supply and satisfactory to Jurisdictional public-health Authority.

4. Do not take samples from hydrants or through unsterilized hose.

B. Protect pipe, openings, valves, and fixtures from dirt, foreign objects and damage during construction.

C. Replace damaged piping, valves, fixtures, and appurtenances.

D. Prior to testing, flush piping with chemically treated water until systems are clean and free of scale, slag, dirt, oil, grease, and other foreign material.

E. Hand-clean expansion joints and strainers.

3.4 FIELD PAINTING

A. Paint exposed soil and waste pipe lines in accordance with Section 09920.

END OF SECTION

# SECTION 15725
# VENTILATING UNITS

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for providing ventilating units.

1.2 RELATED REQUIREMENTS

A. Concrete pads: Sections 03100, 03200 and 03300.

B. Vibration isolation: Section 15070, VIBRATION ISOLATION.

C. Fans: Section 15830, FANS

D. Heating equipment: Section 15765, HEATING EQUIPMENT.

E. Filters: Section 15865, FILTERS

F. Control equipment: Section 15900.

G. Motors: Section 16225, MOTORS

1.3 REFERENCES

A. Comply with codes and regulations of the Jurisdictional Authorities.

B. NFPA: 90A.

C. ARI: 430

1.4 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each.

1. Shop Drawings.

2. Certification.

3. Operation and Maintenance Manuals.

## PART 2 – PRODUCTS

2.1 EQUIPMENT

A. General Requirements

1. In design and purchase of equipment, provide for interchangeability of items of equipment, subassemblies, parts, motors, starters, and relays.

B. Ventilating Units-Fans

1. Class I or II: Double width, double inlet, centrifugal, meeting ARI 430 and bearing ARI seal.

2. Blades backward inclined airfoil sections, with the following additional requirements:

   a. Forward curved blades may be furnished for fan wheel diameter 24 inches or less.

3. Inlets with smooth, rounded edges.

4. Fan housing fabricated of zinc-coated steel sheets, heavy-gauge consistent with size and use of unit.

5. Fan wheels having heavy-gauge rims, blades of heavy-gauge steel consistent with blade size for capacity, with matching heavy-gauge back plates. Steel, painted with zinc-oxide primer or corrosion-proof plastic coating.

6. Fan wheels and sheaves: Splined or keyed, fastened to shafts with set screws.

7. Shafts of steel, solid or hollow, ground to tolerance on working surfaces.

8. Nonworking surfaces of shafts coated with factory-applied corrosion proof plastic coating.

C. Fan Bearing

1. Self-aligning, antifriction type, designed to prevent leakage of lubricant and entrance of dirt.

2. Design life: 200,000 hours minimum.

3. Extended grease fittings when bearings are located internally.

D. Fan Operating Characteristics

1. Brake horsepower necessary to drive fan at air volume and static pressure shown.

2. Fans which do not approach 25 percent of first critical speed of shaft during normal operation or while attaining speed.

3. Prior to shipment, statically and dynamically balance fans on their own shafts in their own units at design speed.

E. Fan Drives

1. Fan driven by electric motor through high-capacity, V-belt drive.

2. Drives protected with belt guard of expanded-metal wire mesh or solid-metal side panels with tachometer opening.

3. Adjustable motor brackets and sheaves with nominal rating at midpoint.

4. Gasketed, hinged access doors with quick-opening latches or removable access panels.

5. Entire fan drive, including sheaves, belts, keys and other items rated by manufacturer at minimum 1.5 times maximum horsepower required to drive fan.

6. Ratings in accordance with manufacturer’s standard catalog data.

7. Fan-shaft sheave-pitch diameter: 30 percent minimum outside diameter of fan wheel.

8. Metal label riveted to unit stating size of replacement belt.

F. Fan Motors: Section 16225, FAN MOTORS.

G. Motor Starters and Control: Section 15900, MOTOR STARTERS AND CONTROL.

H. Unit Casings

1. In sections to facilitate handling.

2. Fabricated of steel sheets, manufacturer's standard heavy-gauge.

3. Steel sheets, angles and other structural shapes used in construction of casings: Zinc-coated steel or chemically pretreated and painted with enamel primer and exterior surface finished with factory-applied enamel coating.

4. Panels removable for access.

5. Cadmium-plated steel bolts, screws, and washers.

6. Structural frame fabricated with members rigidly braced to hold parts in line and to prevent distortion when operating.

7. Structural frame of welded construction; slag and splatter removed after welding.

8. Welds painted with two coats of approved primer and one finish coat of aluminum epoxy paint.

9. Filters: Section 15865, FILTERS.

I. Nameplates

1. Securely attach equipment ID nameplate to each ventilating unit.

2. Ventilating unit to have manufacturer's nameplate with model number and serial number, electrical and operating characteristics.

2.2 SITE CONDITIONS

A. Safety Requirements

1. Properly guard belts, pulleys, chains, gears, couplings, projecting set screws, keys, and other rotating parts to prevent danger to personnel.

**PART 3 – EXECUTION**

3.1 INSTALLATION

A. Fit equipment and appurtenances to space provided and make readily serviceable.

B. Mount ventilating units on concrete pads and vibration isolators in accordance with Sections 03100, 03200, 03300, and 15070.

C. Provide supports, hangers and anchor bolts necessary for proper installation of equipment as recommended by manufacturer.

D. After installation, adjust fans to operate without noticeable vibration.

E. Arrange belt guards to permit oiling, testing, and using tachometer with guards in place.

END OF SECTION

# SECTION 15765

# HEATING EQUIPMENT

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for providing heating equipment and electric heat tracing for piping.

1.2 RELATED REQUIREMENTS

A. Vibration isolators: Section 15070, VIBRATION ISOLATION.

B. Ventilating Units: Section 15725, VENTILATING UNITS.

C. Control equipment: Section 15903, CONTROL EQUIPMENT.

1.3 REFERENCES

A. Comply with codes and regulations of the Jurisdictional Authorities.

B. UL listed

C. NEC

1.4 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each:

1. Product Data.

2. Shop Drawings.

3. Certification

a. Successful dielectric testing of electric heating coil at 2,000 volts.

4. Operation and Maintenance Manuals.

1.5 QUALITY ASSURANCE

A. Source Quality Control

1. Test electric heating coils dielectrically at 2,000 volts before shipment.

## PART 2 – PRODUCTS

2.1 EQUIPMENT

A. General Requirements

1. In design and purchase of equipment, provide for interchangeability of items of equipment, subassemblies, parts, motors, starters, and relays.

2. Controls

a. In accordance with Section 15903, CONTROL EQUIPMENT,, with the following additional requirements:

(1) Heaters provided with built-in step controllers.

(2) Heaters of 30 kW or less with manufacturer's standard steps.

(3) An automatic-reset, snap-action, thermal-overheat switch provided to instantly de-energize heating coil when safe operating temperatures are exceeded.

(4) Heating coil interlocked with fan to prevent energization of heating coil while fan is not running.

(5) Control transformer for lower voltage controls.

B. Electric Unit Heaters

1. Factory-assembled unit heaters consisting of heating element, fan, fan motor, housing and outlet diffuser.

a. Casings

(1) Fabricated of galvanized steel or bonderized steel, factory-primed and finished with baked enamel.

(2) Parts rigidly stiffened to prevent vibration and to hold working parts in line.

(3) Casings for suspended-type units designed for direct attachment to hangers.

(4) Ceiling or wall-mounted type brackets furnished as required by manufacturer to support unit.

(5) Casings readily removable for access to interior parts.

(6) Adjustable horizontal vanes, arranged to give uniform air distribution without objectionable drafts.

b. Fan and fan motor

(1) Propeller fan shall be aluminum directly connected to fan motor.

(2) Fan air throw: As shown.

(3) Fan factory-balanced dynamically and designed for quiet operation.

(4) Unit heater/fan motor: Totally enclosed continuous fan-duty sleeve bearing type equipped with built-in thermal overload protection.

(5) Each unit equipped with combination fan guard/motor support resiliently mounted to absorb motor vibration.

(6) Motor speed: 1,750-rpm maximum.

(7) Integral transformer where fan-motor voltage differs from line voltage.

c. Heating element

(1) Resistance wire of corrosion-resistant metal surrounded by finned metal sheath.

(2) Each heating element wired to built-in, line-voltage, automatic-reset, thermal-overheat protection.

(3) Complete controls, contactors, control-circuit transformers factory-assembled and factory-wired.

(4) Unit heaters tested and listed under UL.

(5) Disconnect switch near unit heater.

C. Nameplates

1. Securely attach equipment ID nameplate to each heater.

2. Heater to have manufacturer's nameplate with, model number, serial number, electrical and operating characteristics.

**PART 3 – EXECUTION**

3.1 INSTALLATION

A. Fit equipment and appurtenances to space provided and make readily serviceable.

B. Mount electric unit heaters on vibration isolators in accordance with Section 15070, VIBRATION ISOLATION.

C. Provide supports, hangers and anchor bolts necessary for proper installation of equipment as recommended by manufacturer

END OF SECTION

# SECTION 15810
# DUCTWORK

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for providing ductwork and accessories.

1.2 RELATED REQUIREMENTS

A. Firestopping; Section 07841, FIRESTOPPING.

B. Dampers: Section 15812, DAMPERS

1.3 REFERENCES

A. Comply with codes and regulations of the Jurisdictional Authorities.

B. SMACNA

1. HVAC Duct Construction Standards - Metal and Flexible.
2. Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems.
3. HVAC Systems - Testing, Adjusting and Balancing.
4. HVAC Air Duct Leakage Test Manual.

C. ASTM: A653.

1.4 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each.

1. Shop Drawings
    a. Scale: 1/4-inch minimum
2. Certification.

## PART 2 – PRODUCTS

2.1 EQUIPMENT

A. Galvanized Sheet Steel: ASTM A653.

B. Flexible Material

1. Fibrous-glass cloth, 32 ounces per square yard, UL-listed.
2. Tensile strength: 450-psi minimum.
3. Coated on both sides with fire-resistant neoprene.

2.2 PERFORMANCE REQUIREMENTS

A. Duct Construction

1. Fabrication in accordance with HVAC Duct Construction Standards-Metal and Flexible.

B. Access Doors in Ducts

1. Provide access doors as shown to gain access to resistance heaters, fans, fan motors, dampers, filters, coils, and controls.

2. Doors: Of same metal thickness as ducts.

3. Gasketed doors: Secured to duct.

C. Flexible-Duct Connections

1. Flexible-duct connections provided between air-handling unit fan and related ductwork and wherever necessary to prevent transmission of vibration to adjacent elements.

2. Factory-assembled flexible material bordered each side with 3-inch wide galvanized-steel edging mechanically attached.

3. Width of flexible portion: Three to 9 inches as necessary for installation conditions and to allow freedom of movement without unnecessary slack.

4. Fabric parts of flexible connections: Unpainted.

D. Instrument Test Holes

1. Factory-fabricated, airtight, non-corrosive instrument test hole with screw cap and gasket.

2. Instrument test holes provided where required by balancing and testing agency.

3. Cap extended up through insulation.

**PART 3 – EXECUTION**

3.1 INSTALLATION

A. Ductwork Installation

1. Install dampers and splitters so as to permit adjustment after completion of the Work.

2. Install dampers without strain or distortion of any part of dampers.

3. Duct penetration through fire-rated partitions to be sealed with approved fireproof sealant in accordance with Section 07841, FIRESTOPPING.

4. At in-line fans, provide flanged removable transition to permit access to and removal of fan motor

B. Flexible Connections

1. Install flexible connections in accordance with HVAC Duct Construction Standards – Metal and Flexible.

C. Protection of Ductwork

1. Protect ductwork, appurtenances, and openings from dirt, foreign objects and damage during construction.

2. Replace damaged ductwork and appurtenances.

3.2 FIELD QUALITY CONTROL

A. Air-Leak Tests for Accessible Ductwork: Perform air-leak tests in accordance with SMACNA HVAC Air Duct Leakage Test Manual.

3.3 CLEANING AND PROTECTION

A. Before fans or filters are operated, clean inside of air system, including casing, plenums, and ductwork used for air supply or return.

B. Accomplish cleaning by means of industrial vacuum cleaners, which will effectively remove dust and foreign material from surfaces swept by air stream.

C. Clean exposed ductwork and leave in satisfactory condition, free from grease, oil, and foreign material prior to application of insulation or finish painting.

D. Clean ducts after the system has been used for adjusting, testing, or temporary ventilation.

END OF SECTION

# SECTION 15812
# DAMPERS

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for backdraft and fire dampers for HVAC system applications.

1.2 RELATED REQUIREMENTS

A. Ductwork – Section 15810, DUCTWORK.

1.3 REFERENCES

A. ACMA 500-D – Laboratory Methods for Testing Dampers for Ratings.

1.4 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each.

1. Product Data: Submit manufacturer's product data.

a. Include leakage, pressure drop, and maximum back pressure data.

b. Indicate materials, construction, dimensions, and installation details.

c. Verify damper pressure drop ratings based on tests and procedures performed in accordance with ACMA 500-D.

2. Shop Drawings.

3. Certification.

4. Operation and Maintenance Manuals.

1.5 QUALITY ASSURANCE

A. Codes, Regulations, Reference Standards and Specifications

1. Comply with codes and regulations of the jurisdictional authorities.

2. Dampers shall be warranted against manufacturing defects for a period of 5 years.

3. Pressure Drop Rating: Damper pressure drop ratings based on tests and procedures performed in accordance with AMCA 500-D.

## PART 2 – PRODUCTS

2.1 EQUIPMENT

A. Backdraft Dampers

1. Factory-assembled backdraft damper.

a. Differential Pressure: Dampers shall have a max differential pressure rating of 2 inches wg.

b. Velocity rating: maximum rating of 2500 fpm.

c. Frame: 18 gauge galvanized steel.

d. Blades: aluminum 0.032 inch thick minimum.

e. Mounting: Horizontal or vertical to match application.

f. Finish: Mill finish.

B. Fire Dampers

1. Factory-assembled fire damper

a. Fabricated to meet requirements of codes and regulations of jurisdictional authorities.

b. Constructed so that, during normal operation, folded blade assembly does not interrupt air stream.

c. Access provided for replacement of links.

d. Sleeve provided for fire damper, 14 gauge hot-rolled steel.

e. Fire dampers remote from partitions, connecting ductwork provided between fire damper and fire partition, fabricated of 11-gauge, zinc-coated sheet steel and supported by 1/2-inch diameter rods.

f. Fire dampers constructed to meet requirements of NFPA 90A and UL555.

C. Nameplates

1. Securely attach equipment ID nameplate to each damper.

**PART 3 – EXECUTION**

3.1 INSTALLATION

A. Install dampers in accordance with the Manufacturer's installation instructions.

B. Dampers must be accessible to allow inspection, adjustment, and replacement of components.

C. Install dampers square and free from racking. Do not compress or stretch damper frame into opening.

D. Adjust moving parts to move freely without binding.

E. The installing Subcontractor shall provide and install bracing for multiple section assemblies to support weight and to hold against system pressure.

F. Attach multiple damper section assemblies together in accordance with manufacturer's instructions. Install support mullions as reinforcement between assemblies as required.

G. Handle dampers using the frame. Do not lift or move dampers using blades or shafts.

H. Install fire dampers to conform to fire, smoke, and radiation damper installation guide for HVAC system.

END OF SECTION

# SECTION 15830

# FANS

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for providing fans.

1.2 RELATED REQUIREMENTS

A. Vibration isolation: Section 15070, VIBRATION ISOLATION.

B. Ductwork: 15810, DUCTWORK.

C. Control equipment: Section 15900.

D. Motors: Section 16225, MOTORS.

E. Motor starters and control centers: Section 16425, MOTOR STARTERS AND CONTROL CENTERS.

1.3 REFERENCES

A. Comply with codes and regulations of the Jurisdictional Authorities.

B. AMCA: 210, 99-2408.

C. SAE: 1035, 1040.

1.4 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each.

1. Shop Drawings

a. Performance tests certified by AMCA or performed either in accordance with AMCA 210 or in a laboratory approved by AMCA, for capacities shown.

b. Performance curves for each fan showing brake horsepower, static pressure and static efficiency plotted against air volume and noise level. For reversible fans, submit curves for both forward and reverse modes.

2. Certification

a. Certify that fans are rated and tested in accordance with AMCA 210.

3. Operation and Maintenance Manuals.

1.5 QUALITY ASSURANCE

A. Factory Wiring

1. In accordance with manufacturer's standard practice.

B. Source Quality Control:

1. Notify the Contracting Officer Representative 14 days prior to each test.

## PART 2 – PRODUCTS

2.1 EQUIPMENT

A. General Requirements

1. In design and purchase of equipment, provide for interchangeability of items of equipment, subassemblies, parts, motors starters, and relays.

2. Requirements of this Section apply to fans, which are not a component part of air-handling units designed as complete units by the manufacturer.

3. Fan rating based on tests performed in accordance with AMCA 210.

4. Fans statically and dynamically balanced and quiet in operation.

5. Fans designed to ensure that resonance frequency of blade assembly is not within 15 percent of harmonics of rotational frequency.

6. Finished parts of fans, such as shafts and bearings, protected from rust prior to operation by means of wrappings or protective grease or plastic coatings.

7. Exhaust fans provided with firestats to stop fan when temperature of air being handled reaches 125 degrees F.

   a. Firestats having adjustable range from 100 degrees F to 200 degrees F and manual reset.

8. Fans with wheels less than 12 inches in diameter, and utility fans operating at less than 0.75 inches WG may have forward-curved blades.

9. Fan construction suitable for operating conditions defined in AMCA 99-2408.

B. Centrifugal Fans

1. Class I or II, non-overloading.

2. Fan blades

   a. Fan wheels larger than 30 inches: Backward-inclined air-foil section.

   b. Fan wheels 30 inches or less: Backward-inclined plate-type blades.

3. Air entering fan uniformly over inlet area.

4. Fan housing: Fabricated of steel sheets, manufacturer's standard heavy-gauge construction, except for those of low-pressure fans of less than 5,000-cfm capacity which may be fabricated of aluminum, 0.080-inch thick or heavier.

5. Fan wheel rims and blades: Fabricated of steel, manufacturer's standard heavy-gauge construction, with back plates of steel, 3/16 inch, except for those of low-pressure fans of less than 5,000 cfm which may be fabricated of aluminum, 0.080-inch thick or heavier.

6. Fan wheels: Aluminum or steel provided with manufacturer's standard corrosion-resistant coating. Balanced in accordance to AMCA Standard 204-05.

7. Fan scroll attached to the side plates by means of continuous lock-seam or welded-seam construction.

8. Fan wheels and sheaves splined or keyed and fastened to the shafts with set screws.

9. Shaft constructed solid or hollow of SAE 1035 or SAE 1040 ground and polished steel.

10. One layer of corrosion-resistant coating on nonworking surfaces of shafts, factory-applied.

11. Inspection openings provided for fan housing having wheels larger than 22 inches in diameter.

    a. Cover plate having pressure latches on fan housing on scroll sheets located opposite outlets.

12. Large fan housings provided in sections to permit installation or removal through openings available in structure.

13. Field joints: Flanged and bolted.

14. Fans designed to provide self-limiting, non-overloading power characteristics.

15. Two bearings for double-inlet and single-inlet fans having wheels larger than 36 inches in diameter, one on each side of wheel, with overhung sheaves.

16. Inside and outside of fan housings factory-painted with baked-enamel primer; exterior surfaces given additional factory finish-coat of enamel.

17. Drives provided with belt guard of expanded-metal wire mesh or belt guards with solid-metal side panels with tachometer opening.

18. Motors

    a. One-half horse power and above: Totally enclosed, fan-cooled and guarded in accordance with Section 16225, MOTORS.

    b. Less than 1/2 horsepower: Manufacturer's standard for intended use.

    c. Permanently lubricated, heavy ball bearing type to match with the fan load and pre-wired to the specific voltage and phase.

19. Vibration isolators: In accordance with Section 15070, VIBRATION ISOLATION.

20. Downblast Centrifugal Roof Fans

    a. Fan Unit: Downblast type. V-belt or direct drive, with spun aluminum housing; resilient mounted motor; aluminum wire bird screen; square base to suit roof curb with continuous curb gaskets.

    b. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheave selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre lubricated ball bearing.

C. Propeller Fans

1. Direct-connected motor-driven.

2. Wheels having steel or aluminum blades; statically and dynamically balanced in accordance with AMCA Standard 204 at the factory.

3. Cast or die-formed mounting rings or plates.

    a. Mounting plates designed to prevent distortion.

    b. Mounting plates turned up at edges or braced with steel angles.

4. Wire-mesh guard completely surrounding fan blades.

5. Steel shafts for fans which are not mounted directly on motor shafts.

   a. Shafts accurately finished on working surfaces.

6. Self-aligning sleeve bearings or ball bearings

   a. Sleeve bearings

      (1) Ring oiled sleeve bearings or wool-packed and provided with oil reservoirs.

      (2) Oiling device arranged in manner so that oil can be added while fan is running without danger of over-oiling.

   b. Ball bearings

      (1) Pre-lubricated sealed bearings.

      (2) Factory-installed grease fittings to permit external bearing relubrication.

7. Motors

   a. Up to and including 1/2 HP: Manufacturer's standard.

   b. Above 1/2 HP: Section 16225, MOTORS.

   c. Permanently lubricated, sleeve bearing type.

8. Wall Housing and Collar

   a. Constructed of galvanized steel with heavy gauge mounting flanges and mounting holes. Housing to include OSHA approved motor guard.

D. Nameplates

1. Fans: Securely attach equipment ID nameplate on each fan. Fan shall have manufacturer’s nameplate with model number and serial number.

2. Motors: As specified in Section 16225, MOTORS.

2.2 PROJECT CONDITIONS

A. Safety Requirements:

1. Properly guard belts, pulleys, chains, gears, couplings, projecting set screws, keys, and other rotating parts to prevent danger to personnel.

**PART 3 – EXECUTION**

3.1 INSTALLATION

A. Fit fans and appurtenances within space provided and make readily serviceable.

B. Provide support beams, concrete pads, support legs, platforms, hangers, and anchor bolts required for proper installation of equipment as recommended by manufacturer.

C. Vibration isolation for fans: As specified in Section 15070, VIBRATION ISOLATION.

D. Concrete pads: As specified in Section 15070, VIBRATION ISOLATION.

E. Tubular centrifugal fans: Provide service access in accordance with Section 15810, DUCTWORK

F. Motor starters and control centers: As specified in Section 16425, MOTOR STARTERS AND CONTROL CENTERS.

END OF SECTION

# SECTION 15865
# FILTERS

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for providing air filters.

1.2 RELATED REQUIREMENTS

A. Remote-surveillance devices: Sections 13810 and 15900.

1.3 REFERENCES

A. UL 900 Class 1.

B. ASHRAE: 52.1.

1.4 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each.

1. Shop Drawings.

2. Certification.

1.5 QUALITY ASSURANCE

A. Source Quality Control

1. Factory-tested or tested by an independent laboratory experienced in testing filters; certify compliance with requirements of ASHRAE Standard 52 for arrestance, efficiency, dust-holding capacity, and pressure drop.

## PART 2 – PRODUCTS

2.1 EQUIPMENT

A. General Requirements

1. In design of equipment, provide for interchangeability of items of equipment, subassemblies, and parts.

B. Throwaway (Replaceable) Filters

1. Flat-panel filter units designed and fabricated for disposal when dust-load limit is reached.

2. Dry or adhesive-coated filter media, as standard with the manufacturer.

3. Maximum air flow through filters: Not exceeding manufacturer's published rated capacity but not exceeding 500 feet per minute at 0.10-inch w.g.

4. Designed to fit within space available and constructed so as to prevent passage of unfiltered air.

5. Filter frames constructed of 18-gauge galvanized steel with air-tight access panels for filter inspection, cleaning and replacement.

6. Filters are UL 900 Class I listed.

C. Controls

1. Control panels factory wired.

a. Adjustable pressure-differential sensing device and wiring for remote surveillance.

b. Pressure range of 0.02-inch w.g.to 2.0-inch w.g. Accuracy of plus or minus 0.03-inch w.g.

**PART 3 – EXECUTION**

3.1 INSTALLATION

A. Fit equipment and appurtenances within the space provided and make readily serviceable.

B. After final testing and cleaning of fans and ductwork, replace prefilters and final filter media with new, clean media.

END OF SECTION

# SECTION 15903

# CONTROL PANELS FOR TRACTION POWER, AC SWITCHGEAR, AND TIE BREAKER STATIONS

## PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes:

1. Software.
2. Hydrogen Detection Control Panel 110VAC.
3. Hydrogen Detection Control Panel 24VDC.
4. Environmental Control Panel – TPAC
5. Environmental Control Panel – TBS
6. Sump Pump Control Panel

B. Products furnished but not installed under this Section

1. Final electrical connections under this Section.

1.2 RELATED REQUIREMENTS

A. Section 16145, WIRING AND CONTROL

B. Section 07841, FIRESTOPPING

C. Section 16225, MOTORS

D. Section 16425, MOTOR STARTERS AND CONTROL CENTERS

1.3 REFERENCES

A. ASHRAE 85 - Automatic Control Terminology for Heating, Ventilating, Air Conditioning.

B. ASME MC85.1 - Terminology for Automatic Control.

C. NFPA 70 National Electrical Code 2011 edition.

D. NFPA 79 Electrical Standards for Industrial Machinery.

E. IEC Wiring Codes for AC/DC Branch Circuits.

F. UL 508A Industrial Control Panels.

G. UL 514B Fittings for Conduit and Outlet Boxes.

H. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

1.4 DEFINITIONS

A. Abbreviations used in this Section include the following. Additional abbreviations are indicated on the Contract Drawings.

AGND ANALOG GROUND

| | |
|---|---|
| AHU | Air Handling Unit |
| AMP | Ampere |
| AWG | American Wire Gauge |
| BL | Blue |
| BLK | Black |
| CB | Circuit Breaker |
| COMM | Communications |
| CR | CONTROL RELAY |
| DIN | Component Mounting Rail |
| DP | Differential Pressure |
| DPDT | Double Pole Double Throw |
| EA | Each |
| EF | Exhaust Fan |
| GND | Ground |
| GRN | Green |
| GRY | Gray |
| HMI | Human Machine Interface |
| HOA | Hand-Off-Auto |
| HDCP | HYDROGEN DETECTION CONTROL PANEL |
| LS | Limit Switch |
| MA | Milliamps |
| MAX | Maximum |
| MFR | Manufacturer |
| MIN | Minimum |
| MS | Motor Starter |
| MTW | Machine Tool Wire |
| NC | Normally Closed |
| NIC | Not In Contract |
| NO | Normally Open |
| NTS | Not To Scale |
| ORG | Orange |

| | |
|---|---|
| PLC | Programmable Logic Controller |
| POE | Power over Ethernet |
| RTD | Resistance Temperature Detector |
| RTN | VDC RETURN |
| SP | Sump Pump |
| SPDT | Single Pole Double Throw |
| SPST | Single Pole Single Throw |
| SWGR | Switchgear |
| TB | Terminal Block |
| TCP | Transmission Control Protocol |
| THHN | Thermoplastic High Heat Resistant Nylon |
| TPSS | Traction Power Substation |
| TP/AC | Traction Power Substation Alternating Current Switchgear |
| TYP | Typical |
| UH | Unit Heater |
| VAC | Volts Alternating Current |
| VDC | Volts Direct Current |
| VU | Ventilator Unit |
| W/ | With |
| WMATA | Washington Area Metropolitan Transit Authority |
| WHT | WHITE |
| YEL | YELLOW |
| # | Number |

B. Standards

1. Power wire colors

a. 480 V

(1) Phase 1: Black with Brown Tape

(2) Phase 2: Black with Orange Tape

(3) Phase 3: Black with Yellow Tape

(4) Neutral: White

(5) Ground: Green with Yellow Stripe

b. 110 V

(1) Hot: Black

(2) Neutral: White

(3) Ground: Green with Yellow Stripe

c. 24 VDC

(1) Positive (+) Blue

(2) Negative (-) White with Blue Stripe

d. Other and Miscellaneous

(1) Green or Green with Yellow Stripe will only be used for ground wire

(2) Orange is to be used for wires that remain energized when the main supply circuit disconnect is in the off position

2. Control wire colors

a. AC Control Circuits 110V: Red

b. PLC Inputs: Violet

c. PLC Outputs: Grey

d. Miscellaneous circuits and data collection circuits: Brown

e. Externally fed circuits (Interlocks): Yellow

3. Ethernet wiring: various

4. Cabinet

a. Cabinets to be NEMA 4X.

b. Cabinets to be three point latched with quarter turn handle capable of being padlocked

c. External cabinet labeling to be screwed and glued in place on white background with black engraved lettering

5. Wire

a. All wires to be identified with Brady heat shrink machine labeled sleeves.

b. Control panel wire to be stranded wires, 12 gauge and below to have end ferrules, all wires to be stranded MTW (Machine Tool Wire) or THHN (Thermoplastic High Heat-resistant Nylon-coated) wire.

c. All analog wire shall be shielded twisted pair with single point ground.

6. Wire Routing

a. Wire to be routed in wire duct or spiral loom and mechanically fastened where practical inside control panel.

7. Terminal Blocks

   a. Terminal Blocks to be screwed lug terminal blocks and colored to match above wiring color schematic.

   b. Terminal Blocks to be mounted on DIN rails, these DIN rails will be mounted to the panel with bracket supports where practical. Angled bracket supports will be used for terminal blocks requiring field wiring where practical.

   c. 10 percent spare terminal blocks to be installed.

   d. Terminal strip to have grounding lug to back panel.

8. Panel Board Connections

   a. All connections on the Panel Board will be with fasteners and threaded holes (panel board holes to be threaded).

   b. Back panel to be grounded to enclosure.

9. Miscellaneous Equipment

   a. PLCs, 24V power supply, and breakers, shall be mounted flush on DIN rails (no angle brackets).

   b. All equipment and internal component shall be identified using machine printed label on back plate, visible with component in place. Letters to be minimum 1/4 inch tall.

   c. Use circuit breakers as opposed to fuses where code allows.

   d. Ice cube relays to have LED indicator light, manual activation button, and independent DIN rail base.

## 1.5 SUBMITTALS

A. General: Follow procedures specified in Division 1 Sections for Submittals, project record documents, and operation and maintenance manuals. All information shall be contained in three-ring binders, logically divided into sections with a detailed table of contents for each binder and each section. All information shall be letter size. AutoCAD drawings shall be 22” x 34” printed at half scale and folded 11-inch by 17-inch size. All documents shall be submitted through PROCORE project folder in PDF format and all final AutoCAD drawings shall be submitted in AutoCAD 2013 format.

B. At the time of Bid, submit an outline of the process for system start-up, testing, commissioning, and demonstration. Describe the activities intended to be performed and the expected results.

C. Compliance with Specifications

   1. At the time of Bid, submit a copy of this Section, and in the right-hand margin, clearly indicate compliance with the Specification on a point-by-point basis.

   2. Where the proposed system complies fully, indicate by placing the word “comply” in the right-hand margin.

   3. Where the proposed system does not comply, or accomplishes the stated function in manner different from that described, provide a full description of the deviation. Use a separate sheet of paper if necessary.

D. Product data

1. Submit manufacturer's specifications, catalog cuts, and technical bulletins for each control device and equipment, including installation instructions and start-up instructions. Clearly identify, by use of symbol or tag number, the service of each item. All irrelevant information shall be marked out leaving only pertinent data.

E. Shop Drawings

1. System schematic and ladder logic diagram.

2. Floor Plans: Floor plans indicating locations of Control Panels, and routing of all conduit and cable.

3. Schematic diagrams to indicate interface between Control Panels, remote panels/sensing devices and power sources. All drawings shall be prepared on a CAD system that produces drawing files that are either compatible with or that may be converted to AUTOCAD Release 2013 or higher and be provided on a disk.

4. Sequences of Operation: Complete narrative text describing, for this Project, sequences of operation and system performance, including control schematic diagrams.

F. Quality Control Submittals

1. Test Log: Sample of checkout sheets to be used later, under testing, to check off that each point is performing properly.

2. Test Reports: Reports of field testing indicating proper performance of all systems and points.

G. Closeout Submittals

1. Operation and Maintenance Manuals: All information shall be contained in three ring binders and PDF electronic format on disk or flash drive, logically divided into sections with a detailed table of contents for each binder and each section. All information shall be either letter size or folded 11-inch by 17-inch size. Electronic PDF version of complete Operation and Maintenance Manuals shall also be supplied.

   a. All O&M Manual data shall be modified from the submittal data to include changes made in the field during construction, demonstration testing, and commissioning. The O&M Manuals shall, therefore, represent the "as-built" condition corrected for testing and commissioning.

   b. Manufacturer's/Installer's name, address, phone number, and e-mail address.

   c. Written Sequences of Operation.

   d. Control Diagrams.

   e. Two end user software licenses for all Programming Software utilized in installed system.

   f. Electronic copy of software programs including but not limited to passwords, any proprietary information needed for full access to program and ability to make programming changes.

   g. Maintenance and Repair Instructions.

   h. Product data.

   i. Parts List, with manufacturer's catalog numbers and ordering information.

j. Lists of ordinary and special tools, operating materials, supplies, and test equipment recommended for operation and servicing.

k. List of spare parts with current prices, which supplier recommends that the Authority purchase.

H. Project Record Documents: Accurately record actual location of control components, including panels, auxiliary equipment, and remote sensors.

1. Revise Shop Drawings to reflect actual installation and operating sequences.

2. Include data specified in Submittals in final Record Documents form.

I. Warranty: Special warranty specified in this Section.

1.6 QUALITY ASSURANCE

A. Qualifications

1. Subject to meeting all specified features and performance, acceptable manufacturers are Automation Direct and ICP-DAS-USA or approved equal.

2. The manufacturer and installer shall have a minimum of 5 years of demonstrated technical expertise and experience in the manufacture, installation and maintenance of Control Panels similar in size and complexity to this project. A list of successful past projects of similar type, size, and complexity shall be submitted. In addition, a reference list of names, addresses, and telephone numbers of the design engineer and the owner's representative for each installation shall be provided. The references may be contacted and questioned about the timely delivery, installation, operation and service received for each installation.

3. The manufacturer and installer shall maintain a competent service organization within 50 miles of the project site, for a period of not less than 5 years. Facility shall include spare parts inventory and all necessary test and diagnostic equipment.

4. Control components shall be products of the same manufacturer only, unless indicated otherwise.

B. Regulatory Requirements

1. Comply with all codes and local regulations. Meet all requirements of local authorities and State Fire Marshal.

2. Electrical standards: Provide electrical products, which have been tested, listed and labeled by Underwriters' Laboratories (UL) and comply with NEMA standards. Electrical work shall be installed in accordance with NEC.

3. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Section 15, and Governing Radio Frequency Electromagnetic Interference and be so labeled.

C. All system components shall be fault-tolerant

1. Components shall maintain satisfactory operation without damage at 110 percent and 85 percent of rated voltage and at plus 3-Hertz variation in line frequency.

2. Provide static, transient and short-circuit protection on all inputs and outputs.

3. Protect communication lines against incorrect wiring, static transients, and induced magnetic interference.

4. Failure of network-connected devices shall not disrupt or halt network communication.

D. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability to upgrade the existing field panels to the latest technology and the ability to install the newest field panel on the existing network without bridges, routers, protocol converters, or gateways.

E. Pre-Installation Meeting

1. Convene a conference 2 weeks prior to commencing work of this Section, under provisions of Division 1.

2. Require attendance of parties directly affecting the Work of this Section.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Provide factory shipping cartons for each piece of equipment and control device. Store equipment and materials inside and protected from weather.

1.8 WARRANTY/BONDS

A. Special Warranty: Manufacturer's standard or custom form in which manufacturer and Installer, through the Contractor, agree to repair, reprogram, or replace system components, system software, and parts that fail in defective materials or workmanship within specified warranty period.

1. Provide labor at no charge during the warranty period.

2. Update all corrective software modifications made during warranty periods on all user documentation and on user and manufacturer archived software disks.

3. All work shall have a single warranty date, even when the Authority has received beneficial use due to an early system startup. If the work specified is split into multiple contracts or a multi-phase contract, then each contract or phase shall have a separate warranty start date and period as agreed to by WMATA and Contractor.

4. At the end of the final startup, testing, and commissioning phase, if equipment and systems are operating satisfactorily to the Contracting Officer Representative, the Contracting Officer Representative will sign certificates certifying that the control system’s operation has been tested and accepted in accordance with the terms of this Section.

5. Software and firmware updates which resolve known software deficiencies as identified by the Control System Contractor shall be provided to WMATA at no charge during the warranty period. Upgrades or functional enhancements associated with the above mentioned items also can be provided during the warranty period under the Maintenance Service Agreement. Obtain written authorization from WMATA prior to the installation of any of the abovementioned items.

6. Warranty Period: One year from date of Project completion.

**PART 2 – PRODUCTS**

2.1 PERFORMANCE REQUIREMENTS

A. System Description

1. Provide a complete and operational Control Panel, fully connecting, activating, testing and verifying all points as outlined in the Sequences of Operation and the Points List, and meeting the system requirements specified.

2. Provide hardware, equipment, wiring, software, inputs, outputs, and controllers, in quantities and locations as required, to meet the functions, performance, and sequences specified and indicated.

3. Protocol: The Control Panels shall use Modbus RTU communication protocols for local systems within the Traction Power Sub Station, AC Switchgear Room, or Tie Breaker Station and Modbus TCP protocol for all communications over the Ethernet beyond the above listed rooms.

4. The system shall be capable of being operated and maintained by competent Authority's staff members without additional materials and services. Provide all software, instruction manuals, operation manuals, maintenance manuals, programming manuals, diagrams, diagnostic or exercise software, configuration/binding tool, and all special accessories that would typically be required to ensure initial and continued system operational integrity in the proposed configuration.

5. Control wiring, both line voltage and low voltage, to serve controls components is Work of this Section.

6. Electrical Power

   a. Coordinate with electrical Work to determine acceptable emergency electrical panels and circuits at which to obtain power.

7. Provide and locate control devices required to perform the specified Sequences of Operation according to the supplied drawings

8. Following control devices shall be furnished and connected under this Section and installed under other Sections of Division 15 work in accordance with control manufacturer's instructions. Coordinate to achieve proper location of these devices.

9. Power Failure

   a. No loss of functionality or memory

      (1) Power failure and switching to and from generator or normal power shall result in no loss of software, data, set-points, or time clock operation.

      (2) Applications shall be kept in non-volatile flash memory to prevent loss of data in the event of loss of power.

      (3) Restoration of Power

         (a) Automatic return to normal operation.

         (b) Network communication shall be unaffected and instantly available upon restoration of power.

         (c) Controller and panel outputs shall, at a minimum, be configured to return to the last commanded state within 30 seconds upon restoration of power.

B. Manufacturers

1. Automation Direct

2. ICP-DAS-USA

3. Greystone Energy Systems, Inc.

4. Honeywell

C. Electric Wiring and Devices

1. Under this Section

a. Electric wiring and wiring connections required for installation of control system.

(1) Provide under this Section unless specifically shown on Contract Drawings or specified to be under Division 16, Electrical.

(2) Wiring shall comply with requirements of State and National Electrical Codes.

b. Low Voltage Wiring: Class II control cable.

(1) Concealed and accessible as permitted by State Codes.

(2) Otherwise, installed in conduit in accordance with Division 16, Electrical.

D. Control Panel Hardware

1. General

a. Provide a full Control Panel consisting of the following digital elements:

(1) All equipment furnished under this Contract shall be UL listed or CE certified.

b. All materials shall be standard components regularly manufactured for this and other systems and not custom designed especially for this project. All components shall have been thoroughly tested and proven in actual use.

c. The Control Panel shall monitor and control the equipment with respect to the sequence of operation.

d. Provide all hardware and software necessary for the complete and operable system specified herein. This includes all Control Panel components, external sensors and HMI interface components/software required to perform the sequences intended.

e. All components for each control unit shall be prewired within a metal cabinet NEMA 4/12 rated with a continuous hinge. Cabinet shall be wall mountable and manufactured of furniture grade steel with a light-grey polyester powder paint finish inside and out. The panel doors shall be hinged type equipped with a latch system with quarter turn latches. Cabinet, power supply, electrical components, and termination modules (numbered) shall be UL labeled.

(1) Standard of acceptance: See Panel Drawing Schedule and Details or approved equal.

E. Control Panel Software

1. The Control Panel shall provide stand-alone operation and shall accept analog and discrete signals from sensors, switches, and relays and shall multiplex the various signals into digital format. All standard and custom control controller based algorithms shall operate independently, and systems that require an on-line host computer or intermediary processor to control mechanical or electrical equipment are not acceptable.

2. Programming will be performed by WMATA.

3. The controller shall provide a power-fail restart routine

4. Alarms

a. Alarm programing will be performed by WMATA.

F. Overrides and Interlocks

1. Provide the capability to manually override any Control Panel functions. Manually initiated overrides shall be local only. The controller shall also be capable of providing event initiated overrides of normal control algorithms.

G. Stand Alone Data Collection

1. The Control Panel TPAC HMI shall be capable or standalone data collection with an ftp server for remote retrieval over the Ethernet.

   a. All discrete or analog input shall be capable of being used to calculate and display consumable data such as; GPM, KWH, and #/hour. This information shall be displayed at the HMI.

   b. The Control Panel TBS HMI is limited to local control of associated equipment.

H. Networking

1. The Control Panels (TPAC & TBS) shall include the inherent ability to be networked with other system elements to allow a dynamic exchange and sharing of information without the addition of communication cards or additional software. Systems that require a host computer to be in the system architecture or on-line are not acceptable. This information exchange shall include but not be limited to the following:

   a. Broadcast of time and date.

   b. Data transfer to receive and utilize I/O point data from and to other system elements.

I. Communicating Input/output

1. The communications input/output modules shall be connected to each other in the facility and transferred to the Ethernet for remote monitoring. The modules shall be capable of performing the following functions:

   a. Interface between remotely located panels and sensing devices.

2. Communication between panels shall be Modbus RTU and remote monitoring shall be Modbus TCP.

J. Communication Bus

1. The Modbus RTU Communications Bus shall be a three-conductor cable with shield. EIA Standard RS-485 Communications protocol shall be employed.

2. The Ethernet Modbus TCP Communication Bus shall be CAT6 cable.

3. Communications Bus shall be capable of having multiple system elements connected. Each Communications Bus shall allow for the use of modules as an interface to secondary Buses.

K. Field Installed Sensors and Actuators

1. Temperature Sensors

   a. Temperature sensors shall meet, at minimum, the following requirements:

      (1) Aluminum LB or ABS enclosure with PVC sun and windscreen.

      (2) Wall mounts weatherproof enclosure with conduit entrance.

(3) The Space/Temperature Sensors shall be mounted approximately 60 inches above the floor, unless otherwise shown on plans.

b. Temperature Sensors connected to the Control TBS shall be 10,000-ohm thermistor Type 3.

(1) Inside temperature sensor standard of acceptance: Greenstone TE200F series or approved equal.

(2) Outside temperature sensor standard of acceptance: Kele ST-A3 series or approved equal.

c. Temperature Sensors connected to the Control TPAC shall be RTD transmitter type 4 to 20 mA output.

(1) Transmitters shall meet at minimum the following requirements.

(a) Measuring range: 10 to 95 percent RH; -15 to 60 degrees Celcius

(b) 24 Vac/DC power supply.

(c) 0 to 10V, 4 to 20 mA.

(d) Digital output: Modbus RTU

(e) Accuracy: plus or minus 2.5 percent RH; plus or minus 0.3 degrees Celsius

(2) Standard of acceptance: E+E Electronic EE160 series or approved equal.

2. The Differential Pressure Transducers shall convert a 0 to 5-inch water column differential to a 4 to 20-mA analog output signal.

a. Standard of acceptance: Mamac Systems PR-274/275 or approved equal.

3. The current switch connected to the Control Panel TBS shall be an enclosed solid core AC sensor. It shall have a solid state switch SPST. A fixed threshold of 0.25 Amp. Current below the threshold shall open the switch and current above the threshold shall close the switch.

(1) Standard of acceptance: Functional Devices RIBXKF series or approved equal.

4. The current switch connected to the Control Panel TPAC shall be an enclosed solid core AC sensor. It shall have a solid state switch SPST, selectable for Normally Open or Normally Closed operation. A selectable threshold between 1 to 175 Amps.

(1) Standard of acceptance: Automation Direct AC TR050-42L-F series or approved equal.

L. Hydrogen Detection Control Panels

1. There are two configurations of the Hydrogen Detection Control Panel. One 110-volt AC and the other is 24 volt DC. The 110-volt panels are used in the TPSS and AC Switchgear rooms. The 110 VAC configurations is used to take advantage of paring the signal and power wiring in a single conduit from the Control Panel TPAC (which is 110VAC). The 24 DC panels are used in the TBS rooms. The 24 VDC configurations is used to take advantage of paring the signal and power wiring in a single conduit from the Control Panel TBS (which is 24 VDC) in a single conduit.

2. Hydrogen Gas Detector

a. The hydrogen gas detector shall be a complete monitoring system with the following characteristics:

(1) Universal power inputs - can be hard-wired to operate on 110/220 Vac or 12 to 48 Vdc input.

(2) Two mechanical relays, easily accessible:

(a) Max Switching voltage 28 Vdc, 277 Vac

(b) Rated Current 10A @ 277 Vac, 15A @ 125 Vac

(c) Relay activation at 1 percent and 2 percent hydrogen concentration, which are below the Lower Explosive Limit.

(3) Push button diagnostic test

(4) Hydrogen sensor is UL Class 1 Division 2, ATEX, and CE certified for hazardous locations

(5) Sensor has a temperature rating of minus 4 degrees F to 176 degrees F

(6) Visual and Audible alarm.

(7) Sensor is field replaceable with quick connect fitting and can be factory or field recalibrated.

(a) Standard of acceptance: Storage Battery System SBS-H2 or approved equal

M. Sequence of operation

1. The programing of controls for the sequence of operation will be performed by WMATA. For a general understanding of the equipment intent the sequence will conform to WMATA design criteria with some exceptions noted here:

a. Programmable controls are not currently employed for the mechanical systems in the TP/AC and TBS locations. Programming will include automatic setback of heating to 50 degrees F after a fixed period of time. Ventilation fans will be called for at temperature threshes holds set forth in the design criteria.

b. Hydrogen exhaust fans will operate on a continuous basis. If the hydrogen level reaches 1 percent concentration, the room ventilation fans will be turned on until the concentration level drops below 1 percent.

c. Duplex sump pumps will be set for alternate duty no assist.

N. Operating Software

1. WMATA will provide the operating software provided the standard of acceptance used.

2.2 SITE CONDITIONS

A. All equipment and devices shall be capable of operation in the following conditions without detriment:

1. 32 to 115 degrees F

2. 0 to 95 percent RH (non-condensing).

**PART 3 – EXECUTION**

3.1 EXAMINATION

A. Prior to starting work, carefully inspect installed work of other trades and verify that such work is complete to the point where work of this Section may properly commence.

B. Notify the Contracting Officer Representative in writing of conditions detrimental to the proper and timely completion of the Work.

3.2 INSTALLATION

A. Accessibility: Locate and install components for easy accessibility. In general, provide three feet of clearance in front of panels.

B. Wiring and Conduit:

1. Provide line voltage and low voltage wiring to serve all components.

2. Coordinate with Electrical Work to determine acceptable electrical panels at which to obtain power.

3. Line voltage wiring:

a. Install in conduit and in accordance with the NEC and with the requirements given in Electrical Specifications for this Project.

4. Low Voltage Wiring:

a. Install without splices between terminal points, color-coded. Install in neat workmanlike manner, securely fastened. Install in accordance with NEC.

b. All wiring shall be installed in conduit.

C. Provide firestopping material at all penetrations of fire-rated partitions, walls, and floors. Firestopping is specified in Section 07841, FIRESTOPPING.

3.3 CONSTRUCTION

A. Interface with Other Work

1. Coordinate with applicable electrical Sections for installation of proper electrical devices such as, momentary start-stops, on-off switches, and auxiliary contacts for proper system operation.

2. Integrate controls with equipment furnished controls for proper system operation.

3. Coordinate with Fire Alarm Work and Security Electronics Work, including locations and quantities of contact closures, zoning arrangement, and all related interface points.

3.4 DEMONSTRATION

A. At completion of testing, demonstrate the system to WMATA's representatives.

END OF SECTION

# SECTION 15950

# SYSTEM BALANCING AND TESTING

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for balancing, adjusting and performance-testing of heating, exhaust, and ventilating systems with ductwork.

1.2 RELATED REQUIREMENTS

A. Section 15205, PIPING SYSTEMS

B. Section 15725, VENTILATING UNITS

C. Section 15810, DUCTWORK

D. Section 15830, FANS

E. Section 15850

1.3 REFERENCES

A. NEBB: Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems.

B. ASHRAE III: Practices for Measurement, Testing, Adjusting and Balancing of Building HVACR Systems.

1.4 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each.

1. Shop Drawings

a. Test and instrument location plans.

b. After initial balancing measurements, submit Shop Drawings for additional equipment such as balancing dampers and pressure taps necessary to effect proper air and water balance.

2. Certification

a. Testing and balancing work to be performed by NEBB Certified personnel.

b. Complete air -balance report certified by professional engineer licensed in the jurisdiction where the Work is to be performed.

c. Collect data in accordance with referenced standards.

d. Submit complete data on standard NEBB testing and balancing report forms without omissions or on approved report forms bearing identical data. Data to include types, serial numbers and calibration dates of instruments and to cover the following:

(1) Ventilating units: Section 15725, VENTILATING UNITS.

(2) Fans: Section 15830, FANS.

(3) Electric heating coil: Section 15725, VENTILATING FANS.

(4) Ductwork including transverse and pilot tube test: Section 15810, DUCTWORK.

(5) Air outlets: Section 15850.

1.5 QUALITY ASSURANCE

A. Instrument Calibration

1. Calibrate instruments required for air balance within 6 months prior to use on this project. Documentation of calibration shall be available to Authority upon request.

**PART 2 – PRODUCTS**

2.1 EQUIPMENT

A. Provide, as specified in Section 15810, DUCTWORK, and Section 15205, PIPING SYSTEMS, additional equipment, such as balancing dampers and pressure taps necessary to affect proper air balance.

2.2 PERFORMANCE REQUIREMENTS

**PART 3 – EXECUTION**

3.1 INSTALLATION

A. Balancing and Performance Testing

1. After completion of installation of heating, exhaust, and prior to acceptance by the Contracting Officer Representative, adjust and balance ventilation systems, and appurtenances applicable to those systems to deliver the air quantities as specified and as shown, within plus or minus 10 percent of the design value. Make final tests after modifications are completed. Seal instrument test holes upon completion of balancing operation.

2. Air Balance

a. Perform testing in accordance with referenced NEBB Standard, ASHRAE 111, or other approved standard.

b. Perform tests, adjust, and balance when outside conditions approximate design conditions as shown for heating functions.

END OF SECTION

# SECTION 16052

# BASIC MATERIALS AND METHODS FOR TRACTION POWER

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for furnishing and installing basic materials for traction power.

1.2 RELATED REQUIREMENTS

A. Section 16128, WIRE AND CABLE FOR TRACTION POWER

B. Section 16260, UNINTERRUPTIBLE POWER SYSTEM (STATIC)

C. Section 16261, TRANSFORMER-RECTIFIER UNITS FOR TRACTION POWER

D. Section 16291, LOCAL ANNUNCIATOR PANEL FOR TRACTION POWER

E. Section 16292, REMOTE TERMINAL UNIT (AEMS RTU) FOR TRACTION POWER

F. Section 16293, MIMIC PANEL-STORAGE YARD

G. Section 16294, CONTACT RAIL HEATING SYSTEM FOR TRACTION POWER

H. Section 16321, HIGH VOLTAGE AC SWITCHGEAR (13.8KV) FOR TRACTION POWER

I. Section 16322, HIGH VOLTAGE AC SWITCHGEAR (34.5KV) FOR TRACTION POWER

J. Section 16341, METAL-ENCLOSED DC SWITCHGEAR FOR TRACTION POWER

K. Section 16441, DRAINAGE AND NEGATIVE SWITCHBOARD

L. Section 16451, SUBSTATION BUSWAY FOR TRACTION POWer

1.3 REFERENCES

A. Codes and regulations of Jurisdictional Authorities

B. NEC

C. UL: 6, 50, 67, 94, 198D, 224, 360, 486, 489, 496, 508, 514, 651, 870, 1029, 1572

D. ASTM: A36, A47, A123, A153, A325, A386, A500, A507, A523, A525, A532, A536, B138, B187, B633, D149, D150, D257, D412, D495, D570, D638, D648, D696, D790, D792, D1000, D1056, D1518, D1682, D1784, D2240, D2583, E84, F593, F594, G21, G235

E. ANSI: C80.1, C80.5, Z55.1, A14.1, B18.21.1, C119.1

F. NEMA: VE1, AB1, PB1,CC1, ST-20, FG-1, 250

G. FS: TT-S-227, FF-S-760, FF-S-325,

H. ACI: 318

I. MS: MIL-I-23053/15

1.4 SUBMITTALS

A. Submit the following for review in accordance with the instructions elsewhere in this.Section and with the additional requirements as specified for each.

1. Shop Drawings: Shop drawings for cable trays and mounting details, DTS Cabinet, complete ETS Enclosure including all devices and components, ETS light fixture and remote ballast, ETS relay cabinet, panelboards, fiberglass panels, plastic material, and through-floor barrier/firestop.

2. Submit Shop Drawings for incoming service cable tray to the Contracting Officer Representative for approval by PEPCO and Virginia Power.

3. Certification: Certificates from manufacturers verifying that equipment furnished conforms to the specified requirements.

4. Product Data: Manufacturer's product data for all materials.

5. Samples: ETS enclosure and light fixture, one of each size nameplate, tags, wire labels, contact rail cable connector assembly, plastic material, and danger markers.

1.5 QUALITY ASSURANCE

A. Qualifications: Select manufacturers who are regularly engaged in production of specified materials. Select installation contractors who are regularly engaged in the installation of specified materials.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Mark each item in accordance with applicable reference standard.

B. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage.

C. Store products in secure and dry storage facility.

**PART 2 – PRODUCTS**

2.1 MATERIALS

A. Floor Sealant

1. Floor sealant: Water-epoxy concrete floor protective coating providing good resistance to wear, abrasion, soiling, and chemical attack.

a. Product: Tennant ECO-LTS (405) coating system mixed with Tennant 413SF solvent-free bonding additive (for first coat only) as manufactured by Tennant Company, Minneapolis, or approved equal.

b. Tennant 409 Pre-Kote cleaner or approved equal, for floor preparation and better adhesion of the coating.

B. Insulated Floor Topping

1. Description: Insulated floor topping consisting of epoxy resin with filler where indicated. Gray color.

2. Epoxy resistivity: Minimum $10^{12}$ ohm-cm.

3. Epoxy manufacturers: Hallemite Grey Amazite by Hallemite, 25 Holden Street, Providence, R.I., 02908, or FX-70-6EE by Fox Industries, 3100 Falls Cliff Road, Baltimore, MD, 21211, or approved equal.

4. Filler: Manufacturer's standard for this service.

C. Furniture

1. Workbench: Heavy duty, 2-5/8-inch laminated maple top, 35 inches high by 60 inches wide by 30 inches deep with steel base, which can be bolted to the floor. Provided with three 14-inch wide by 22-inch deep by 6-inch high drawers, one 20-inch deep by 50-inch wide by 20-inch high cabinet with center shelves and two steel doors. Provided with 4-inch toe clearance.

2. Stool: 14-inch diameter seat with tubular steel adjusting leg extensions that lock securely at 1-inch intervals, adjustable from 18 inches to 27 inches.

3. Storage Cabinet: Steel, 36 inches high, 60 inches long and 16 inches deep with one, adjustable height shelf supported every 15 inches. Provided with four doors.

4. Stepladder: Wood, heavy duty, eight-foot. ANSI A14.1, Type 1, industrial.

5. Finish for metallic surfaces: Cleaned, degreased, primed with zinc primer and finished with one coat of light gray enamel, ANSI Z55.1, color 61, minimum dry film thickness: one mil.

2.2 EQUIPMENT

A. Conduit, Cable Tray, Boxes, Cabinets, and Fittings.

1. General Requirements

a. Size: As shown, minimum conduit size 3/4 inch.

b. Materials

(1) Steel sheet: ASTM A507.

(2) Zinc-coated steel sheet: ASTM A653, coating G235.

(3) Malleable iron: ASTM A47

(4) Cast iron: ASTM A532

(5) Ductile iron: ASTM A536

(6) Fiberglass Reinforced Polyester (FRE): NEMA FG-1

(7) Bronze Extrusion: ASTM B455, Alloy C38500

(8) Bronze Casting: ASTM B584, Alloy C38600

c. Zinc coating

(1) Hot Dip Galvanizing: ASTM A123 and ASTM A386

(2) Electrogalvanizing: ASTM B633

2. Galvanized Steel Rigid Conduit and Fittings: UL 6 and ANSI C80.1, zinc coating tested in accordance with reference test in appendix.

3. Aluminum Rigid Conduit and Fittings

    a. ANSI C80.5 and UL6.

4. Liquid-tight Flexible Conduit and Fittings: (for use with galvanized steel rigid conduit)

    a. Applicable requirements of UL 360.

    b. Flexible galvanized steel core with extruded liquid-tight neoprene or PVC jacket overall.

    c. Sizes up to 1-1/4 inches provided with continuous copper bonding conductor, spiral wound between convolutions.

    d. Sizes 1-1/2 inches and above provided with separate grounding conductor.

5. Rigid fiberglass reinforced epoxy conduits and fittings

    a. Rigid fiberglass reinforced epoxy conduit, UL 1684, IPS (Iron Pipe Size) based conduit.

    b. Conduit shall be manufactured by using filament winding process with minimum fiberglass content of 65 percent by weight and no fillers.

    c. IPS based conduit shall have nominal wall thickness of 0.09 inch for 5-inch nominal conduit size.

    d. Conduits, elbows and fittings manufactured from the same material and using the same manufacturing process.

    e. Conduit sections formed with integral bell-and-spigot type couplings shall use adhesive epoxy compound to make the joints watertight. Rubber sealing gasket at bell end is prohibited.

    f. Adhesive epoxy compound as recommended by conduit manufacturer.

    g. Conduits, elbows and fittings are specified for use throughout a temperature range of minus 40 degrees F to 230 degrees F, and they are to be protected from exposure to sunlight by pigmentation uniformly dispersed through the resin material.

    h. Conduits, elbows and fittings shall be suitable for encasement in concrete below grade and conform to UL 1684, and listed and labeled by UL meeting the requirements of NEC Article 347 for Rigid Nonmetallic Conduit and its use.

6. Conduit Expansion Fittings: Weatherproof, fabricated from material compatible with conduit with which fittings are to be used. Metallic fittings equipped with bonding jumper cable to provide electrical continuity.

7. Conduit Connector Fittings

    a. UL 514, material and finish similar to that of conduit with which they are to be used.

    b. Indoor Locations: For enclosures, cabinets, boxes, and gutters: Nylon-insulated bushing and locknut.

    c. Outdoor Locations: Watertight nylon-insulated bushing and locknut for termination of galvanized rigid steel conduit. Watertight PVC threaded adapter with 0-ring and locknut or bushings for termination of PVC conduit.

8. Conduit seal

    a. To provide watertight seal between concrete and conduit where it penetrates wall, floor, or ceiling.

    b. Size as shown or necessary.

    c. Materials: Body and pressure clamp of malleable or cast iron with a neoprene sealing grommet and PVC-coated or galvanized-steel pressure rings, oversized sleeve of PVC or galvanized.

    d. Seal between conduit and concrete to withstand pressure from 50-foot head of water without leakage.

9. Cable and Seal Fittings

    a. To provide watertight seal between cable and conduit for use with single-conductor or multiple-conductor cable as necessary.

    b. Size as necessary, drilled to accommodate cable.

    c. Pressure discs of PVC-coated steel and sealing ring of neoprene.

    d. Seal between cable and conduit to withstand water pressure of 50 psi without leakage.

    e. O-Z type CSBI, CSBE or approve equal as shown on Contract Drawings.

    f. Seal all unused conduits for traction power and auxiliary power using blank seals.

10. Seal Compound

    a. FS TT-S-227, two-component, fast-setting, polymeric sealing compound to provide watertight seal between cable and conduit.

    b. Pour-type for horizontal and gun-grade for vertical or overhead application.

    c. When cured, sealant to have rubber-like flexibility allowing minimum movement of conduit and cable in temperature range of minus 10 degrees F to plus 150 degrees F without loss of watertight seal.

    d. Pot life: 15 minutes.

    e. Minimum ambient temperature for application: 35 degrees F.

    f. Initial cure: 15 minutes.

    g. Final cure: Seven days.

    h. Hardness, Durometer A: 20 to 35.

    i. Seal between conduit and single-conductor or multiple-conductor cable to withstand water pressure of 50 psi without leakage.

    j. Fox Industries, Type FX-571G or approved equal.

11. Conduit, Cable Tray and Cable Supports

    a. Retaining straps and fasteners: FS FF-S-760, with the following additional requirements:

        (1) Type, style, and size: As necessary.

(2) Material and finish: Steel or malleable iron, hot-dip galvanized after fabrication, fiberglass reinforced polyester.

(3) For separating conduit from masonry surface: Galvanized malleable iron spacer assembled with Style A strap.

(4) For vertical run of metallic sheath cable: Basket weave cable support.

(5) For fastening conduit or cable to channel inserts: Galvanized steel fasteners.

b. Trapeze type hangers: Consisting of two or more hanger rods, horizontal member, U-bolt clamp and other attachment necessary for securing hanger rods and conduit, with the following additional requirements:

(1) Material and finish: Steel, hot-dip galvanized after fabrication or Fiberglass Reinforced Polyester conforming to the requirements specified for fiberglass channel struts.

(2) Hanger rod: Not smaller than 5/8-inch diameter, threaded for sufficient distance at each end to permit at least 1-1/2 inches of adjustment.

(3) Horizontal member: Channel, 1-5/8 inches square by 12 gauge or heavier. Weld two or more channels together for greater strength if necessary.

(4) Design: Capable of supporting load equal to sum of weights of conduit, cable and hanger plus 200 pounds. At design load, stress at root of thread on hanger rod 9,500 psi maximum; stress in horizontal member 12,500 psi maximum.

c. Steel Channel Struts

(1) Size and shape as shown, 12 gauge or heavier hot-dip galvanized, with 7/8 inch wide continuous slot, 9/16 inch base slot, two inches on center or solid base with field drilled holes as required with minimum pull out load rating of 1,000 pounds per linear foot.

(2) Fittings and accessories compatible with associated steel channel struts and having same material and finish.

d. Stainless Steel Channel Struts

(1) Size and shape as shown, 12-gauge or heavier stainless steel, type 304, with 7/8-inch wide continuous slot, 9/16 inch base slot, 2 inches on center or solid base with field drilled holes as required with minimum pull out load rating of 1,000 pounds per linear foot.

(2) Fittings and accessories compatible with associated channel struts and having same material and finish.

e. Fiberglass Channel Struts

(1) Fiberglass reinforced polyester, self-extinguishing, with 7/8-inch wide continuous slot, 13/32-inch pre-drilled holes in base on 1-5/8-inch centers, or solid base with field drilled holes as required with the following additional requirements:

| Physical Properties | Value | Method |
|---|---|---|
| Tensile Strength | 30,000 PSI | ASTM D638 |
| Flexural Strength | 30,000 PSI | ASTM D790 |
| Barcol Hardness | 50 | ASTM D2583 |
| Dielectric Constant | 200 VPM | ASTM D150 |

| | | |
|---|---|---|
| Coefficient of Thermal Expansion | $5 \times 10^{-6}$ in/in/°F | ASTM D696 |
| Specific Gravity | 1.7 | ASTM D792 |
| Flammability Rating | 15 | ASTM E84 |
| Moisture Absorption | 1% (24 hrs. at 72°F) | ASTM D570 |

(2) Fittings and accessories compatible with associated fiberglass channel struts and having same material or approved similar material.

f. Cinch anchors: One-piece wedge type, galvanized with threaded stud.

g. Cable support brackets: Size and type as shown, 12 gauge or heavier, hot-dip galvanized.

h. Cable insulators: Saddle type, high glazed porcelain, designed for use with the brackets provided.

i. Boxes

j. Outlet boxes

(1) UL 514, capable of accommodating conduit as shown.

(2) Material and finish:

(a) Steel, cast iron, ductile iron or malleable iron.

(b) Hot-dip galvanized or electro galvanized after fabrication.

k. Junction and pull boxes

(1) Internal volume up to 100 cubic inches, UL 514; internal volume above 100 cubic inches, UL 50.

(2) Flush-mounted or surface-mounted as shown.

(3) Size: Suitable to accommodate conduit, raceways, ducts, number of cables and splices shown.

(4) Material

(a) Stainless Steel, Type 316.

(b) Hot-dip galvanized or electro galvanized after fabrication.

12. Cable Trays

a. General

(1) Dimensions: Minimum 4-inch inside depth; 9-inch rung spacing unless otherwise shown.

(2) Maximum load rating: 50 pounds per linear foot with safety factor of 2.0 at 12-foot support span for steel trays. 200 pounds per linear foot with safety factor of 1.5 at 12-foot support span for fiberglass reinforced polyester trays. Support additional concentrated load of 200 pounds at any point without permanent deflection.

(3) Bend Radius

(a) For incoming service cable: 36 inches or as approved by the utility.

(b) For all other cable: 24 inches or as shown.

b. Fiberglass Cable Tray

(1) NEMA FG-1, fiberglass ladder type.

(2) Allowed for carrying all DC positive and negative cable except as otherwise noted. Fiberglass material shall be used for all fittings and accessories associated with the installation of fiberglass trays.

(3) Fiberglass Reinforced Polyester in accordance with the following:

| **Physical Properties** | **Value** | **Method** |
|---|---|---|
| Tensile Strength | 40,000 PSI | ASTM D638 |
| Flexural Strength | 45,000 PSI | ASTM D790 |
| Barcol Hardness | 95 | ASTM D2583 |
| Dielectric Strength | 200 VPM | ASTM D149 |
| Specific Gravity | 1.7 | ASTM D792 |
| Coefficient of Thermal Expansion (Longitudinal) | $5x10^{-6}$in./in./°F | ASTM D696 |
| ASTM D696 | 1% (24hrs. at 72°F) | ASTM D570 |
| Flammability Classification | V-O | UL 94 |
| Flammability Rating | 15 | ASTM E84 |

13. Expansion Bolt Anchors: FS FF-S-325C Group II, Stainless Steel-316, type and class as approved, galvanized.

14. Wireways and auxiliary gutters

a. Galvanized steel with formed flanges on both body and cover, screw on covers, in accordance with UL870, complete with all necessary fittings, couplings and end pieces.

b. Size as shown.

c. Electro galvanized and finished with light gray enamel, ANSI Z55.1, Color 61.

15. DTS Cabinet/Remote Control and Monitoring Cabinet

a. Wall-mounted, single-door, NEMA 250, Type 12, with panel, similar to Hoffman Engineering Company or equal, as shown.

b. Enclosure: Formed of minimum 14-gauge steel, seams continuously welded and ground, without openings or knockouts, with threaded conduit entrance hubs, lugs for mounting enclosure and collar studs for mounting panel. Rolled lip formed on all sides of door opening. Enclosure and door reinforced when size exceeds 30 inches square. Size as shown. (Note: The Remote Control & Monitoring Cabinet shall be identical to the DTS Cabinet for Tie Breaker Station, except that the nameplate shall be modified to suit.)

c. Door: Formed of minimum 14-gauge steel, with rolled lip along top and sides to mate with enclosure. Fitted with removable print pocket. Closed-cell neoprene gasket attached with oil-resistant adhesive and steel retaining clips.

d. Hardware: Corrosion-resistant steel continuous piano hinge with removable pin. Hasp and staple for padlocking.

e. Panel: Formed of 12-gauge steel.

f. Finish: Galvanized enclosure, door, panel and latch mechanism. Painting by manufacturer's standard method in accordance with the following:

(1) Outside: Phosphatized, primed and finished with two coats of light gray enamel or epoxy coating, ANSI Z55.1, Color 61; minimum dry film thickness, 2 mils.

(2) Inside including panel: Two coats of white enamel or epoxy coating.

g. Breather drain: One 1/2-inch diameter, Crouse-Hinds Catalog No. ECD11 or approved equal.

h. Grounding stud: Manganese bronze, ASTM B138, Alloy No. 675 hard, 3/8 inch high; Evedur GSI, American Brass Company or approved equal.

i. Terminations: Assembly rail and modular terminals, Weidmuller Terminations, Incorporated or approved equal.

(1) Terminal: Modular test terminal, Melamine plastic, screw clamp connections, with socket screws; type SAKC4, Catalog No. 3406.2, with the following additional requirements:

(a) Amperes: 25.

(b) Volts: 300.

(c) Wire gauge range: 22 AWG to 12 AWG.

(d) Thickness: 0.256 inch.

(e) UL-listed.

(f) Standard accessories: compatible with terminal, with the following additional requirements:

(i) End section: Type AP, No. 1179.2.

(ii) End bracket: Type EWK1, No. 2061.6.

(iii) Test plug: Type PS, No. 1804.0

(iv) Jumpering Combination: Type QB, No. 91455.0.

(v) Disconnect plug for SAKC4 terminal: Type TST, No. 413074.

(vi) Locking pin: Type SST3, No. 1527.0.

(2) Assembly rail: Type TS 32 steel standard section compatible with terminals, with fixing slots, Catalog No. 1228.0 and standard rail mounting screws.

(3) Marking tags: Horizontal in sequence, Type FW, No. 4681.6 white thermoplastic. Consecutive numbering conforming to that of DTS box.

(4) Group marking carrier with paper marking strip and transparent cover.

(a) Type SCHT5, Catalog No. 2924.6.

(b) Type ES05, Catalog No. 2937.0.

(c) SST5, Catalog No. 2940.0

16. ETS Enclosures

a. Enclosure: Nonventilated, single-door fiberglass enclosure NEMA 250, Type 3R, with mounting brackets as shown, complies with applicable requirements of UL 508.

(1) Molded fiberglass reinforced polyester material 1/8-inch thickness, minimum, and in accordance with the following:

| Physical Properties | Value | Method |
|---|---|---|
| Flexural Strength | 17,000 PSI | ASTM D790 |
| Deflection Temp | 400F | ASTM D648 |
| Water Absorption (24 hours) | 0.5% | ASTM D570 |
| Tensile Strength | 6,500 PSI | ASTM D638 |
| Specific Gravity | 1.8 | ASTM D792 |
| Flammability | V-O | UL94 |
| Dielectric Strength | 400 Volts/Mil | ASTM D149 |
| Arc Resistance | 180 Sec | ASTM D495 |

(2) Gasket: Oil-resistant 100 percent neoprene by polymer content, ASTM-D1056 grade SCE-42 with oil-resistant adhesive.

(3) Piano hinges: Stainless Steel, one inch wide by 1-3/4 inches high with model pins and fasteners, two per enclosure.

(4) Door handle: T-handle, One half turn, Vise Action Type, die cast zinc, matte black, polyester powder finish with stainless steel hardware, SOUTHCO catalog No. E3-10-105-50 or approved equal.

(5) Panels, back plates, barriers, and brackets: 10 gauge stainless steel as shown.

(6) Hardware: Stainless steel bolts, nuts, and screws; ASTM F593, size as shown.

(7) For ultra-violet protection of fiberglass box, the material shall material shall contain ultra-violet inhibitor on inside and outside surfaces coated with polyurethane paint, 1.5 mils minimum dry film thickness.

(8) Color: Fiberglass material, gray inside and out.

(9) Open/Close Decal: Pressure sensitive weatherproof, vinyl tape with 1/4 inch high red on a white background. “OPEN” shall have red letters, “CLOSE” shall have green letters.

(10) Nameplates: Each ETS Enclosure provided with three-ply laminated plastic, multi-layered nameplates inscribed with 1-inch lettering identifying the ETS Box Number, Supervisory Control Identification Nos. of the DC breakers being tripped. A typical example of engraving is as follows:

(a) EMERGENCY TRIP SWITCH NO.

(b) E-F07-31

(c) E-F08-41

b. Emergency pushbutton: Provide on the backplate, mushroom head trip switch with 4 NC poles similar to Square-D Cat. No. 9001-4-KA-3 with head No. 9001-KR-5R.

c. Terminal block: Provide on the backplate one 12-point terminal board similar to GE Cat. No. CR151B2 or approved equal.

17. ETS Relay Cabinets

a. Wall mounted, single door, NEMA 250, type 12, with enclosure and back panel similar to Hoffman Engineering Company or approved equal, as shown.

b. Enclosure formed of minimum 14-gauge steel with sufficient structural reinforcements to ensure a plane surface, to limit vibration and to provide sufficient rigidity during shipment, installation and operation. A print pocket shall be attached to the inside of the door of enclosure.

c. Door formed of minimum 14-gauge steel with rolled lip formed along top and sides to mate with enclosure. Provided with hasp and staple for padlocking.

d. Back panel formed of minimum 12-gauge steel.

e. Relays and Terminal Blocks: The cabinet shall have mounted on its back panel auxiliary relays of hinged armature construction, 125V dc rated coil and electrically held, self-reset type with 2 NO and 4 NC contacts similar to GE Catalog No. 12HFA51A42H code No. 24 contact arrangement or approved equal. Terminal blocks with cover similar to GE Type EB shall be mounted on back panel. Quantity of relays and points on terminal blocks as shown.

f. Name Plates and Wire Labels: In accordance with Article 2.02C herein.

B. Circuit Breakers and Panelboards

1. General Requirements

a. Interchangeability: Components of the same type, size, rating, functional characteristics and make shall be interchangeable.

b. Finish for enclosures for panelboards.

(1) Clean and degrease metallic surfaces.

(2) Prime with zinc primer.

(3) Finish with one coat of light gray enamel, ANSI Z55.1, Color 61; 2 mils minimum DFT.

2. Circuit Breaker: NEMA AB1, UL489, molded-case, bolt-on, quick-make/quick-break, mechanically trip-free, switching mechanism, with thermal trip for inverse time delay overcurrent protection and magnetic trip for instantaneous short-circuit protection. Frame size 225 amperes and above equipped with interchangeable thermal trip and adjustable magnetic trip unit. Designed to carry continuous rating in ambient temperature of 40 degrees C with the following parameters as shown:

a. Number of poles.

b. Rated voltage, AC or DC

c. Rated interrupting current.

d. Trip setting.

e. Frame size.

3. Enclosed Circuit Breaker

   a. NEMA AB1.

   b. Circuit breaker: As shown and specified. Overcurrent trip device coordinated to provide selective tripping under overload conditions.

   c. Enclosure

      (1) Galvanized steel, surface-mounted, unless otherwise shown.

   d. Type

      (1) Above-ground indoor locations and electrical rooms: NEMA 1.

      (2) Tunnel areas and underground locations, except electrical rooms: NEMA 12.

      (3) Outdoor locations: NEMA 3R.

4. Panelboard

   a. NEMA PB1, UL 67.

   b. Enclosure

      (1) UL 50.

      (2) Galvanized steel, surface mounted unless otherwise shown.

      (3) NEMA 250, Type 1

      (4) Gutter size:

| Main Bus Rating Amperes | Minimum Top and Bottom Gutter Size in Inches | Minimum Side Gutter in Inches |
|---|---|---|
| 100 and below | 4 | 4 |
| 225 | 6 | 4 |

      (5) Interior components mounted on backplate of reinforced steel for rigid support and accurate alignment.

      (6) One piece sheet steel front panels with hinged door and lock so constructed that when panelboard door is locked front cannot be removed.

      (7) Provide latch and handle in accordance with UL 50; screw fastenings will not be accepted in lieu of latch.

      (8) Provision for enclosure grounding.

   c. Busbars

      (1) ASTM B187.

      (2) 98 percent conductivity copper.

      (3) Contact surface silver-plated or tin-plated.

      (4) Rating of neutral and ground bus: Equal to that of phase bus.

(5) Neutral bus mounted on insulating block.

(6) Neutral and ground bus equipped with integral mechanical connectors.

d. Circuit Directory

(1) Neatly typed to identify the load fed by each circuit by number.

(2) Mounted on a metal frame with clear plastic cover inside cabinet door.

e. DC Panelboard: 125 Volts DC, 2-wire. Main and branch circuits with 2-pole breakers, quantity and ratings as shown. AIC-10,000 amps minimum.

C. Nameplates, Tags and Wire Labels

1. Nameplates

a. Three-ply, laminated phenolic plates, engraved through black face to white core, attached by stainless steel rivets or screws.

b. Lettering: Vertical gothic using round or square cutter. V-shape groove is prohibited.

c. Size: One-inch high with 1/2-inch high lettering.

2. Conduit and Cable Tags: Stainless steel, round, punched with cable or conduit number as shown.

3. Wire labels: Sleeve-type, heat shrinkable, flame retardant Raychem TMS product line, Type XPE or approved equal and conforming to UL224. Wire identification same as corresponding terminal block identification unless otherwise shown. The labels on 1000 KCMIL cable shall be clear, heat shrinkable with 1/2-inch height yellow lettering stamped on inside. The labels shall have reference of substation or tie-breaker station breaker Supervisory Control ID number and cable sequence in the branch of the feeder (e.g. BRK. 32-A) at both ends.

D. Emergency Trip Station Light Fixture Type 9

1. Lighting Fixture: Enclosed and gasketed mercury-vapor fixture suitable for outdoor locations conforming to UL-1572 and as shown. Hubbell Catalog No. VMWX-50C-R or approved equal.

a. Lamp: Mercury-vapor, 40 watt B-17, medium base, 24,000 hours rated average life, and conforming to applicable ANSI Standards.

b. Lampholder: In accordance with UL 496, glazed porcelain base and body, rated 660 watts, 600 volts, medium screw base, and self-retaining neoprene gasket for dust and moisture-proof seal between lamp and lampholder.

c. Housing: Copper free heavy-duty die cast aluminum with 90-degree arm for wall mounting, natural color, threaded to provide a secure fit for the globe and guard.

d. Globe: Thermal shock and impact resistant blue tempered glass, threaded to ensure secure fit to housing.

e. Guard: Copper free die cast aluminum to provide protection to the globe and lamp, threaded and provided with a flush mounted set screw for a positive and secure fit to housing.

f. Ballast: UL 1029, high power factor, H45 type, Class H insulated, capable of starting a 40-watt mercury vapor lamp at an ambient temperature of minus 20 degrees F and above, 277-volt, 60 Hertz, suitable for mounting in an enclosure for remote mounting.

g. Remote ballast enclosure: Fiberglass or aluminum with polyester powder paint finish, front access and weather tight construction with 3/4-inch conduit entry and exit knockouts, with mounting lugs suitable for mounting on channel inserts or inside interface box as shown.

E. Danger Markers

1. Danger markers for conduit and cable installed in track areas

a. Danger plate for use on timber ties supporting conduit and cable

(1) Three-ply, laminated phenolic plates, engraved through red face to white core, attached by stainless steel lag screws.

(2) Lettering: Vertical Gothic using round or square cutter. V-shape groove is prohibited.

(3) Size: Four-inch high with 1-inch high lettering as below and applicable:

(a) “DANGER 750 VOLTS”

(4) Ultra-Violet Protection: coated with polyurethane paint 1.5 mils minimum dry film thickness on all surfaces.

b. Danger label for use on conduit

(1) 2-1/2-inch wide pressure sensitive vinyl with red background and white lettering 1-1/4-inch high, Gothic Capital Style as follows and applicable:

(a) "DANGER 750 VOLTS"

(b) "DANGER 480 VOLTS"

(2) Lettering printed with weather resistant ink and shall be durable and scuff resistant.

(3) Marker provided with permanent type back adhesive for long-term, outdoor use.

2.3 ACCESSORIES

A. Wire Connection Accessories

1. Connectors, terminal lugs and fittings

a. In accordance with UL486, and NEMA CC1.

b. For 10 AWG and smaller conductors: Compression type, high conductivity copper, tin-plated ring tongues, with nylon self-extinguishing insulating grip with temperature rating equal to that of conductor insulation. Thomas and Betts STA-KON type or approved equal.

c. For 8 AWG to 4/0 AWG conductor cable: Tin-plated copper compression connectors and terminal lugs with nylon insulating sleeve for insulation grip.

d. For 250 KCMIL and larger conductor cable: Long barrel double-compression tin-plated copper connectors and terminal lugs with two-hole pad.

e. For multiple conductor cable: Watertight aluminum fittings with stainless steel pressure ring and set screws or compression cone for grounding of aluminum sheath of MC Cable.

f. Hardware: High strength silicon bronze, corrosion resistant, non-magnetic, and electrolytic action free when in contact with copper.

g. Ground connector

(1) O-Z, Type KG or approved equal.

(2) Two-piece, designed for connecting grounding conductor to bus bar.

(3) Copper-alloy bolt and silicon-bronze bolt nut and lock washer with interlocking clamp.

h. Contact rail terminal lugs: Compression type, 98-percent-pure copper, hot-dip tin-coated to 0.3-mil minimum thickness. Tongues not less than 2 inches square by 1/2 inch thick and drilled for 5/8-inch diameter fastener. Compatible with 1000 KCMIL, extra flexible cable.

2. Bundling Straps

a. Self-locking steel barb on one end, with tapered strap of self-extinguishing nylon, temperature rating minus 65 degrees F to 250 degrees F.

b. For outdoor use: Ultraviolet-resistant.

3. Insulating Tape

a. Plastic tape: Vinyl plastic tape with rubber-based pressure-sensitive adhesive, pliable at zero degrees F with the following minimum properties when tested in accordance with ASTM D1000:

(1) Thickness: 8.5 mils.

(2) Breaking strength: 20 pounds per inch width.

(3) Elongation: 200 percent.

(4) Dielectric breakdown: 10,000 volts.

(5) Insulation resistance, indirect method of electrolytic corrosion: 1,000,000 megohms.

b. Rubber tape: Silicone rubber tape with silicone pressure-sensitive adhesive, with the following minimum properties when tested in accordance with ASTM D1000:

(1) Thickness: 12 mils.

(2) Breaking strength: 13 pounds per inch width.

(3) Elongation: 525 percent.

(4) Dielectric breakdown: 13,000 volts.

(5) Insulation resistance, indirect method of electrolytic corrosion: 1,000,000 megohms.

c. Arc-proof tape: Flexible and conformable organic fabric tape, coated one side with flame-retardant flexible elastomer, self-extinguishing, non-combustible, with the following minimum properties:

(1) Thickness, ASTM D1000: 30 mils.

(2) Tensile strength, ASTM D1000: 1500 pounds per square inch @ 23 degrees C.

(3) Elongation, ASTM D1000: 150 percent @ 23 degrees C.

(4) Thermal conductivity, ASTM D1518: 0.078 BTU per hour per square foot per degree F.

(5) Electrical arc resistance: one half-lap layer capable of withstanding a high current fault arc temperature of 13,000K for 75 cycles.

d. Glass tape: Woven glass fabric tape with pressure-sensitive thermosetting adhesive, with the following minimum properties when tested in accordance with ASTM D1000:

(1) Nominal width: 3/4 inch.

(2) Thickness: 7 mils.

(3) Breaking strength: 170 pounds per inch width.

(4) Elongation: 5 percent.

(5) Dielectric breakdown: 2,500 volts.

(6) Insulation resistance, indirect method of electrolytic corrosion: 5,000 megohms.

4. Epoxy Resin: Suitable for insulating and moisture sealing cable splices, with the following minimum properties:

a. Dielectric strength, ASTM D149: 400 volts per mil.

b. Volume resistance, ASTM D257: $2.8 \times 10^{15}$ ohm per centimeter cube at 30 degrees C.

c. Water absorption, ASTM D570: 0.193 percent in 24 hours at 23 degrees C; 0.62 percent in 24 hours at 53 degrees C.

d. Tensile strength, ASTM D638: 8,000 psi.

e. Elongation, ASTM D638: 2.4 percent.

f. Coefficient of expansion, ASTM D696: $6.8 \times 10^{-5}$ inches per degree C.

5. Contact rail cable connector assemblies

a. Cable connectors: Compression type, MAC Products, Inc., No. B-9180 or approved equal, 98 percent pure copper with four hole tongues and necessary silicon-bronze flat washers, lock washers, nuts and bolts. Tongues not less than 9/16 inch thick and drilled for 1/2-inch bolts on 1-3/4-inch centers.

b. Insulating covers and accessories: Two-piece, glass reinforced polyester, orange colored, not less than 0.125 inch thick. Equipped with neoprene gaskets, sealing collars and captive screw fasteners.

c. Heat shrinkable tubing: T & B Cat. No. HSB400-225-1 or approved equal.

d. Completed assembly to be watertight and readily disassembled.

6. Terminal blocks

a. Barriered, screw type equipped with washer head binding screws, white marking strips for terminal identifications and hinged covers; unless otherwise shown or specified.

b. Rated 600 volts, 30 amperes per point and designed to accommodate wire sizes 19 AWG through 10 AWG inclusive.

B. Exothermic mold kit, consisting of mold and handle and Exothermic Weld Cartridge

1. Exothermic weld mold for making #4 AWG cable connections to the base of the composite contact rail. Erico part No. PB10QTIL84C or approved equal.

2. Exothermic weld mold for making #4 cable connections to the neutral axis of the running rail, Erico part No. PB13STIL or approved equal.

3. Mold handle for holding the exothermic mold to the composite contact rail and the running rail. Erico part No. PBL160 or approved equal.

4. Exothermic Weld Cartridge: Consisting of welding powder, steel discs and packing material required to make an exothermic weld of #4 AWG cable to the composite contact rail and running rail. Erico part No. PB65 or approved equal.

C. Heat-shrinkable tubing: UL-approved, flame retardant, corrosion resistant thick wall tubing with factory-applied sealant for field insulation on inline splices and taps or wraparound type sleeve for retrofit installation on existing splices and taps to provide a watertight seal and insulating encapsulation, with the following additional properties:

1. Material: Cross-linked polyolefin.

2. Shrink ratio: 3 to 1 (min.)

3. Physical properties:

| | | |
|---|---|---|
| Ultimate tensile strength | 2350 psi | ASTM D412 |
| Hardness, Shore D | 42 | ASTM 2240 |
| Water absorption Method 6.1 | 0.05% | ASTM D570 |
| Specific gravity | 1.28 | ASTM D792 |

4. Electrical properties

   a. Dielectric strength 450 volts ASTMD149 per mil

   b. Volume resistivity 1 x $10^{14}$ ASTMD 257 ohm cm

5. Thermal properties

   a. Continuous operating temp. minus 55 degrees C to plus135 degrees C

   b. Air oven aging (7 days @ 175 degrees C):

      (1) Tensile strength — 2680 psi

      (2) Elongation — 375 percent

      (3) Low temp. flexibility (4 hours @ minus 55°C) — No cracking when flexed

      (4) Heat shock (4 hours @ 225°C) — No cracking, flowing or dripping

6. Chemical properties

   a. Corrositivity Non-corrosive MIL-I-23053/15

   b. Fungus resistance Non-nutrient ASTM G21

D. Nuts, Bolts, U-Bolts and Miscellaneous Hardware.

1. Material

a. All nuts, bolts, U-bolts and washers for outdoor locations including tunnels shall be Type 316 stainless steel in accordance with ASTM F593 and F594.

b. All nuts, bolts, and flat washers for indoor locations in TBS and TPS shall be galvanized steel in accordance with ASTM A325.

c. The dimensional data and type hardware for all nuts, bolts and miscellaneous parts shall be shown and specified; where not shown as recommended by the manufacturer.

2. Galvanizing

a. All parts to be galvanized shall be galvanized after manufacture. Unless otherwise specified, parts to be galvanized shall be coated in accordance with the requirements of ASTM A123. Bolts and miscellaneous hardware shown or specified to be galvanized shall be coated in accordance with ASTM A153 or alternate method in accordance with ASTM B633

E. Structural Steel Shapes

1. Shapes, plates and bars: ASTM A36.

2. Structural tube: ASTM A500, Grade A, hot-dip galvanized. Galvanizing: Hot-dip galvanized after fabrication in accordance with ASTM A123, zinc coating weight 2 ounces per square foot, minimum.

**PART 3 – EXECUTION**

3.1 INSTALLATION

A. Install generally as shown and in accordance with approved Shop Drawings, the NEC and jurisdictional agencies.

B. Conduit, Cable Tray, Boxes, Cabinets, and Fittings

1. General

a. Use size, type, general routing, location of conduit, raceways, boxes, and cabinets as shown and specified.

b. Install metallic raceway, fittings, boxes, and cabinets free from contact with reinforcing steel.

c. Where aluminum is placed in contact with dissimilar metal or with concrete, separate contact surfaces by means of gasket, non-absorptive tape or coating to prevent corrosion.

d. Unless specified or shown otherwise, make metallic conduit, raceways, and cable trays, electrically and mechanically continuous, and grounded in accordance with NEC and as shown.

2. Conduit

a. Run exposed conduit parallel to building lines.

b. Install exposed conduit to avoid interference with other work.

(1) Where shown and as necessary, install cable seal in accordance with the manufacturer's recommendation.

(2) Use sealing compound where approved and in accordance with manufacturer's recommendations, with the following additional requirements:

(a) Before applying sealing compound, prime conduit ,and cable surface using primer recommended by the manufacturer.

(b) Pour or inject compound to prevent voids inside seal and to keep cable centered in conduit.

(3) In empty conduit installed for future use, install blank cable seal inside conduit to prevent seepage of water.

(4) Ensure conduits are free of water before conduit seals are installed.

c. Apply lead-free conductive anti-seize compound to threaded conduit joints.

d. For outdoor locations use threaded conduit hub to attach conduit to equipment enclosure. Use watertight conduit fitting for attachment of conduit to enclosure having punched or formed knockout.

e. For indoor locations use locknut and nylon-insulated bushing to attach conduit to enclosure.

f. Install suitable caps or plugs in empty conduit for future extension.

g. Thread and ream ends of field-cut conduit to remove rough edges. Use bushing at conduit entrance to boxes, cabinets, and equipment enclosures.

h. Bends

(1) Unless otherwise shown or specified, install conduit bends in accordance with reference codes.

(2) Bend conduit so that field made bend is free from cuts, dents and other surface damage and does not reduce cross-sectional area of conduit.

i. Support horizontal conduit 1-1/2 inches and smaller with one-hole pipe straps or individual pipe hangers.

j. Support horizontal conduit larger than 1-1/2 inches with individual pipe hangers.

k. Spring steel fasteners, clips or clamps specifically designed for supporting exposed single conduits may be used in lieu of pipe straps or pipe hangers. Use 1/4-inch minimum diameter galvanized steel rods for hanger rods with spring steel fasteners, clips and clamps.

l. Secure conduit supported on multi-hangers (trapeze) or channel inserts by fasteners suitable for such purpose.

m. Where conduit is attached to masonry surface, use malleable iron spacers with Style A pipe straps.

n. Support and secure vertical conduit spanning open areas at intervals not exceeding 10 feet.

o. Install conduit so as to drain moisture to nearest outlet or pull box.

p. Use only metallic conduit in exposed locations in tunnels and buildings.

q. Ensure waterproof conduit connection where conduit is installed in outdoor locations.

r. Use Schedule 80 PVC conduit for cable, which is buried directly in ballast or at trackside locations for contact rail heater segment jumper cables.

s. Install expansion fittings in exposed conduit runs longer than 300 feet.

t. Use metallic conduit routed between control cable trays and equipment enclosures.

3. Channel Inserts and Spot Inserts

a. Mount outlet boxes.

b. Keep number of knock-outs to minimum.

c. Clean boxes thoroughly after installation and correct damage to boxes and to finish.

d. Install covers on boxes mounted on walls and ceilings.

e. Install junction and pull boxes so that covers are readily accessible.

4. Cabinets

a. Fasten cabinets using expansion bolts, toggle bolts, or mounting ears.

b. Touch-up damaged painted finish.

5. Cable Trays

a. For incoming service cable from power company, coordinate with the power company, and install cable tray with covers as approved by the power company.

b. Support cable tray straight sections, elbows, tees and crosses at the locations specified in NEMA FG-1 for fiberglass tray. Provide supports on 10-foot centers for horizontal positive and negative cable tray and not more than 12 feet on center for all other cable trays.

6. Fasteners

a. Fasten equipment and devices to concrete surfaces with lag screw shields, cinch anchors, expansion bolt anchors or lead jacketed tamp-in inserts. Use bolt sizes providing a safety factor of 2.5.

b. Fasten equipment and devices to concrete masonry units with toggle bolts.

c. Fasten equipment, devices and supports to structural steel with beam clamps, welded studs or drilled and tapped holes no greater than 1/4-inch diameter.

7. DTS Cabinet and ETS Relay Cabinet

a. Install as shown. Wall-mounted and fixed by expansion bolt anchors or toggle bolts.

b. Terminate all wires as shown, including spares.

c. Ground DTS and ETS relay cabinets.

8. ETS Enclosures

    a. Install as shown.

9. ETS lighting fixtures

    a. Install as shown.

10. Filling of openings

    a. Where conduit and raceway (including cable tray and bus duct) pass through fire-rated walls, ceilings or floors, provide approved firestop to prevent passage of fire and fumes and to maintain integrity of fire-rated structure.

    b. Close unused openings or spaces in floors, walls, and ceilings. Plug or cap unused conduit and sleeves.

    c. Seal unused traction power conduits in duct bank at both ends using OZ Gedney CSBE seals or approved equal.

11. Cleaning of raceways

    a. Rod and swab raceways and ducts through which cables are to be installed. Use a mandrel with an outside diameter 3/8 inch less than the inside diameter of the duct and remove all obstructions. Install a non-metallic pull line fish wire, as approved by the Contracting Officer Representative in each raceway or duct immediately after rodding and swabbing and, unless cables are pulled immediately.

    b. The Contractor shall be responsible for the dewatering and removal of all dirt, rocks, track ballast, and trash from trenches, pipe, manholes, pull chambers, cable trough, surface trench, conduit and duct bank prior to and during the installation of cable, at no additional cost to the Authority.

12. Cable Troughs (Track Right-of-Way)

    a. Remove the trough covers, install wire and cables, and reinstall the trough covers.

    b. The Contractor is specifically warned of the following conditions and potential problems with the track right-of-way cable troughs:

        (1) The covers for these troughs are not of uniform length and locations of drill holes, i.e., each cover section must be replaced on the trough section from where it was removed.

13. Apply anti-corrosion joint compound to connectors, terminal lugs, and bolting pads before installation. Install lock washer under each bolt head and nut.

14. Install terminal fittings on multiple-conductor cable in accordance with manufacturer's recommendation. Completely seal cable from moisture.

15. Attach contact rail cable connector assembly compression connectors to the cable with manufacturer's recommended tooling. Install a lock washer under the head of each bolt and under each nut when bolting tongues together. Tighten bolted connections to a uniform torque of 450 inch-pounds.

16. Prior to assembly of contact rail cable terminal lugs to composite contact rail, coat mating services with oxide-inhibiting paste, NO-OX-ID, Dearborn Chemical, or approved equal. Coat all interfaces of the compression fasteners. Fasten terminal lugs to the composite compact rail using methods and equipment recommended by the rail manufacturer.

17. Exothermic Welded Connections: Make connections using exothermic mold kit and cartridge in accordance with the manufacturer's recommendations. Remove all extraneous weld metal and test connection for mechanical strength by striking twice with a 2-pound hammer.

18. The splicing of power and control cables is not permitted in manholes, duct banks and cable troughs. However, if permitted by the Contracting Officer Representative, make watertight splices as approved.

C. Panelboards

1. Install panelboards at locations shown.

2. Mound panelboards with front straight and plumb.

3. Connect branch circuit wires as shown. Connect neutral wire of branch circuit to neutral bar in panelboard.

4. Make power cable connections to circuit breakers, neutral and ground bus bars in panelboard by means of integral mechanical connectors. If such items are not furnished with integral mechanical connectors, make connections using compression connectors.

5. Ground panelboards.

6. Apply matching touch-up paint where necessary.

7. Provide directory for each panelboard.

D. Furniture

1. Provide one workbench, two stools, one storage cabinet, and one stepladder for each traction power substation. Provide one storage cabinet and one stepladder for each tie breaker station. Place furniture inside each location where directed by the Contracting Officer Representative.

E. Insulated Floor Topping

1. Job Conditions

a. Maintain substrate temperature within limits recommended by the flooring materials manufacturer.

b. Provide adequate ventilation during installation and curing.

2. Inspection: Examine substrate and conditions under which flooring materials are to be prepared and installed. Do not proceed with the installation until all unsatisfactory conditions have been corrected.

3. Surface Preparation

a. Inspect all surfaces to determine that entire area to receive insulating floor topping is structurally sound. Remove loose sections down to the substrate.

b. Remove grease, oil, asphalt, mastics, and other contaminants that may prevent adhesion, by scrubbing with degreasers, detergents, or solvents. Grinding, scarifying, or sandblasting is other acceptable methods.

c. Repair cracks, holes, eroded and damaged areas with patching materials recommended by the insulating flooring manufacturer.

d. Prepare concrete surface by acid etching, grinding, sandblasting, scarifying, or other approved method.

e. Saw cut at all termination points.

f. Prior to applying base coats and top coats, apply marking tape at all termination points and adjacent surfaces not to be coated.

g. Remove tape immediately after broadcasting and after top coating.

4. Materials Protection: Mix and prepare materials in accordance with manufacturer's written instructions.

5. Application: Mix and apply each component of the insulating flooring system in accordance with the manufacturer's written instructions and as indicated to provide an uninterrupted, uniformly thick, seamless, and monolithic surface.

6. Contraction Joints: When floor insulating topping material crosses contraction joints in the floor slab, a contraction joint shall be provided in the topping. Provide a vie shaped groove, 1/2 inch wide at the base of the groove, but not less than the width of the contraction joint, and ensure the groove is 1/2 inch wider at the top than at the bottom. A bond breaker shall be provided to top of the concrete. An epoxy shall be used to seal damp surfaces before application of the primer and polysulfide. The groove shall then be filled with two-component, self-leveling, gray polysulfide. Epoxy primer and polysulfide material shall be as recommended by the floor topping manufacturer. Surface preparation, and mixing and installation of materials shall be in accordance with manufacturer's instructions. Sheets of Hayside, not less than 1/16 inch thick, and 1/4 inch narrower than the groove at the top, shall be placed on top of the polysulfide and flush with the top of the insulated floor topping.

7. Cleaning: After completion of insulating flooring installation, clean free of residue those surfaces not required to receive insulating flooring materials.

8. Protection: Close to all traffic for 24 hours, minimum completed insulating flooring installation. Protect it for 3 days from acid, alkali, or solvent, which may spill on the flooring.

F. Install appropriate power company furnished metering panel as shown and in accordance with power company instructions. Ground metering panel to substation ground bus. Connect to 120V, AC, 1-phase circuit in emergency panel as shown.

G. Nameplates, Tags and Wire Labels

1. Nameplates: Attach nameplates to all panelboards, DTS cabinets; remove control and monitoring cabinet, ETS enclosures, and ETS relay cabinets.

2. Cable Tags: Attach cable tags to each cable at all pull boxes, manholes, and terminations.

3. Wire labels: Attach wire labels at all control, annunciation and supervisory wiring at each terminal point. Attach label to a clean, dry section of wire as close as possible to the terminal point.

H. Danger Marker

1. Attach danger marker plate on top of timber ties on both ties where contact rail heater conduit transition occurs.

2. Attach conduit danger label on each exposed conduit carrying contact rail heater control and power cable installed in track area at a maximum interval of 5 feet as noted below:

3. Conduit carrying DC power cables: DANGER 750 VOLTS.

4. Conduit carrying AC power and control cables: DANGER 480 VOLTS.

I. Arc-Proofing

1. Cover all cables installed in manholes and pits with arc-proof tape, applied in a single layer, half-lapped with the coated side next to the cable and held in place with random wrap of glass cloth electrical insulating tape.

J. Floor Sealant

1. Apply to finished floor surfaces in all traction power substations and tie breaker stations excluding areas with insulating floor topping.

2. Prepare floor by removing compacted dirt.

3. Treat with 409 Pre-Kote cleaner, mixed in ration one part 409 to nine parts water. Apply mix solution to the floor liberally (100 square feet per gallon) with a spray. Allow to soak for 10 minutes but do not allow it to dry. Scrub floor clean and vacuum using a wet vacuum. Scrub and rinse with clear water and repeat the scribe/rinse/vacuum process to ensure removal of all residue. The texture of floor should feel like sand paper before applying sealant.

4. Let the floor dry completely.

5. Mix Tennant ECO-LTS Parts A and B and Bond Additive (for the first coat) as recommended.

6. Applicator or airless sprayer. Ensure ambient temperature is 65 degrees F or higher during application. Apply two additional coats of the mix with four hours drying time in between.

7. Allow to cure for 16 hours at 75 degrees F before opening up the floor to traffic.

3.2 FIELD QUALITY CONTROL

A. Submit test procedure for approval and perform approved tests. Do not perform tests without approved test procedure. Schedule tests through the Contracting Officer Representative with minimum of 14 days prior notice. Furnish the necessary equipment and perform the following tests:

1. Test metallic conduit and boxes for electrical continuity.

2. Panelboards: Perform insulation resistance tests of each bust section phase-to-phase and phase-to-ground for one minute using 1,000 volt megger. Insulation resistance not less than manufacturer's recommended value, 2 megohms minimum. Test enclosure for continuity to substation ground bus. Test circuit connections in accordance with wiring diagrams.

3. Molded case circuit breakers: Perform pole-to-pole and pole-to-ground insulation resistance tests with a 1,000 volt megger. Insulation resistance: 50 megohms minimum.

4. Prior to installation, test two contact rail cable connector assembly compression connections, prepared under the direction of foremen who will supervise the installation, as follows:

a. Measure the electrical resistance between distal end of the cable and the connector tongue. Resistance shall not be greater than that of an equivalent length of uncut cable.

b. Subject the test connections to a sustained tension of 5000 psi for 3 hours. At the end of 3 hours, verify that there has been no slipping of the cable in the connector, deforming or loosening of the connection or increase in the electrical resistance beyond that specified.

c. Should any sample fail to meet the specified test requirements, the qualification of the foreman and the equipment will be disapproved.

d. Test contact rail, DC switchgear, and negative switchboard 1,000 KCMIL cable terminal lugs as specified for contact rail cable connector assembly compression connectors.

e. Testing of Exothermic Connections of Composite Contact Rail and Steel Running Rail:

(1) All exothermic connections shall be tested for mechanical strength using a 2-pound hammer. A minimum of three sharp blows 15 inches in stroke shall be directed to the weld nugget. The weld shall sustain the blows without cracking weld metal or at the interface with the steel contact rail. Defective welds shall be removed and the rail and cable thoroughly cleaned before rewelding.

(2) Electrical Resistance: Using a megohmeter, measure and record the insulated flooring electrical resistance to ground at four points designated by the Contracting Officer Representative. Resistance not less than 100 megohms for a 12-inch by 12-inch floor area.

B. Submit Certified test reports within 10 days of completion of tests.

END OF SECTION

# SECTION 16060
# GROUNDING AND BONDING

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for providing complete grounding and bonding system.

1.2 RELATED REQUIREMENTS

A. Fencing: Section 02820.

B. Earth tunneling: Section 02415.

C. Fabricated gray iron and ductile iron segmental tunnel lining: Section 02416.

D. Fabricated steel segmental tunnel lining Section 02417.

E. Concrete reinforcement: Section 03200.

F. Piping systems: Section15205, PIPING SYSTEMS

G. Wire, cable and busways: Section 16120, WIRE, CABLE, AND BUSWAYS.

1.3 REFERENCES

A. Comply with codes and regulations of the Jurisdictional Authorities.

B. National Electrical Code (NEC)

C. ANSI/IEEE 80-2000, IEEE Guide for Safety in AC Substation Grounding.

D. UL 467, Grounding and Bonding Equipment.

E. American Standards of Testing and Materials (ASTM) B187-00, Standard Specification for Copper Bar, Bus Bar, Rod and Shapes.

F. ITS: Directory of ITS Listed Products.

1.4 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each:

1. Shop Drawings.

2. Certification.

a. Certified test reports verifying that ground resistance of each ground grid when installed and each ground bus when connected to ground grid does not exceed specified values.

1.5 QUALITY ASSURANCE

A. Source Quality Control

1. Each item, except for exothermic-welded electrical connections, listed in accordance with referenced UL or ITS directory.

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Mark each item in accordance with applicable reference standard.

B. Ship each unit securely packaged and labeled for safe handling and to avoid damage.

C. Store equipment in secure and dry storage facility.

**PART 2 – PRODUCTS**

2.1 PRODUCTS AND MATERIALS

A. Grounding and Bonding Equipment

1. General Requirements

a. UL 467.

2. Ground rods: Solid steel, with stainless steel or copper jacket, 1-inch or 5/8-inch diameter as shown, by 10 feet long or of necessary length in 10-foot sections.

3. Grounding conductor

a. Grounding electrode conductors

(1) Insulated or bare conductor, as shown, in accordance with the following:

(a) Insulated conductor: As specified in Section 16120, WIRE, CABLE, AND BUSWAYS, for single-conductor cable.

(b) Bare conductor: Section 16120, WIRE, CABLE, AND BUSWAYS.

(2) Size

(a) For use in ground grid and for connecting of ground grid to ground bus: 4/0 AWG.

(b) For connection of ground bus in train-control, communications, electrical, dispatcher, Bell system and mechanical rooms to main ground bus in AC-switchboard rooms: 2/0 AWG.

(c) For other grounding electrode conductors: In accordance with NEC Table 250-66.

b. Equipment grounding conductor

(1) Sized in accordance with NEC Article 250-122 unless otherwise shown.

(2) Insulated equipment grounding conductor: Single-conductor cable as specified in Section 16120, WIRE, CABLE, AND BUSWAYS.

(3) Bare equipment grounding conductor integral with multiple-conductor cable: Section 16120, WIRE, CABLE, AND BUSWAYS.

c. Bonding conductor for stray current and cathodic protection and electrical continuity

(1) Insulated or bare conductors, as shown, in accordance with the following:

(a) Insulated conductors: As specified in Section 16120, WIRE, CABLE, AND BUSWAYS, for single-conductor cable.

(b) Bare conductor: Section 16120, WIRE, CABLE, AND BUSWAYS.

(2) Size: As shown or as specified.

4. Bus bar: ASTM B187-00, 98-percent-conductivity copper bus bar, size 2 inches wide by 1/4-inch thick, length as necessary.

5. Terminal lugs

   a. For 4/0 AWG and smaller conductors: Copper compression terminal lugs.

   b. For 250 MCM and larger: Long-barrel, copper, double-compression terminal lugs.

6. Ground connector

   a. O-Z, Type KG or approved equal.

   b. Two-piece, designed for connecting grounding conductor to bus bar.

   c. Copper-alloy body and silicon-bronze bolt nut and lock washer with interlocking clamp.

7. Jumpers: Copper braided or leaf-type flexible jumper, size as necessary.

8. Bus-bar insulators: Fiberglass reinforced-polyester insulator with 1/2-inch diameter threaded holes at both ends for bus-bar installation.

9. Exothermic welded electrical connections

   a. Exothermic process using powdered metals contained in a mold to form a molecular bond between materials to be connected without application of an external source of heat or power in accordance with ANSI/IEEE 80-2000.

   b. Molds, weld metal and associated accessories designed for making electrical connections between copper and copper, copper and steel, copper and cast iron and copper and ductile iron as required.

   c. Welding system designed for making connections suitable for the application as follows:

      (1) Connections made outdoors for grounding using the standard process and not containing phosphorous or any caustic, toxic or explosive materials.

      (2) Connections made indoors or in confined spaces for grounding using a low-smoke, low-emission process.

      (3) Connections made specifically for cathodic protection applications using the standard process.

   d. Molds made of graphite with permanent marking indicating name of manufacturer, model, conductor size, and type and size of welding mixture compatible with the welding process. Mold connection type suitable for making connections between various configurations of items as shown or specified.

   e. Weld metal consisting of copper oxide and aluminum contained in a moisture-resistant container along with other necessary materials required for the specific application as determined by the manufacturer. Container for applications other than low-smoke, low-emission process shall also include suitable starting material.

   f. Container for weld metal identified with part number, type of metals to be connected, and application such as standard outdoor, low emission or cathodic application.

## PART 3 – EXECUTION

3.1 GROUNDING

A. Ground Connections

1. Weld buried ground connections exothermically, in accordance with manufacturer's recommendations. Clean and coat with coal-tar epoxy before backfilling. Encapsulate with epoxy resin buried ground connection of grounding electrode conductors running to ground bus.

2. Use terminal lug to connect grounding conductor to equipment enclosure. Use ground connector to connect grounding conductor to ground bus. Secure connector or terminal lug to the conductor so as to engage all strands equally. Install terminal lug using tools and pressure recommended by the manufacturer. Indent mark terminal lug with the number of die used for installation.

3. Exothermically weld connections to ground rods in handholes, junction boxes and manholes, frame columns of bus passenger, and bus supervisor shelters and station entrance pylon (type B) and light poles.

4. Splices in grounding conductor are prohibited.

5. For making ground connections located indoors and in confined spaces located outdoors such as manholes, use exothermic welds with low-smoke, low-emission process.

B. Ground Grid

1. Install ground grid consisting of ground-grid conductors and ground rods buried in earth in pattern and at locations shown.

2. Use ground rod 1-inch in diameter by 10 feet long or of greater length in 10-foot sections as shown.

3. Bury top of ground rod 24 inches minimum below unfinished surfaces.

4. Ensure 24-inch minimum separation between ground rods or bare grounding conductors and concrete structures or soldier piles bonded for stray current and cathodic protection.

5. Interconnect ground rods using 4/0 AWG insulated or bare grounding conductor as shown.

6. For connecting ground grid to ground bus in associated traction-power substation and AC-switchboard room, provide minimum of four 4/0 AWG insulated grounding electrode conductors as shown.

7. For connecting ground grid to ground bus in DC tie-breaker station, chiller plant, fan shaft and drainage-pumping station, provide two 4/0 AWG insulated grounding electrode connections.

8. For additional grounding of service transformer in outdoor location, provide one grounding electrode conductor from nearest ground grid to transformer pad.

9. Unless otherwise shown, leave pigtail, three-foot six-inch minimum length, above finished floor for connection to ground bus or service-entrance equipment.

10. When ground grid is provided for electrical room, connect ground grid to ground bus in electrical room with two 4/0 AWG insulated grounding electrode conductors.

C. Ground Bus

1. Install ground bus bar, two inches wide by 1/4-inch thick, around the inside periphery of traction-power substation, DC tie-breaker station, ac-switchboard room and electrical rooms; on full length of wall adjacent to service equipment such as switchboard and motor controls in chiller plants and mechanical rooms.

2. Install ground bus bar, two inches by 1/4 inch by 24 inches long in train-control, communications, dispatcher, Bell system and mechanical rooms, kiosk, fan shafts, drainage-pumping stations, escalator pits, elevator rooms, battery rooms and where shown.

3. Mount ground bus bar on insulators two feet above finished floor, unless otherwise shown, using cap screws and expandable threaded anchor.

4. Provide insulator support at each end of ground bus and at 3-foot intervals.

5. In traction-power substation, DC tie-breaker station, ac-switchboard room, chiller plants, fan shafts, and drainage-pumping station, connect the ground bus to 4/0 AWG grounding electrode conductor running from associated ground grid.

6. In train-control, communications, electrical, dispatcher, Bell system and mechanical rooms, escalator pits, elevator rooms, battery rooms and other locations shown, connect ground bus to main ground bus in associated AC-switchboard room, traction-power substation or DC tie-breaker station, using 2/0 AWG insulated conductor.

7. Install 4/0 AWG insulated ground conductor, sub-ground bus, with one end connected to ground bus in AC-switchboard room, at following locations:

   a. In each tunnel for mainline track, support grounding conductor on channel inserts in tunnel wall.

   b. In each cable trough and duct bank along mainline track, install grounding conductor in cable-trough area and conduit reserved for AC power.

   c. In each cable space under station platform, install grounding conductor on channel inserts on wall.

8. Installing grounding connections in train-control and communication rooms

   a. The only ground connection on the bus bar provided for train control and communication equipment grounding is the cable leading to the AC Switchboard room.

   b. Do not bond equipment or metallic structure to the ground bus provided for train control equipment.

   c. For items requiring bonding, have the bonding conductors go to the nearest ground bus beyond the ground bus provided for train control equipment.

   d. Grounding transformers to the dedicated train control and communication room ground bus bars is not permitted.

D. Equipment Grounding Conductor: Provide insulated equipment grounding conductor for following services and as shown:

1. Feeders.

2. Branch circuits.

E. Grounding of Service Equipment

1. Ground in accordance with NEC.

2. Ground enclosure and ground bus in switchgear, switchboard, motor-control center or panel board to ground bus provided in substation or room using insulated grounding electrode conductor.

3. Install copper bonding jumper between neutral and ground bus as shown.

F. Grounding of Separately Derived AC System

1. Ground in accordance with NEC.

2. Ground secondary neutral and enclosure of transformers to nearest ground bus or sub-bus using insulated grounding electrode conductor.

3. For transformer located outside of building, install additional grounding connector between transformer secondary neutral/enclosure and ground bus or grid using insulated grounding electrode conductor.

G. Grounding for Personnel Safety

1. In substation, electrical and mechanical rooms, tie-breaker stations, chiller plants, fan shaft and pumping stations, bond exposed metallic structure, motor frame, AC-equipment enclosure, ductwork and metallic piping to local ground bus, using minimum of 6 AWG insulated grounding conductor as follows:

   a. Ground multiple items of exposed metallic structure to local ground bus using a separate grounding conductor for each item or by using series-connected grounding conductors to connect two or more items.

   b. Ground each AC equipment enclosure to local ground bus using a separate grounding conductor.

   c. Connection of grounding conductor for AC equipment enclosure in series with grounding conductor for exposed metal structure is prohibited.

2. Bond escalator's and elevator's motor frames, AC-equipment enclosures and metallic structures to equipment grounding conductor in AC-power feeder and to local ground bus bar. Provide a second ground path, connecting trusses and guide rails, using #1/0 AWG insulated ground conductor connected to ground bus bar in AC Switchboard room. Leave 20-foot length of conductor coiled up in pits or well way for making the grounding connections to trusses and guide rails by the escalator stage contractor.

3. Bond metallic ladders and stairs in fan shafts, vent shafts and other locations to local ground bus, using insulated grounding conductor, 6 AWG minimum.

4. Bond and ground exposed metallic structures in open areas to separate grounding electrode in accordance with the following requirements:

   a. Metal pole for mounting light fixtures: Bond and ground each metal pole to separate 5/8-inch diameter by 10-foot long ground rod, buried with top 2 feet below grade with 2-foot separation from footing, using 6 AWG insulated grounding conductor.

   b. Cable troughs alongside track: Bond and ground metal cable troughs to 5/8-inch diameter by 10-foot long ground rod, buried with top two feet below grade, at approximate 50-foot intervals and at each end with 2-foot separation from reinforced or buried metallic

structures, using 4 AWG insulated grounding conductor. At expansion and contraction joints, install 4 AWG insulated grounding conductor for electrical continuity.

c. Metallic railings and fences alongside track: Bond and ground railings and posts for galvanized steel fence to 5/8-inch diameter by 10-foot long ground rod, buried with top 2 feet below grade, at approximate 50-foot intervals and at each end, with 2-foot separation from railing and fence-post footing and other reinforced structure, using 4 AWG insulated grounding conductor. For electrical continuity, where necessary, install flexible copper braided or leaf-type jumper or 4 AWG insulated grounding conductor. In addition to the above requirements for grounding galvanized steel fences, provide the following for grounding PVC-coated steel fences:

(1) Bond and ground each fence post to bottom tension wire using 6 AWG bare grounding conductor, O-Z Type CG, Burndy Type GAR or approved equal connector at fence post, and Burndy Type KS or approved equal tap connector at tension wire.

(2) At connections of grounding conductors to posts and tension wires, remove vinyl coating at contact surfaces before making connections and apply vinyl coating over finished connections to match original coating.

d. Railing, cable trough and metallic-deck structure at aerial track

(1) In each abutment and pier, install 4/0 AWG insulated grounding conductor with one end connected to pile or one-inch diameter by 10-foot long ground rod, buried with top 2 feet below grade, with 2-foot separation from concrete structure and 3-foot pigtail on the top of pier or abutment for bonding and grounding of deck structure.

(2) Bond and ground deck structure, cable trough and hand railing to 4/0 AWG insulated grounding conductor installed at each abutment and pier using 4AWG insulated grounding conductor. For providing electrical continuity, where necessary, install flexible copper braided or leaf-type jumper or 4 AWG insulated grounding conductor.

5. In underground locations, bond and ground hand railing and metallic safety walk grating at each end and at approximate 50-foot intervals to nearest ground bus or sub-bus, using 6 AWG insulated grounding conductor. For electrical continuity, where necessary, install flexible copper braided or leaf-type jumper or 6 AWG insulated grounding conductor.

6. Bus passenger and supervisor shelters equipped with light fixtures: Provide multiple ground paths as follows:

a. Bond and ground two separate frame columns of each single or double bus passenger shelter or supervisor shelter to two separate ground rods using 6AWG insulated grounding conductor. Drive 5/8-inch diameter by 10-foot long ground rod with top of rod 6 inches below finished grade.

b. Bond and ground each shelter to equipment grounding conductor in branch circuit.

7. Passenger shelter equipped with illuminated diorama and receptacle at station platform: Provide multiple ground paths as follows:

a. Bond and ground two separate frame columns of each shelter to nearest ground bus in electrical room or sub-bus or to 5/8-inch diameter by 10-foot long ground rod driven so that the top of rod is 3 inches above finished floor of under platform space using 6 AWG insulated grounding conductor unless otherwise shown.

b. Bond and ground each shelter to equipment grounding conductor in branch circuit.

8. Illuminated diorama, station pylon equipped with light fixtures, map case and telephone enclosure: Provide multiple ground paths as follows:

    a. Bond and ground illuminated diorama frame, column of station pylon equipped with light fixtures, map case, and telephone enclosure to nearest ground bus in electrical room or sub-bus or to 5/8-inch diameter by 10-foot long ground rod driven so that the top of rod is 3 inches above finished floor of under platform space using 6AWG insulated grounding conductor unless otherwise shown.

    b. Bond and ground frame of each illuminated diorama, pylon equipped with light fixture, map case, and telephone enclosure to equipment grounding conductor in branch circuit.

9. Station entrance pylon (Type B): Provide multiple ground paths as follows:

    a. Bond and ground the pylon frame using 6 AWG insulated grounding conductor to 5/8-inch diameter by 10-foot long ground rod driven so that top of rod is 6 inches below finished grade.

    b. Bond and ground the pylon frame to equipment grounding conductor in branch circuit.

10. Handhole, manhole, and junction box metallic body, cover frame, and cover: Provide a minimum of two ground paths as follows:

    a. Bond and ground handhole, manhole and junction box metallic cover frame and metallic body to 5/8-inch diameter by 10-foot long ground rod driven with top of rod 3 inches above bottom of manhole, handhole and junction box using 6 AWG insulated grounding conductor.

    b. Provide a minimum of 6AWG insulated grounding conductor and a bronze or brass chain with 210-pound breaking strength in a 1/2-inch or 5/8-inch rubber hose to bond metallic cover to metallic cover frame. Length of cable, chain, and hose as required allowing removal of cover adjacent to and clearing of handhole or manhole opening.

    c. When cable is spliced in handhole, manhole or junction box, bond metallic cover frame and body to equipment grounding conductor.

11. Exothermically weld or gas torch braze grounding and bonding connection to exposed metallic structure, metallic cable trough, galvanized steel fence, hand railing, metallic safety walk grating, map case and telephone enclosure, frame columns of shelter, pylon and diorama, and metallic cover, metallic cover frame and metallic body of handhole, and manhole and junction box. Repair damaged galvanized coating in accordance with Section 02820. Repair finish of shelter, map case and telephone enclosure and diorama frame to match existing finish.

## 3.2 BONDING FOR STRAY CURRENT AND CATHODIC PROTECTION

A. Reinforcing Steel in Tunnel, At-Grade and Aerial Sections

1. Bond reinforcing steel using 250 MCM, Class G, and stranded bare conductor exothermically welded to steel straps as shown, in accordance with Section 03200.

B. Floating-Slab Expansion Joints

1. Bond floating-slab expansion joints, using 1/0 AWG, Class G, stranded bare conductor exothermic welded to longitudinal bar.

C. Fabricated Gray-Iron or Ductile-Iron Tunnel-Lining Segments

1. Bond gray-iron or ductile-iron segments as shown in accordance with Sections 02415 and 02416.

D. Fabricated Steel Tunnel-Lining Segments

1. Bond steel segments as shown in accordance with Sections 02415 and 02417.

E. Metallic Pipe

1. Bond across joint for the following pipe, pipe fittings and pipe appurtenances, except those welded or soldered joints, using 2 AWG insulated conductor as shown and in accordance with Section 15205, PIPING SYSTEMS.

a. Buried pipe, except soil pipe unless shown bonded.

b. Pressure pipe.

c. Pipe parallel to and within 20 feet of centerline of track.

2. Do not bond District of Columbia, Department of Public Works (DCDPW), buried piping systems.

F. Permanent Metal Piles

1. Interconnect permanent metal piles, except those used in ground grid, using 4/0 AWG insulated conductor exothermically welded to piles. At each end of line of bonded piles, connect 4/0 AWG insulated conductor and terminate it in box inside line structure. Identify conductor termination using non-metallic tags or plastic labels attached to conductor with slip-free plastic lacing or nylon bundling strap.

G. Drainage Cables in Tunnel, At-Grade and Aerial Sections

1. Between bonded reinforcing steel and negative switchboard in traction-power substation, install stray-current discharge cable in accordance with the following requirements:

a. Adjacent to each traction-power substation, install two 250 kcmil, Class G, stranded bare conductors, one end of each conductor welded to the reinforcing steel, which has been bonded as specified herein, and the other end terminated in 12-inch by 18-inch by 4-inch junction box.

b. From the junction box, install two 250 kcmil insulated cables in FRE conduit to DC negative switchboard area of the traction-power substation for future connection by others.

H. Separate reinforcing steel and other buried metallic structures, bonded for stray current and cathodic protection, from ground grid, grounding electrode, or exposed metallic structures grounded for personnel safety. Metallic contact or electrical bonding between two systems is prohibited.

3.3 FIELD QUALITY CONTROL

A. Test ground resistance of each ground grid after installation and each ground bus when connected to ground grid, using approved test procedure.

B. Ground resistance not to exceed the following:

1. Ground grid/bus in ac-switchboard rooms, chiller plants, and traction-power substations: 2 ohms.

2. Ground grid/bus in fan shafts, drainage-pumping stations, electrical rooms, dispatcher rooms, Bell system rooms, mechanical rooms and DC tie-breaker stations: 5 ohms.

C. To meet resistance requirements, install additional ground rods or use permanent metal piles as ground rods.

D. Isolate permanent metal piles used for grounding from those bonded for stray-current and cathodic protection.

E. Test metallic conduits and raceways, metallic enclosures for equipment, metallic cable troughs, fences, metallic hand railings, metallic safety walk gratings, metallic structures, metallic covers, cover frames and bodies of manholes, handholes and junction boxes, frames of shelters, pylons and dioramas, map case and telephone enclosures, and poles for mounting lighting fixtures for continuity to grounding system.

F. Test resistance of connection between ground bus in train-control rooms/communications rooms and ground bus in associated ac-switchboard rooms, traction-power substations or DC tie-breaker stations for resistance not to exceed one ohm.

G. Conduct tests in presence of Contracting Officer Representative.

H. Inspect and test exothermic welds as follows:

1. Inspect finished exothermic welds for visual characteristics that are consistent with a properly made connection in accordance with the manufacturer's instructions and recommendations. Remove welds that do not meet minimum visual requirements as acknowledged by the Contracting Officer Representative, and reweld after cleaning the area to be welded.

2. Test mechanical strength of exothermic weld by applying three sharp blows to the weld with a 2-pound hammer using 15-inch strokes. Acceptable welds to sustain the blows without cracking the weld metal or the bond between the two connecting materials. Remove defective welds and reweld after cleaning the area to be welded.

END OF SECTION

# SECTION 16120

# WIRE, CABLE AND BUSWAYS

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for providing wire, cable, and busways.

B. Requirements for single-conductor cable and for multiple-conductor cable as stated except as otherwise specified.

1.2 RELATED REQUIREMENTS

A. Grading, excavating and backfilling: Section 02320.

B. Wire connection accessories: Section 16125, WIRE CONNECTION ACCESSORIES.

C. Raceways, boxes and cabinets: Section 16130, RACEWAYS, BOXES, AND CABINETS.

1.3 REFERENCES

A. Comply with codes and regulations of the Jurisdictional Authorities.

B. National Electrical Code (NEC).

C. Insulated Cable Engineers Association (ICEA): S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, S-81-570.

D. Institute of Electrical and Electronics Engineers (IEEE):

1. 1202 IEEE Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies,

2. 383 IEEE Standard for Type Test of Class 1E Electrical Cables, Field Splices, and Connections for Nuclear Power Generating Stations.

E. National Electrical Manufacturers Association (NEMA): BU1, WC70, WC71, WC74.

F. American National Standards Institute (ANSI):

1. C37.20.1, Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear;

2. C37.20.2, Metal-Clad and Station-Type Cubicle Switchgear;

3. C37.20.3, Metal-Enclosed Interrupter Switchgear;

4. Z55.1, Gray Finishes for Industrial Apparatus and Equipment.

G. Underwriter's Laboratory (UL):

1. 44, Rubber-Insulated Wires and Cables Thermoses-Insulated Wires and Cables;

2. 62, Flexible Cord and Fixture Wire;

3. 857, Electric Busways and Associated Fittings; and

4. 1581, Standard for Electrical Wires, Cables, and Flexible Cords.

H. ASTM International (ASTM):

1. B3, Standard Specification for Soft or Annealed Copper Wire;

2. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft;

3. D471, Standard Test Method for Rubber Property-Effect of Liquids,

4. E662, Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials.

I. Intelligent Transportation Society (ITS):

1. Directory of ITS Listed Products

1.4 DEFINITIONS

A. Cable: Cable having low smoke generating characteristics.

1.5 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each.

1. Shop Drawings.

2. Samples

a. Smoke-density test sample for jacket material: Specified sample will become property of the Authority.

3. Certification

a. Certified flame-retardancy test reports (VW-1, IEEE 383, and IEEE 1202, Article 18) and data for tests performed not more than 12 months prior to submittal, for materials, which are identical to those of cable furnished. Include test reports with submittal of Shop Drawings.

b. Submit smoke-density test reports and data for tests performed on the jacket material not more than 12 months prior to the submittal, for materials, which are identical to those of the furnished cable. Include test reports with submittal of Shop Drawings.

c. Certified test reports demonstrating that cable complies with specified requirements and those of referenced ICEA Standards. Submit test reports prior to cable shipments.

d. Certificates from manufacturers verifying that products conform to specified requirements. Include certificate with submittal of Shop Drawings and with each cable shipment.

1.6 QUALITY ASSURANCE

A. Qualifications: Select a manufacturer who is engaged in production of similar wire, cable, and busways.

B. Source Quality Control

1. Cable and busways: Listed or labeled in accordance with UL or ITS directory.

1.7 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Mark each single-conductor cable, each multiple-conductor cable and each busway to show label in accordance with referenced UL or ITS directory, size, voltage, manufacturer and number of conductors or phases in accordance with NEC requirements.

B. Ship each unit securely packaged and labeled for safe handling and shipment.

C. Store products in a dry and secure facility.

**PART 2 – PRODUCTS**

2.1 PRODUCTS AND MATERIALS

A. General Requirements for Single-Conductor and Multiple-Conductor Cable

1. Type and size: As shown.

2. Rated voltage: 600 volts.

3. Conductors

a. ASTM B3 or B8 annealed copper.

b. Size 10 AWG and smaller: Solid or Class B or Class C stranded.

c. Size 8 AWG and larger: Class B stranded.

4. Standards: Except as modified, wires and cable complying with the following standards:

a. Cross-linked polyethylene (XLPE) insulated cable: ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, S-81-570.

b. Other cable: ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, and S-81-570.

5. Non-metallic jacket for single-conductor cable and an overall covering on multiple-conductor cable

a. Chlorosulfonated polyethylene or cross-linked polyolefin.

b. Cross-linked polyolefin complying with the following physical requirements. Properties tested in accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, and S-81-570 if ethylene-propylene-rubber (EPR) insulation is used, or with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692 if cross-linked polyethylene insulation is used. Jacket material free of PVC and PVC-based compounds.

(1) Tensile strength, minimum pounds per square inch: 1,800.

(2) Elongation at rupture, minimum percent: 150.

(3) Aging requirement: After 168 hours in air oven test at 100 degrees C, plus or minus 1 degree C

(a) Tensile strength, minimum percentage of unaged value: 100.

(b) Elongation at rupture, minimum percentage of unaged value: 80.

(4) Oil immersion: 18 hours at 121 degrees C, plus or minus 1 degree C, ASTM D471, Table 1, No. 2 oil

(a) Tensile strength, minimum percentage of unaged value: 80.

(b) Elongation at rupture, minimum percentage of unaged value: 80.

c. Jacket materials other than cross-linked polyolefin complying with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692. Jacket material free of PVC and PVC-based compounds.

6. Flame retardancy: Single-conductor and multiple-conductor cable tested by independent agency demonstrating flame retardancy in accordance with the following:

a. Single-conductor cable and individual conductors of multiple-conductor cable passing vertical wire (VW-1) flame test in accordance with UL1581 or ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692. Cable size for testing: 14AWG.

b. Single-conductor cable, size 1/0 AWG and larger, passing vertical tray flame test, using ribbon gas burner in accordance with IEEE 1202 or IEEE 383. Cable size for testing: 1/0 AWG.

c. Multiple conductor cable passing vertical tray flame test using ribbon gas burner in accordance with IEEE 383 or IEEE 1202. Cable size for testing: 7/C or 9/C with No. 12 AWG or No. 14 AWG conductors.

7. Smoke generation: Single and multiple-conductor cable jacket materials demonstrating low-smoke generation when tested in accordance with ASTM E662 by independent, nationally recognized testing agency.

a. Conduct tests on specimens of overall jacket material for multiple-conductor cable and of jacket material for single-conductor cable.

b. Prepare slab specimens for each material. 100 inch, plus or minus 0.005-inch thick, identical to those of finished cables and meeting minimum physical requirements specified.

(1) Prior to testing, submit 6-inch square portion of each specimen. Tag sample with manufacturer's jacket or insulation identification code or number.

c. Test values for chlorosulfonated polyethylene not to exceed the following:

(1) Flaming mode

(a) Uncorrected maximum specific optical density during first 4 minutes of test: 325.

(b) Uncorrected maximum specific optical density for entire 20-minute test: 400.

(2) Nonflaming mode

(a) Uncorrected maximum specific optical density during first 4 minutes of test: 325.

(b) Uncorrected maximum specific optical density for entire 20-minute test: 480.

d. Test values for cross-linked polyolefin not to exceed the following:

(1) Flaming mode

(a) Uncorrected maximum specific optical density during first 4 minutes of test: 150.

(b) Uncorrected maximum specific optical density for entire 20-minute test: 300.

(2) Nonflaming mode

(a) Uncorrected maximum specific optical density during first 4 minutes of test: 150.

(b) Uncorrected maximum specific optical density for entire 20-minute test: 300.

8. Applied voltage testing

a. Single-conductor cable and individual conductors of multiple-conductor cable to be given applied A- voltage dielectric-strength test, i.e., 6-hour water-immersion test.

b. For single conductors of multiple-conductor cable, conduct tests prior to assembly as multiple-conductor cable.

c. Test procedures

(1) Polyethylene-insulated conductors: In accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692.

(2) Other conductors: In accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, and S-81-570.

B. Single-Conductor Cable

1. Insulated with ethylene-propylene-rubber with non-metallic jacket as specified. UL-Labeled as Type RHW-2.

2. Color coding: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.

C. Multiple-Conductor Cable

1. Individual conductors

a. Number of conductors: As shown.

b. Construction: Complying with one of the following:

(1) Insulated with ethylene-propylene-rubber, with or without non-metallic jacket.

(2) Insulated with composite compound of ethylene-propylene-rubber and polyethylene, without outer jacket.

(3) Insulated with filled cross-linked polyethylene without jacket.

c. Phase and neutral conductors: Individually insulated.

d. Neutral conductors: Same size as phase conductors.

e. Bare ground conductors: Sized in accordance with the NEC, unless otherwise shown.

f. UL Listed as Type RHW-2 or XHHW-2.

2. Conductors assembled with nonwicking, flame-retardant filler to form cable of circular cross section.

3. Metallic sheath

   a. Provide one of the following:

      (1) Size 1 AWG and larger

         (a) Interlocked aluminum-tape armor.

         (b) Continuous corrugated aluminum sheath conforming to ICEA S-19-81, Table 4-26A.

      (2) Size 2 AWG and smaller: As specified for 1 AWG and larger or continuous smooth aluminum sheath conforming to ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692.

   b. Metallic covering not required for multiple-conductor TC cable with overall non-metallic jacket when installed in cable tray.

4. Multiple-conductor cable provided with overall non-metallic jacket as specified.

5. Cable UL-listed as follows:

   a. Non-metallic-sheathed cable: Type TC, suitable for wet and dry locations.

   b. Metallic-sheathed cable: Type MC, suitable for wet and dry locations.

6. Color coding

   a. Power cables: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.

   b. Control cables: In accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692.

D. Fixture Wire: UL 62, with the following additional requirements:

1. Type: SF-2 silicone-rubber insulated or as necessary to suit temperature rating of lighting fixture, minimum 90 degrees C.

2. Conductor: Stranded copper conductor 16 AWG or larger as shown.

E. Bare Conductors: ASTM B3 or B8, annealed copper conductor; 8AWG and larger, Class B stranded, unless otherwise shown or specified.

F. Busway (Busduct) and Fittings

1. UL 857, NEMA BU1.

2. Totally enclosed, three-phase, four-wire feeder busway system, as shown, with necessary fittings, hanging devices, accessories and provision for flange bolting over circuit breaker.

3. Continuous current rating

   a. Secondary tie duct for use in combined substation: Sized in accordance with ANSI C37.20.1, C37.20.2, C37.20.3, and NEC.

4. Voltage rating: 480/277 volts.

5. Busway system braced to withstand minimum short-circuit current of 75,000 amperes symmetrical, unless otherwise shown.

6. Maximum allowable temperature rise in busway at continuous full load above maximum ambient temperature of 40 degrees C:55 degrees C.

7. Housing: Nonventilated, fabricated from galvanized sheet steel. Removable gasketed cover provided at transformer connection for maintenance and test. Hardware galvanized or cadmium-plated.

8. Joints

   a. Single-bolt pressure joint designed for optimum electrical contact and mechanical strength.

   b. To permit safe testing of its tightness without de-energizing systems.

   c. To permit removal of duct sections without disturbing adjacent pieces.

   d. To permit making up joint from one side when busway is installed against wall or ceiling.

9. Busbars: Fabricated from 98-percent-conductivity copper and insulated over entire length except at joints and contact surface. Joints and contact surfaces tin-plated or silver-plated. Neutral bar same size as phase bar. Ground bar half size of phase bar.

10. Entire busway system polarized.

11. Expansion fittings provided where necessary.

12. Flexible connections, braided or laminated, provided for connecting bus conductor to transformer terminals.

13. Finish: Light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, 2 mils.

**PART 3 – EXECUTION**

3.1 INSTALLATION

A. Install type cable as specified.

B. Install single-conductor cable in conduit, underfloor duct, or wireway. Install UL Type TC multiple-conductor cable in cable trays only. Install UL Type MC multiple-conductor cable and ground cable on channel inserts, cable trays, racks, trench or trough using straps and fasteners as specified in Section 16130, RACEWAYS, BOXES, AND CABINETS. Install UL Type MC multiple-conductor cable in conduit where shown or required. On walls or ceilings, fasten cable and bus duct directly to channel inserts, or use expansion-bolt anchors to attach to concrete and toggle bolts to attach to concrete masonry unit walls. Splice cable only when unavoidable.

C. Install motor feeders, service connections, and extensions in accordance with reference codes. Install motor feeder in 18-inch minimum length liquid-tight flexible conduit at motor conduit box.

D. Use nylon straps to bundle and secure wire and cable located in panelboards, cabinets, switchboards, motor control centers, and switchgear.

E. Minimum bending radius 12 times outer diameter of cable. Where shown, use shorter bending radius as permitted by NEC, ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692, and cable manufacturer.

F. To facilitate pulling cable, use listed in accordance with UL or ITS directory lubricant recommended by cable manufacturer.

G. Use direct-burial cable only for stray current and cathodic protection.

H. To install direct-burial cable, prepare trench of uniform width and free of sharp projections and rocks and place 3-inch bed of sand. Do not pull cable directly into trench from stationary reel; unreel cable beside trench. Place cable on sand bed and backfill with 3-inch deep sand cover. Fill remainder of trench with approved fill material and compact in accordance with Section 02320. Provide temporary supports in trench as necessary to prevent damage to insulation or jacket during installation.

I. In damp and dusty indoor locations, tunnel areas, manholes and outdoor locations, seal cable at conduit termination using duct-sealing compound.

J. Where shown or necessary, install cable-seal fitting specified in Section 16130, RACEWAYS, BOXES, AND CABINETS, to prevent entry of water into electrical facilities. Where approved, use seal compound specified in Section 16130, RACEWAYS, BOXES, AND CABINETS.

3.2 IDENTIFICATION

A. Identify cable terminations, feeders, and power circuits using non-metallic fiberboard tags or plastic labels. Attach tags to cable with slip-free plastic lacing or nylon bundling straps. Use designation shown.

3.3 FIELD QUALITY CONTROL

A. Furnish equipment required to perform tests. Prior to insulation and high-potential tests, disconnect instruments and equipment, which might be damaged during such tests. Conduct tests in presence of the Contracting Officer Representative.

B. Submit test procedure for approval and perform approved tests including, but not limited to, the following:

1. Single-conductor cable and multiple-conductor cable

a. Test continuity of cable conductors using ohmmeter.

b. Proof-test insulation resistance to ground and between insulated conductors for minimum of 1 minute using 1,000-volt megger. Insulation resistance: 200,000 ohms minimum.

c. When cable shows unsteady insulation resistance of less than 200,000 ohms, perform high-potential test at 80 percent of factory AC test voltage or as recommended by cable manufacturer.

2. Busway

a. Clean contact surfaces before making connections. For bolted connections, apply torque recommended by manufacturer.

b. Test resistance of busway connections. Resistance not to exceed value recommended by manufacturer.

c. Test insulation resistance to ground and between insulated busbars for minimum of 1 minute using 1,000-volt megger. Insulation resistance: One-megohm minimum. When busway shows insulation resistance of less than 1-megohm minimum, perform high-potential test.

C. Submit certified test reports.

END OF SECTION

# SECTION 16125

# WIRE CONNECTION ACCESSORIES

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for providing wire-connection accessories, such as connectors, terminal lugs and fittings, bundling straps, insulating tape, and resin.

1.2 REFERENCES

A. Comply with codes and regulations of the Jurisdictional Authorities.

B. National Electrical Code (NEC).

C. Underwriter's Laboratory (UL)

1. 486A, Wire Connectors and Soldering Lugs for Use with Copper Conductors.

D. ASTM International (ASTM)

1. D149, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

2. D257, Standard Test Methods for DC Resistance or Conductance of Insulating Materials

3. D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers-Tension

4. D570, Standard Test Method for Water Absorption of Plastics

5. D638, Standard Test Method for Tensile Properties of Plastic

6. D696, Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30°C and 30°C with a Vitreous Silica Dilatometer

7. D792, Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

8. D1000, Standard Test Method for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications

9. D1518, Standard Test Method for Thermal Transmittance of Textile Materials

10. D5034, Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)

11. D5035, Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)

12. D2240, Standard Test Method for Rubber Property-Durometer Hardness; and

13. G21, Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.

E. American National Standards Institute (ANSI)

1. C119.1, Sealed Insulated Underground Connector System 600V

F. Intelligent Transportation Society (ITS)

1. Directory of ITS Listed Products.

1.3 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each:

1. Shop Drawings.

2. Certification.

1.4 QUALITY ASSURANCE

A. Qualifications: Select a manufacturer who is engaged in production of similar wire connection accessories.

B. Source Quality Control

1. Connectors, terminal lugs, and fittings listed, in accordance with referenced UL or ITS directory.

2. Factory testing: Submit certified copies of test report for cable splice and tap-insulation/sealing kits as specified.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Mark each item in accordance with applicable reference standard.

B. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage.

C. Store products in secure and dry storage facility.

**PART 2 – PRODUCTS**

2.1 PRODUCTS AND MATERIALS

A. Connectors, Terminal Lugs and Fittings

1. In accordance with UL 486A.

2. For 10 AWG and smaller conductor cable: Tin-plated copper pressure connectors with nonflammable, self-extinguishing insulation grip with temperature rating equal to that of conductor insulation.

3. For 8 AWG to 4/0 AWG conductor cable: Tin-plated copper compression connectors and terminal lugs with nylon insulating sleeve for insulation grip.

4. For 250 Kcmil and larger conductor cable: Long-barrel, double-compression tin-plated copper connectors and terminal lugs with two-hole pad.

5. For multiple-conductor cable: Watertight aluminum fittings with stainless-steel pressure ring and set screws or compression cone for grounding of aluminum sheath of MC Cable.

B. Bundling Straps

1. Self-locking steel barb on one end, with tapered strap of self-extinguishing nylon, temperature rating minus 40 degrees F to plus 185 degrees F.

2. For outdoor use: Ultraviolet-resistant.

C. Insulating Tape

1. Plastic tape: Vinyl plastic tape with rubber-based pressure-sensitive adhesive, pliable at zero degree F with the following minimum properties when tested in accordance with ASTM D1000:

   a. Thickness: 8.5 mils.

   b. Breaking strength: 20 pounds per inch width.

   c. Elongation: 200 percent.

   d. Dielectric breakdown: 10,000 volts.

   e. Insulation resistance, indirect method of electrolytic corrosion: 1,000,000 megohms.

2. Rubber tape: Silicone-rubber tape with silicone pressure-sensitive adhesive, with the following minimum properties when tested in accordance with ASTM D1000:

   a. Thickness: 12 mils.

   b. Breaking strength: 13 pounds per inch width.

   c. Elongation: 525 percent.

   d. Dielectric breakdown: 13,000 volts.

   e. Insulation resistance, indirect method of electrolytic corrosion: 1,000,000 megohms.

3. Arcproof tape: Flexible, coated one side with flame-retardant flexible elastomer, self-extinguishing, non-combustible, with the following minimum properties:

   a. Thickness, ASTM D1000: 30 mils.

   b. Breaking strength, ASTM D5034-95 and D5035: 50 pounds per inch width.

   c. Thermal conductivity, ASTM D1518: 0.0478 BTU per hour per square foot per degree F.

   d. Electrical arc resistance: Withstand 200 amperes arc for 30 seconds.

4. Glass tape: Woven-glass fabric tape with pressure-sensitive thermosetting adhesive, with the following minimum properties when tested in accordance with ASTM D1000:

   a. Nominal width: 3/4 inch.

   b. Thickness: 7 mils.

   c. Breaking strength: 170 pounds per inch width.

   d. Elongation: 5 percent.

   e. Dielectric breakdown: 2,500 volts.

   f. Insulation resistance, indirect method of electrolytic corrosion: 5,000 megohms.

D. Epoxy Resin: Suitable for insulating and moisture sealing cable splices, with the following minimum properties:

1. Dielectric strength, ASTM D149: 400 volts per mil.

2. Volume resistance, ASTM D257: 2.8 x $10^{15}$ ohm per centimeter cube at 30 degrees C.

3. Water absorption, ASTM D570

   a. 0.193 percent in 24 hours at 23 degrees C.

   b. 0.62 percent in 24 hours at 53 degrees C.

4. Tensile strength, ASTM D638: 8,000 psi.

5. Elongation, ASTM D638: 2.4 percent.

6. Coefficient of expansion, ASTM D696: 6.8 X $10^{-5}$ inch per inch per degree C.

E. Cable splice and tap-insulation/sealing kit: Suitable for use on 600-volt, 90 degrees C cables, material compatible with cable insulation and jacket, meeting the seal test requirements of ANSI C119.1.

1. Heat-shrinkable tubing or wraparound heat-shrinkable sleeve: approved per referenced UL or ITS directory, flame-retardant, corrosion-resistant thick-wall tubing with factory-applied sealant for field insulation on in-line splices and taps or wraparound-type sleeve for retrofit installation on existing splices and taps to provide a watertight seal and insulating encapsulation, with the following additional requirements:

   a. Material: Cross-linked polyolefin.

   b. Shrink ratio: 3 to 1 minimum.

   c. Physical properties

      (1) Ultimate tensile strength: 2,350 psi, ASTM D412.

      (2) Ultimate elongation: 350 percent, ASTM D412.

      (3) Hardness, Shore D: 42, ASTM D2240.

      (4) Water absorption: 0.050 percent, ASTM D570, Method 6.1.

      (5) Specific gravity: 1.28, ASTM D792.

   d. Electrical properties

      (1) Dielectric strength: 450 volts per mil, ASTM D412.

      (2) Volume resistivity: 1 x $10^{14}$ ohm cm, ASTM D257.

   e. Thermal properties

      (1) Continuous operating temp: minus 55 degrees C to plus 135 degrees C.

      (2) Air oven aging (14 days at 175 degrees C):

         (a) Tensile strength: 2,680 psi.

         (b) Elongation: 375 percent.

      (3) Low temp. flexibility (4 hours at minus 55 degrees C): No cracking when flexed.

      (4) Heat shock (4 hours at 250 degrees C): No cracking, flowing or dripping.

f. Chemical properties

(1) Corrosivity: Non-corrosive.

(2) Fungus resistance: Non-nutrient, ASTM G21.

(3) Flammability: Self-extinguishing.

**PART 3 – EXECUTION**

3.1 SPLICES AND TERMINATIONS

A. Make wire and cable splices in outlet, junction, or pull boxes, in cable troughs or in equipment cabinets. Splices in conduit are prohibited.

B. Secure connectors or terminal lugs to conductor so as to engage all strands equally.

C. Do not rupture insulation nor expose bare conductors.

D. Install compression connectors and terminal lugs using tools and pressure recommended by manufacturer. Indent mark connectors and terminal lugs with number of die used for installation.

E. Apply anti-corrosion joint compound to connectors, terminal lugs, and bolting pads before installation.

F. Wrap 1/2-lapped layer of arcproof tape, glass tape overall on cable splices installed in air tunnels, ducts and shafts.

G. Install terminal fittings on multiple-conductor cable in accordance with manufacturer's recommendation. Completely seal cable from moisture.

H. On cable splices, taps and terminations in manhole handhole and outdoor junction and pull boxes, cover connectors with electrical putty, wrapped with three layers of plastic tape or final layer of rubber tape and then install watertight encapsulation as follows and under the supervision of kit manufacturer's representative or using a factory-certified installation technician, proficient in field installation of heat-shrinkable sealing kits.

1. Use heat-shrinkable tubing for encapsulation of new splices, taps, and terminations.

2. Use wraparound-type heat-shrinkable sleeve for encapsulation of existing splices, taps and terminations.

3.2 CATHODIC PROTECTION SPLICES AND TERMINATIONS

A. For splices made in aboveground cable, use compression connectors covered with electrical putty, wrapped with three layers of plastic tape and final layer of rubber tape.

B. Install compression terminal lugs using tools and pressure recommended by manufacturer. Indent mark terminal lugs with number of die used for installation.

C. For splices made in direct-burial cable, use thermite weld sealed with cast epoxy-resin encapsulation.

3.3 INSPECTION

A. Have splices in direct-burial cable for stray current and cathodic protection inspected by the Contracting Officer Representative before backfilling.

B. Have splices and taps in manholes, handholes and outdoor junction and pull boxes inspected by the Contracting Officer Representative or the manufacturer's representative, when available.

END OF SECTION

# SECTION 16130

# RACEWAYS, BOXES AND CABINETS

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for providing conduit, raceways, cable trays, boxes, and cabinets to form raceway and support system for power, communication, and control cables.

1.2 RELATED REQUIREMENTS

A. Underground electrical and communications distribution systems: Section 02585.

B. Concrete formwork: Section 03100.

C. Cast-in-place structural concrete: Section 03300.

D. Structural precast concrete: Section 03400.

E. Firestopping: Section 07841, FIRESTOPPING.

F. Grounding and bonding: Section 16060, GROUNDING AND BONDING.

1.3 REFERENCES

A. Comply with codes and regulations of the Jurisdictional Authorities.

B. National Electrical Code (NEC).

C. National Electrical Manufacturers Association (NEMA)

1. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).

2. VE 1, Metallic Cable Tray Systems

3. TC-2, Electrical Polyvinyl Cloride (PVC) Tubing and Conduit.

D. American National Standards Institute (ANSI)

1. C80.1, Rigid Steel Conduit - Zinc Coated.

2. C80.5, Aluminum Rigid Conduit - (ARC).

3. Z55.1, Gray Finishes for Industrial Apparatus and Equipment.

E. Underwriter"s Laboratories (UL):

1. 5, Surface Metal Raceways and Fittings.

2. 6, Rigid Metal Conduit.

3. 50, Enclosures for Electrical Equipment.

4. 94, Test for Flammability of Plastic Materials for Parts in Devices and Appliances.

5. 360, Liquid Tight Flexible Steel Conduit.

6. 514A, Metallic Outlet Boxes.

7. 514B, Fittings for Conduit and Outlet Boxes.
8. 514C, Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers.
9. 651, Schedule 40 and 80 Rigid PVC Conduit.
10. 884, Underfloor Raceways and Fittings.
11. 1684, Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

F. Federal Specifications (FS): FF-S-325C, FF-S-760, TT-S-227.

G. ASTM International (ASTM)

1. A47/A47M, Standard Specification for Ferritic Malleable Iron Castings.
2. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
3. A185, Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement.
4. A276, Standard Specification for Stainless Steel Bars and Shapes;
5. A507, Standard Specification for Drawing Alloy Steel, Sheet and Strip, Hot-Rolled and Cold-Rolled.
6. A532/A532M, Standard Specification for Abrasion-Resistant Cast Irons.
7. A536, Standard Specification for Ductile Iron Castings.
8. A615/A615M, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
9. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
10. B138, Standard Specification for Manganese Bronze Rod, Bar and Shapes.
11. B455, Standard Specification for Copper-Zinc-Lead Alloy (Leaded-Brass) Extruded Shapes.
12. B584, Standard Specification for Copper Alloy Sand Castings for General Applications.
13. B633, Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
14. C109/C109M, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens).
15. C173, Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
16. C231, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
17. D149, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
18. D495, Standard Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation.

19. D570, Standard Test Method for Water Absorption of Plastics.

20. D638, Standard Test Method for Tensile Properties of Plastics.

21. D648, Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position.

22. D790, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

H. American Association of State Highway and Transportation Officials (AASHTO):

1. Standard Specifications for Highway Bridges (SSHB).

I. Intelligent Transportation Society (ITS):

J. Directory of ITS listed products.

1.4 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each.

1. Shop Drawings.

2. Certification.

1.5 QUALITY ASSURANCE

A. Qualifications: Select a manufacturer who is engaged in production of similar raceways, boxes, and cabinets.

B. The following items shall be listed or labeled in accordance with referenced UL or ITS directory:

1. Conduit and fittings.

2. Surface raceways and fittings.

3. Underfloor raceways and fittings.

4. Boxes.

5. Cabinets.

1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Mark each item in accordance with applicable reference standard.

B. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.

C. Store products in secure and dry storage facility.

**PART 2 – PRODUCTS**

2.1 PRODUCTS AND MATERIALS

A. General Requirements for Conduit, Raceways, Cable Trays, Boxes, Cabinets, and Fittings:

1. Size: As shown, minimum conduit size 3/4 inch.

2. Materials

   a. Steel sheet: ASTM A507.

   b. Zinc-coated steel sheet: ASTM A653/A653M.

   c. Cast iron: ASTM A532/532M.

   d. Ductile iron: ASTM A536.

   e. Malleable iron: ASTM A47/A47M.

   f. Bronze extrusion: ASTM B455, Alloy C38500.

   g. Bronze casting: ASTM B584, Alloy C83600.

   h. Rigid fiberglass reinforced epoxy: UL 1684.

   i. Stainless steel: ASTM A276, Type 304.

3. Zinc coating

   a. Hot-dip galvanizing: ASTM A123/A123M.

   b. Electro galvanizing: ASTM B633.

B. Galvanized-Steel Rigid Conduit and Fittings: UL 6 and ANSI C80.1, zinc coating tested in accordance with reference test in appendix.

C. Plastic Conduit and Fittings

1. PVC, UL 651, NEMA TC-2, Schedule 40 and 80 heavy-wall, for use with 90 degrees C conductors.

2. Solvent cement: Manufacturer's standard.

D. Aluminum Rigid Conduit and Fittings

1. ANSI C80.5 and UL 6.

E. Liquid-Tight Flexible Conduit and Fittings

1. Applicable requirements of UL 360.

2. Flexible galvanized-steel core with extruded liquid-tight neoprene or PVC jacket overall.

3. Sizes up to 1-1/4 inches provided with continuous copper bonding conductor, spiral wound between convolutions.

4. Sizes 1-1/2 inches and above provided with separate grounding conductor.

F. Conduit Expansion Fittings and Expansion and Deflection Fittings

1. Materials

   a. For galvanized-steel rigid conduit

      (1) Expansion fittings: Steel or malleable iron, hot-dip galvanized.

      (2) Expansion/deflection fittings: Bronze or ductile iron end couplings, neoprene sleeve, and stainless steel clamping bands.

b. For PVC conduit: Rigid metal expansion/deflection fitting with galvanized rigid steel to PVC conduit adapters at each end.

2. Conduit expansion fitting: Weatherproof.

3. Conduit expansion and deflection fitting: Watertight.

4. Metallic fittings equipped with bonding jumper cable to provide electrical continuity.

G. Conduit Connector Fittings

1. UL 514B, material and finish similar to that of conduit with which they are to be used.

2. For enclosures, cabinets, boxes, and gutters in electrical rooms and aboveground indoor locations: Threaded nylon-insulated bushing and locknuts.

3. For enclosure, cabinets, boxes, and gutters with hub in outdoor, tunnel and underground locations, except electrical rooms: Threaded watertight hub fitting with gasket.

4. For enclosure having punched or formed knockout for conduit entry in outdoor and underground locations, except electrical rooms: Threaded watertight fitting with gasket, nylon-insulated throat, and sealing locknut.

H. Conduit and Cable-Seal Fittings

1. Conduit seal

a. To provide watertight seal between concrete and conduit where it penetrates wall, floor, or ceiling.

b. Size as shown or necessary.

c. Materials: Body and pressure clamp of malleable or cast iron with a neoprene sealing grommet and PVC-coated or galvanized-steel pressure rings, oversized sleeve of FRE or galvanized steel.

d. Seal between conduit and concrete to withstand pressure from 50-foot head of water without leakage.

2. Cable seal

a. To provide watertight seal between cable and conduit for use with single-conductor or multiple-conductor cable as necessary.

b. Size as necessary, drilled to accommodate cable.

c. Pressure discs of PVC-coated steel and sealing ring of neoprene.

d. Seal between cable and conduit to withstand water pressure of 50 psi without leakage.

3. Seal compound

a. FS TT-S-227, two-component, fast-setting, polymeric sealing compound to provide watertight seal between concrete and conduit, between cable and conduit.

b. Pour-type for horizontal and gun-grade for vertical or overhead application.

c. When cured, sealant to have rubber-like flexibility allowing minimum movement of conduit and cable in temperature range of minus 40 degrees F to plus 150 degrees F without loss of watertight seal.

d. Pot life: 15 minutes.

e. Minimum ambient temperature for application: 35 degrees F.

f. Initial cure: 15 minutes.

g. Final cure: 7 days.

h. Hardness, Durometer A: 20 to 35.

i. Seal between conduit and concrete to withstand pressure from 50-foot head of water without leakage.

j. Seal between conduit and single-conductor or multiple-conductor cable to withstand water pressure of 70 psi without leakage.

k. Fox Industries, Type FX-571G or approved equal.

I. Conduit and Cable Supports

1. Retaining straps and fasteners: FS FF-S-760, with the following additional requirements:

a. Type, style and size: As necessary.

b. Material and finish: Stainless steel, Type 304, or approved equal.

c. For separating conduit from masonry surface: Hot-dip galvanized malleable-iron spacer assembled with Style a strap.

d. For vertical run of metallic-sheath cable: Basket-weave cable support.

e. For fastening conduit or cable to channel inserts: Stainless steel, Type 304, or approved equal.

2. Multiple pipe hangers (trapeze-type): Consisting of two or more hanger rods, horizontal member, U-bolt clamp and other attachment necessary for securing hanger rods and conduit, with the following additional requirements:

a. Material and finish: Stainless steel, Type 304, or approved equal.

b. Hanger rod: Not smaller than 3/8-inch diameter, threaded for sufficient distance at each end to permit at least 1-1/2 inches of adjustment.

c. Horizontal member: Channel, 1-1/2 inches square or 1-5/8 inches square by 12 gauge or heavier. Weld two or more channels together for greater strength if necessary.

d. Design: Capable of supporting load equal to sum of weights of conduit, cable and hanger plus 200 pounds. At design load, stress at root of thread on hanger rod 9,500-psi maximum; stress in horizontal member 12,500-psi maximum.

3. Channel inserts

a. Size and shape as shown 12 gauge or heavier stainless steel, Type 304, or approved equal, with 7/8-inch wide slot.

b. For surface mounting: Channel inserts with 9/16-inch base slot, eight inches on center with minimum pullout-load rating of 1,000 pounds per linear foot.

4. Spot inserts: Rated 800 pounds with safety factor of five, fabricated from steel galvanized after fabrication, covered to prevent entrance of concrete during installation.

J. Surface Raceways and Fittings: UL 5, fabricated from galvanized steel.

K. Underfloor Raceways and Fittings

1. UL 884.

2. Size: As shown.

3. Fabricated from steel 14 gauge or heavier steel sheet.

4. Finish: Corrosion-resistant coating listed per referenced UL or ITS directory.

L. Boxes and Cabinets

1. Outlet boxes

a. UL 514A, capable of accommodating conduit as shown.

b. Material and finish

(1) Steel, malleable iron, cast iron, or ductile iron.

(2) Hot-dip galvanized or electro galvanized after fabrication.

c. For aboveground indoor locations and electrical rooms: Punched or formed knockouts.

d. For outdoor and underground locations, except electrical rooms

(1) Threaded-conduit entrance hub.

(2) Threaded watertight fitting with gasket, nylon-insulated throat and sealing locknuts for enclosures having punched or formed knockouts for conduit entry.

e. For wall receptacles and switches, single or double devices: Outlet boxes 4-11/16 inches square by 1-1/2 inches deep.

f. For floor receptacles: Watertight cast-iron outlet boxes, 4-inch diameter, of suitable depth and complete with the following:

(1) Adjustment screws for final leveling.

(2) Bronze floor plate with flush-mounted screw plug, without exposed fastener, M32 finish.

(3) Screw plug attached to outlet-box assembly by chain or other means, M32 finish.

(4) Bronze floor plate flange, 5 inches in diameter, extending beyond box 1/2 inch above finished floor, M32 finish.

(5) One special screw-plug removal tool with every ten receptacles.

g. For recessed wall-mounted receptacles: Watertight cast-iron outlet box, 3-inch diameter, of suitable depth and complete with the following:

(1) Bronze faceplate with flush-mounted screw plug, without exposed fasteners, M32 finish.

(2) Screw plug attached to outlet-box assembly by chain or other approved means, M32 finish.

(3) Bronze faceplate flange, 5 inches in diameter, extending beyond box, M32 finish.

(4) One special screw-plug removal tool with every ten receptacles.

2. Junction and pull boxes

a. Internal volume up to 100 cubic inches, metallic boxes: UL 514A, non-metallic boxes: UL514C; internal volume above 100 cubic inches, UL 50.

b. Flush-mounted or surface-mounted as shown.

c. Size: Suitable to accommodate conduit, raceways, ducts, number of cables, and splices shown.

d. Material and finish

(1) Metallic boxes

(a) Steel, malleable iron, cast iron, or ductile iron.

(b) Hot-dip galvanized or electro galvanized after fabrication.

(c) Stainless steel in tunnel areas.

(2) Non-metallic boxes

(a) Precast concrete: Compressive strength 3,500 psi; air entrainment six-percent minimum, ASTM C173 or C231; Section 03300 and Section 03400 and in accordance with the following:

(i) Box: Concrete formed with closed bottom and sides and recess at top of box or at edge of cover to provide mating surfaces to prevent lateral movement of flush-mounted cover. Knockouts provided to accommodate conduits as shown.

(ii) Cover

((a)) Material same as for box. Use of metallic cover and cover frame prohibited.

((b)) Metro Type "B" logo with 3-1/8-inch by 4-inch envelope and service designation recessed in center of cover.

((c)) Non-protruding provisions provided for lifting.

(iii) Reinforcement

((a)) Sidewalk and landscape locations: Welded wire fabric, ASTM A185.

((b)) Areas subject to vehicular traffic: Deformed steel bars, ASTM A615/A615M.

(iv) Loading

((a)) Sidewalk and landscape locations: AASHTO„s SSHB H15-44.

((b)) Areas subject to vehicular traffic: AASHTO„s SSHB H20-44.

((c)) Hardware: Stainless steel.

((d)) Size: As shown or next available larger size.

(b) Composite material: Sand and gravel bound together with a polymer and reinforced with continuous woven glass strands and in accordance with the following:

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

(i) Box: Gray-color material formed with closed bottom and sides and flange with recess at top of box to accommodate flush-mounted cover.

(ii) Cover

((a)) Material same as for box.

((b)) Skid-resistant top surface with minimum 0.5 coefficient of friction.

((c)) Metro Type "B" logo with 3-1/8-inch by 4-inch envelope and service designation recessed in center of cover.

((d)) Secured to box with bolts.

((e)) Non-protruding provisions provided for lifting.

(iii) Loading

((a)) Sidewalk and landscape locations: AASHTO‟s SSHB H15-44.

((b)) Areas subject to vehicular traffic: AASHTO‟s SSHB H20-44.

(iv) Hardware: Stainless steel.

(v) Size: As shown or next available larger size.

(c) Molded fiberglass-reinforced polyester 1/8-inch thickness, minimum, and in accordance with the following requirements:

| Physical Properties | Values | Method |
|---|---|---|
| Flexural strength | 17,000 psi | ASTM D790 |
| Deflection temperature | 400F | ASTM D648 |
| Water absorption (24 hours) | 0.5 percent | ASTM D570 |
| Tensile strength | 6,500 psi | ASTM D638 |
| Specific gravity | 1.8 | ASTM D794 |
| Flammability | 94-5V | UL 94 |
| Dielectric strength | 400 volts per mil | ASTM D149 |
| Arc resistance | 180 seconds | ASTM D495 |

(i) Ultraviolet protection: Fiberglass material containing ultraviolet-inhibitor, or coated with polyurethane paint, 1.5-mil minimum dry-film thickness on both inside and outside surfaces.

(ii) Color: Fiberglass material, gray inside and outside.

(d) Molded polyvinyl chloride 1/8-inch thickness, minimum.

e. For aboveground indoor locations and electrical rooms: Punched or formed knockouts.

f. For outdoor and underground locations, except electrical rooms:

(1) Threaded conduit entrance hub.

(2) Threaded watertight fitting with gasket, nylon-insulated throat and sealing locknuts for boxes having punched or formed knockouts for conduit entry.

3. Cabinets

a. UL 50, fabricated from galvanized steel.

b. Surface-mounted, unless otherwise shown.

c. Backplate of reinforced steel for mounting interior components and to ensure rigid support and accurate alignment.

d. Provision for cabinet grounding.

e. Provide latch and handle in accordance with UL 50; screw fastenings will not be accepted in lieu of latch.

f. Finish: Metallic surface thoroughly cleaned, degreased, primed with zinc primer and coated after fabrication with light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, 2 mils.

M. Cable Trays

1. NEMA VE1, ventilated-steel ladder-type.

2. Dimensions: Three inches inside depth; nine inches rung spacing unless otherwise shown.

3. Maximum load rating: 50 pounds per linear foot with safety factor of 1.5 at 12-foot support span.

4. Bend radius:

a. For incoming service cable: As required by power company.

b. For all other cable: 24 inches or as necessary and approved.

5. Finish: Cable trays, fittings, and accessories hot-dip galvanized or electro galvanized after fabrication.

N. Expansion Bolt Anchors: FS FF-S-325C Group II, stainless steel, Type 304, or approved equal.

O. Data-Transmission System (DTS) Cabinet

1. Wall-mounted, single-door, NEMA 250 Type 12, with panel, Hoffman Engineering Company, as shown, or approved equal.

2. Enclosure: Formed of minimum 14-gauge steel, seams continuously welded and ground, without openings or knockouts, with threaded-conduit entrance hubs, lugs for mounting enclosure and collar studs for mounting panel. Rolled lip formed on all sides of door opening. Enclosure and door reinforced when size exceeds 30 inches square. Size as shown.

3. Door: Formed of minimum 14-gauge steel, with rolled lip along top and sides to mate with enclosure. Fitted with removable print pocket. Closed-cell neoprene gasket attached with oil-resistant adhesive and steel retaining clips.

4. Hardware: Corrosion-resistant steel continuous piano hinge with removable pin. Hasp and staple for padlocking.

5. Panel: Formed of 12-gauge steel.

6. Finish: Galvanized enclosure, door, panel and latch mechanism. Prepared for painting by manufacturer's standard method in accordance with the following:

    a. Outside: Phosphatized, primed and finished with two coats of light-gray enamel or epoxy coating, ANSI Z55.1, Color 61; minimum dry-film thickness, 2 mils.

    b. Inside including panel: Two coats of white enamel or epoxy coating.

7. Breather drain: One 1/2-inch diameter, Crouse-Hinds Catalog No. ECD11, or approved equal.

8. Grounding stud: Manganese bronze, ASTM B138, Alloy No. 675 hard, 3/8 inch high; Evedur GSI, American Brass Company or approved equal.

9. Terminations: Assembly rail and modular terminals, Weidmuller Terminations, Incorporated or approved equal.

    a. Terminal: Modular test terminal, Melamine plastic, screw-clamp connections, with socket screws; Type SAKC4, Catalog No. 3406.2 or approved equal, with the following additional requirements:

        (1) Amperes: 25.

        (2) Volts: 300.

        (3) Wire-gauge range: 22 AWG to 12 AWG.

        (4) Thickness: 0.256 inch.

        (5) Listed per referenced UL or ITS directory.

        (6) Standard accessories; compatible with terminal, with the following additional requirements:

            (a) End section: Type AP, No. 1179.2 or approved equal.

            (b) End bracket: Type EWK1, No. 2061.6 or approved equal.

            (c) Test plug: Type PS, No. 1804.0 or approved equal.

            (d) Cross-connection combination: QB25, No. 91455.D or approved equal.

            (e) Disconnect plug for SAKC4 terminal: Type TST, No. 3399.0 or approved equal.

    b. Assembly rail: Type TS32 steel standard section compatible with terminals, with fixing slots, Catalog No. 1228.0 and standard rail-mounting screws or approved equal.

c. Marking tags: Dekafix 6.5-FS or approved equal, consecutive vertical, Number 4682.6 or Number 5766.6 as approved. Consecutive numbering conforming to that of DTS box.

d. Group marking carrier with paper marking strip and transparent cover.

(1) Type SCHT5, Catalog No. 2924.6 or approved equal.

(2) Type ESO5, Catalog No. 2937.0 or approved equal.

(3) SST5, Catalog No. 2940.0 or approved equal.

P. Fiberglass Conduit and Fittings

1. Rigid fiberglass reinforced epoxy conduit, UL 1684, IPS (Iron Pipe Size) based conduit.

2. Conduit shall be manufactured by using filament winding process with minimum fiberglass content of 65 percent by weight and no fillers.

3. IPS based conduit with nominal wall thickness of 0.09 inches for 5-inch nominal conduit size.

4. Conduits, elbows, and fittings manufactured from the same material and using the same manufacturing process.

5. Conduit sections formed with integral bell and spigot type couplings. Rubber sealing gasket at bell end is prohibited.

6. Conduits, elbows and fittings provided with protection from exposure to sunlight by pigmentation uniformly dispersed through resin material.

7. Adhesive as recommended by conduit manufacturer.

8. Conduits, elbows and fittings are specified for use throughout a temperature range of minus 40 degrees F to plus 230 degrees F, and they are to be protected from exposure to sunlight by pigmentation uniformly dispersed through the resin material.

9. Conduits, elbows and fittings shall be suitable for encasement in concrete below grade and conform to UL 1684, and listed and labeled by UL meeting the requirements of NEC Article 347 for Rigid Nonmetallic Conduit and its use.

10. Each piece of the straight length conduit and each piece of the elbow and other bend made from and for use with such conduit is to be labeled with the following information, mark clearly legible and durable every 10 feet or as recommended by the manufacturer.

a. “Reinforced Thermosetting Resin Conduit”, “RTRC”; “Fiberglass Reinforced Epoxy Conduit”, “FREC”; or equivalent, as applicable.

b. Normal Size: (IPS)

c. Manufacturer‟s name and trademark.

d. Temperature range for conduit application.

e. “Above Ground”, “AG”, “Below Ground”, “BG”, or equivalent wording, as applicable.

## PART 3 – EXECUTION

3.1 INSTALLATION

A. General

1. Use size, type, general routing, location of conduit, raceways, boxes, and cabinets as shown and specified.

2. Install metallic raceway, fittings, boxes, and cabinets free from contact with reinforcing steel.

3. Where aluminum is placed in contact with dissimilar metal or with concrete, separate contact surfaces by means of gasket, nonabsorptive tape, or coating to prevent corrosion.

4. Make metallic conduit, raceways, ducts and cable trays, electrically and mechanically continuous and ground them in accordance with Section 16060, GROUNDING AND BONDING.

5. Install FRE conduit where conduit runs are embedded in concrete and where conduit is shown as direct-burial.

B. Conduit

1. Run exposed conduit parallel to building lines.

2. Install exposed conduit to avoid interference with other work.

3. Traction-power substations, tie-breaker stations, AC-switchboard, electrical, train-control, communication and mechanical rooms: Where shown or where necessary to prevent seepage of subsoil or water into such areas, seal where conduits in contact with concrete and seal cable inside conduit using cable seal or sealing compound in accordance with the following requirements:

a. Where shown and as necessary, install cable seal and conduit seal in accordance with the manufacturer's recommendations.

b. Use sealing compound where approved and in accordance with manufacturer's recommendations, with the following additional requirements:

(1) Before applying sealing compound, prime concrete, conduit and cable surface using primer recommended by manufacturer.

(2) Pour or inject compound to prevent voids inside seal and to keep cable centered in conduit.

(3) Use FRE sleeve for conduit seal installed on traction-power, train-control, and communication conduit.

c. For 34.5 kv incoming-service cable with concentric neutral, install cable seal in traction-power substations, ac-switchboard rooms and 34.5 kv utility company manholes adjacent to WMATA facilities in accordance with the following requirements:

(1) Do all work in coordination with a utility company representative.

(2) Install O-Z CSBI cable seal at each end of the conduit for the service entrance cables (one at the last utility company manhole and one at the WMATA facility entrance). Use torque recommended by manufacturer for this type of cable seal, do not over-torque.

d. For 13.8 kv incoming-service cable, install cable seal in traction-power substation, AC-switchboard rooms and utility company manholes adjacent to WMATA facilities. Coordinate the work with utility company representative.

e. In empty conduit installed for future use, install blank cable seal inside conduit to prevent seepage of water.

f. All conduits free of water before conduit seals are installed.

4. Apply lead-free conductive anti-seize compound to threaded-conduit joints.

5. In outdoor and underground locations, except electrical rooms, use threaded-conduit hub to attach conduit to equipment enclosure. Use watertight conduit fitting with gasket, nylon-insulated throat and sealing locknuts for attachment of conduit to enclosure having punched or formed knockout.

6. In aboveground indoor locations and electrical rooms, use locknut and nylon-insulated bushing to attach conduit to enclosure.

7. Install suitable caps or plugs in empty conduit for future extension. Leave approved nylon or polyester pull line in each conduit.

8. Thread and ream ends of field-cut conduit to remove rough edges. Use bushing at conduit entrance to boxes, cabinets, and equipment enclosures.

9. Bends

a. Unless otherwise shown or specified, install conduit bends in accordance with reference codes.

b. Install bends in buried conduit in accordance with the following:

| Size of Conduit (in inches) | Minimum Radius of Factory-Bend (in inches) | Minimum Radius of Field-Bend (in inches) |
|---|---|---|
| 3 | 18 | 24 |
| 4 | 24 | 30 |
| 5 | 48 | 48 |
| 6 | 48 | 48 |

c. Total bends in each conduit run for traction-power cable: 225 degrees maximum.

d. Bend conduit so that field-made bend is free from cuts, dents, and other surface damage.

10. Support conduit during construction to prevent distortion and to ensure independent support.

11. Support horizontal conduit with one-hole pipe straps or individual pipe hangers.

12. Secure conduit supported on multiple-hangers (trapeze) or channel inserts by fasteners suitable for such purpose.

13. Where conduit is attached to masonry surface, use malleable-iron spacers with Style A pipe straps.

14. Support and secure vertical conduit spanning open areas at intervals not exceeding 10 feet.

15. Support conduit above suspended ceiling using applicable specified methods.

16. Install conduit so as to drain moisture to nearest outlet or pull box.

17. Use minimum of 18-inch long liquid-tight flexible-conduit connection for equipment enclosure subject to vibration.

18. Do not use wire for support of conduit and cable.

19. Install expansion fitting in exposed conduit runs longer than 300 feet and where shown. Install expansion/deflection fittings where embedded conduits cross structural expansion joints. Where embedded conduits cross a structural contraction joint, paint the external surface of conduit with linseed oil or other compatible bond breaker for two feet on each side of contraction joint.

20. Buried FRE conduit: Install in accordance with the following requirements in addition to those specified elsewhere:

    a. Arrange conduit to cross each expansion joint at right angle to joint.

    b. Prevent concrete and other materials from obstructing the conduit. Pack outlets, pull boxes and junction boxes and cap conduit ends prior to pouring concrete.

    c. Use Tight Lock Joint method to join conduit sections for providing water tightness and pull out strength.

    d. Provide compatible conduit supports and spacers to maintain position of conduit during placement of concrete.

    e. Install buried non-metallic conduit for cable over 600 volts in accordance with reference code.

    f. Waterproof conduit connections.

    g. Rod and swab conduit after installation so as to remove water, cement and other foreign matter; cap conduit ends. If obstructions cannot be removed or if condition exists which may result in damage to cable, replace conduit.

    h. Leave approved nylon or polyester pull-line in each conduit.

21. Use metallic conduit or above ground FRE conduit in exposed locations.

22. Conduit installed in outdoor location: Waterproof conduit connection.

23. Use IPS FRE conduit for all concrete-encased applications except as follows:

    a. Use FRE conduit with minimum wall thickness of 0.95 inch for train control conduit direct buried without concrete encasement where shown.

    b. Install conduits encased in concrete ductbanks, associated manholes, and handholes outside the structural work in accordance with Section 02585.

C. Channel Inserts and Spot Inserts

    1. Surface-mount channel inserts as shown.

D. Surface Raceways

    1. Install as shown.

E. Underfloor Raceways

1. Install underfloor raceways as specified in Section 03100. Align and level raceways accurately. Hold raceways in place during placing of concrete.

F. Outlet, Junction and Pull Boxes

1. Mount outlet boxes as shown.

2. Arrange front of box or attached plaster cover flush with finished wall or ceiling.

3. Keep number of knock-outs to minimum.

4. Clean boxes thoroughly after installation and correct damage to boxes and to finish.

5. Install covers on boxes mounted on walls and ceilings.

6. Measure height of wall-mounted outlet box from finished floor to horizontal centerline of cover plate.

7. Fasten floor boxes securely in place.

8. Install junction and pull boxes so that covers are readily accessible.

9. Do not install boxes above suspended ceilings except where ceilings are removable or definite provision is made for access to boxes.

10. Use stainless steel (Type 304) mounting channels, retaining straps and fasteners, pipe hangers for conduits and cables; expansion bolt anchors, junction boxes, outlet boxes, cover plates for receptacles, enclosures for load centers in tunnel environment, which includes vent and fan shafts and under-platform areas.

11. Use non-metallic boxes as follows:

    a. Buried with cover flush-mounted with finish grade: Precast concrete or composite material junction and pull boxes within AASHTO load designations as specified.

    b. For indoor and outdoor locations not subject to pedestrian or vehicular traffic: Molded fiberglass-reinforced polyester junction and pull boxes.

    c. For outdoor locations but not for burial: Molded polyvinyl chloride junction and pull boxes.

G. Cabinets

1. Fasten cabinet securely using expansion bolts, toggle bolts, or mounting ears.

2. Touch-up damaged painted finish.

H. Cable Trays

1. Install cable trays neatly, adequately supported and as shown.

2. For incoming-service cable from power company, install cable tray as approved by the power company.

I. Use expansion-bolt anchors to secure equipment to concrete surfaces.

J. Attachments to Prestressed-Concrete Girders

1. Attach pipes, conduits, boxes, or similar items to prestressed girders by welding to embedded plates or bolting to embedded fittings. Drilling into prestressed girders is prohibited, except for track fasteners and appurtenances as shown.

K. DTS Cabinet and Terminals

1. Install as shown.

L. Car Wash Areas

1. Use PVC-coated galvanized steel conduit.

3.2 FILLING OF OPENINGS

A. Where conduit and raceway pass through fire-rated walls, ceilings, or floors, provide seals to prevent passage of fire and fumes and to maintain integrity of fire-rated structure in accordance with Section 07841, FIRESTOPPING.

B. Where openings are provided for passage of conduit and raceways in walls, ceilings or floors, use fire-resistant fibrous-glass safing or similar material to seal unused openings to prevent passage of fire and fumes in accordance with Section 07841, FIRESTOPPING.

C. Close unused openings or spaces in floors, walls, and ceilings. Plug or cap unused conduit and sleeves.

3.3 IDENTIFICATION

A. At end of each run, use stainless steel or aluminum tags, minimum 1-1/2-inch diameter, with stamped markings, minimum 1/4-inch high lettering, and tag holders attached to conduit using a stainless steel band with worm screw clamping device to establish identification of conduits and raceways in accordance with designations shown. Where conduits are terminated flush with concrete structure, install three-ply laminated phenolic plate, engraved through black face to white core and attached adjacent to conduits' entrance by means of non-metallic screws. Engrave conduits' designations within circles arranged in pattern similar to that of conduits.

B. Identify by red painted color code and by marking EMERGENCY SYSTEM on all boxes and enclosures for emergency circuits to identify them as part of an emergency system in accordance with the NEC.

3.4 FIELD QUALITY CONTROL

A. Arrange with the Contracting Officer Representative for inspection and approval of embedded conduit and boxes prior to concrete placement.

B. Arrange with the Contracting Officer Representative for inspection by electrical utility company representative of incoming-service conduit prior to placing concrete.

C. Test metallic conduit and boxes for electrical continuity. Conduct tests in presence of Contracting Officer Representative.

D. Test not less than 0.5 percent of total installed channel inserts and spot inserts as directed for compliance with specified pullout-load rating. Replace and retest inserts which fail. Conduct tests in presence of Contracting Officer Representative.

E. Arrange with the Contracting Officer Representative for inspection and approval of direct-buried conduits for future train control circuits prior to backfilling.

END OF SECTION

# SECTION 16145

# WIRING AND CONTROL DEVICES

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for providing wiring and control devices which include switches, cover plates, limit switches, occupancy sensors, receptacles, plugs, magnetic contactors, automatic transfer switches, photoelectric controls and time switches.

1.2 RELATED REQUIREMENTS

A. Ornamental metal: Section 05700.

B. Grounding and bonding: Section 16060, GROUNDING AND BONDING.

C. Wire connection accessories: Section 16125, WIRE CONNECTION ACCESSORIES.

D. Raceways, boxes and cabinets: Section 16130, RACEWAYS, BOXES, AND CABINETS.

1.3 REFERENCES

A. Comply with codes and regulations of the Jurisdictional Authorities.

B. National Electrical Code (NEC).

C. National Electrical Manufacturers Association (NEMA)

1. WD1, General Color Requirements for Wiring Devices.

2. KS1, Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).

3. ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC.

4. ICS 12, Profiles of Networked Industrial Devices--Part 1: General Rules.

5. NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum).

D. American National Standards Institute (ANSI)

1. Z55.1, Gray Finishes for Industrial Apparatus and Equipment.

E. Underwriter's Laboratories (UL):

1. 98, Enclosed and Dead-Front Switches.

2. 198D, Class K Fuses.

3. 198E, Class R Fuses.

4. 508, Industrial Control Equipment.

5. 773, Plug-In Locking-Type Photo controls for Use With Area Lighting.

6. 1008, Transfer Switch Equipment.

F. ASTM International (ASTM)

1. A47/A47M, Standard Specification for Ferritic Malleable Iron Castings.

2. A276, Standard Specification for Stainless Steel Bars and Shapes.

3. A507, Standard Specification for Drawing Alloy Steel, Sheet and Strip, Hot-Rolled and Cold-Rolled.

G. Intelligent Transportation Society (ITS)

1. Directory of ITS Listed Products

1.4 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each:

1. Shop Drawings.

2. Certification.

a. Certified test reports of factory tests performed on each automatic transfer-switch unit in accordance with reference standards.

b. Furnish certificate from manufacturer verifying that automatic transfer switches conform to specified requirements. Include certificate with submittal of shop drawings.

3. Documentation for Automatic Transfer Switch

a. Submit field test plan within 60 days after award with accompanying documentation in the form of test data recording sheets and list of proposed test equipment for approval prior to testing.

b. Submit certified copies of test data, dated and clearly identified within two weeks after completion of testing.

4. Operation and Maintenance Manuals for Automatic Transfer Switch.

1.5 QUALITY ASSURANCE

A. Source Quality Control

1. Following items listed in accordance with referenced UL or ITS directory:

a. Snap switches.

b. Disconnect switches.

c. Receptacles and plugs.

d. Automatic transfer switch.

e. Lighting contactor.

f. Photoelectric control.

g. Time switch.

h. Occupancy sensor.

B. Qualifications: Select a manufacturer who is regularly engaged in the production of automatic transfer switches.

1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Mark each item in accordance with applicable reference standard.

B. Ship each unit securely packaged and labeled for safe handling and to avoid damage.

C. Store products in secure and dry storage facility.

**PART 2 – PRODUCTS**

2.1 PRODUCTS AND MATERIALS

A. Snap Switches

1. NEMA WD1, specification grade.

2. Rating

a. Twenty amperes at 120 to 277 volts AC.

b. Horsepower-rated when used as disconnecting device for motor circuit.

3. Body and base: Fully enclosed, brown, fire-resistant, non-absorptive thermosetting urea or nylon.

4. Contacts: Silver alloy.

5. Mounting yoke: Corrosion-resistant metal with plaster ears.

6. Poles: Single-pole, double-pole, three-way or four-way as shown.

B. Disconnect (Safety) Switches

1. UL 98, NEMA KS1, heavy-duty, fusible, or non-fusible as shown.

2. Voltage rating: 240 volts AC, 480 volts AC, or 250 volts DC as shown and as necessary.

3. Number of poles and current rating: As shown and as necessary.

4. Fuses

a. UL 198D.

b. For fused disconnect switch associated with motor load: UL Class RK5 with time delay or as shown.

c. For fused disconnect switch associated with other loads: UL Class RK1 or as shown.

d. Current rating: As shown.

5. Enclosure: (NEMA 250)

a. Type

(1) For aboveground indoor locations and electrical rooms: Type 1.

(2) For tunnel and underground locations, except electrical rooms: Type 4.

(3) For outdoor locations: Type 3R.

b. Materials

(1) Steel sheet: ASTM A507.

(2) Malleable iron: ASTM A47/A47M.

c. Finish: Metallic surface cleaned, degreased, primed with zinc primer and finished with light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, 2 mils.

6. Quick-make/quick-break switching mechanism with operating handle external to enclosure with positions labeled ON/OFF and capable of being padlocked in OFF position, defeatable interlock to prevent opening of enclosure door when switch is closed.

C. Receptacles and Plugs

1. NEMA WD1, specification grade.

2. Rating: 20 amperes at 125 or 250 volts as shown.

3. Base and body: Brown, fire-resistant, non-absorptive thermosetting urea or nylon.

4. Receptacles

a. Outlet: Single or duplex as shown.

b. Mounting yoke: Corrosion-resistant metal with plaster ears.

c. Configuration:

| Rating | NEMA Configuration |
|---|---|
| Two-pole, three-wire, 20 amps, 125 volts | 5-20 R |
| Two-pole, three-wire, 20 amps, 250 volts | 6-20 R |

d. For use in restroom; water service room; locker room; wash rooms; elevator machine room, pit, and hoistway; and outdoor locations: Equipped with solid-state ground-fault circuit interrupter with 5-milliampere trip level.

5. Plugs

a. Configuration and design: As follows unless otherwise shown:

| Rating | | NEMA Configuration |
|---|---|---|
| Two-pole, three-wire, 20 amps, 125 volts | Urea or neoprene with cord grip | 5-20 P |
| Two-pole, three-wire, 20 amps, 250 volts | Armored cap with cord grip | 6-20 P |

D. Cover Plates

1. Wall plates

a. NEMA WD1, suitable for specified receptacles and switches, size suitable for recess-mounted or surface-mounted associated outlet box, stainless steel, ASTM A276, Type 304, or approved equal.

b. For use in indoor public areas: Bronze, with M32 medium satin finish as specified in Section 05700.

c. For above ground, indoor service areas and electrical rooms: Steel, stainless steel or aluminum plate, as standard with the manufacturer.

d. For receptacles in outdoor and underground locations, except electrical rooms: Stainless steel, ASTM A276, Type 304, wall plate with gasketed, spring-loaded hinged cover.

2. Floor plates: Section 16130, RACEWAYS, BOXES, AND CABINETS.

E. Automatic transfer switch: UL-1008, electromechanical, in surface-mounted enclosure as shown, with the following additional requirements:

1. Operating and electrical characteristics

a. Capable of transferring load automatically from normal source to alternate source when the voltage drops to 85 percent of rated voltage on any phase for set time. Operating point adjustable over range of 80 to 90 percent of rated voltage and time-delay adjustable over range from zero to 5 minutes in increments of at least eight steps.

b. Capable of transferring load automatically from alternate source to normal source when normal source returns to 90 percent of rated voltage for set time. Operating point adjustable over range of 85 to 100 percent of rated voltage and time-delay adjustable over range from zero to 5 minutes in increments of at least eight steps.

c. Capable of transferring load automatically from normal source to alternate source when normal source failure is simulated by integral test switch.

d. Rating

(1) Number of poles: Three or four as shown.

(2) Voltage rating: 480-volt, three-phase, three-wire or 480Y/277-volt, three-phase, four-wire, 60 Hertz system as shown.

(3) Current rating: As shown and rated 100 percent.

(4) Transfer time: Ten cycles maximum on 60-Hertz base after initiation signal.

(5) Short-circuit current rating, rms, symmetrical amperes: 14,000; 22,000; 25,000; 30,000; 35,000; or 50,000 as required and shown.

(6) Capacity to close into available short-circuit current or let-through current of fuses without functional degrading.

e. Solid-state control panel for sensing and control logic with accuracy of plus-or-minus 2 percent on voltage and frequency settings over a temperature range of minus 20 degrees to plus 70 degrees.

2. Design and construction features

   a. Mechanically held, electrically operated, double-throw switch.

   b. Electrical and mechanical interlock to prevent maintained neutral position.

   c. Designed to break-before-make on transfer and retransfer.

   d. Equipped with renewable silver-alloy contact.

   e. Neutral bus or terminal provided on 480Y/277-volt, three-phase, four-wire unit to allow interconnection of neutral conductors.

   f. Pilot lights on door to indicate switch position as follows:

      (1) On normal source: Green light.

      (2) On alternate source: Red light.

   g. Pilot lights on door to indicate:

      (1) Normal source available: Green or white light.

      (2) Alternate source available: Red or white light.

   h. Contacts opened by single solenoid, motor operator or stored energy mechanism.

   i. Handle provided to permit manual operation of automatic transfer switch for maintenance purposes.

   j. Power conductors made of silver-plated copper bus.

   k. Equipment ground lug provided.

3. Enclosure

   a. Type

      (1) For aboveground indoor locations and electrical rooms: NEMA Type1.

      (2) For tunnel and underground locations, except electrical rooms: NEMA Type 12.

   b. Door: Hinged with handle and latch.

   c. Material: Steel.

   d. Finish: Metallic surface thoroughly cleaned, degreased, primed with zinc primer and finished with gray enamel, ANSI Z55.1, Color No. 61; 2-mil minimum DFT.

F. Lighting Contactors

1. NEMA ICS 2, UL 508, electrically held, equipped with silver-alloy contacts, designed to control incandescent, tungsten, halogen, fluorescent, high-intensity discharge lamp load.

2. Number of poles: As shown.

3. Continuous current rating: As shown.

4. Line and load voltage: 480-volt or 208-volt three-phase or 277-volt or 120-volt single-phase as shown.

5. Control coil rated 120 volts.

6. 480-volt or 277-volt to 120-volt control transformer fused on secondary and primary as required.

7. Control

   a. Heavy-duty, three-position selector switch with positions labeled HAND/OFF/AUTO for lights controlled by photo-electric cell.

   b. ON-OFF push button for indoor lights.

8. Enclosure: NEMA 250, Type 1; fabricated from steel, cleaned, degreased, primed with zinc primer and finished with light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, 2 mils.

G. Photoelectric Control

1. UL 773, designed to respond to natural daylight with 15-second inherent delay to prevent functioning due to sudden bright light such as vehicle lights or lightning and to operate in ambient temperature from minus 50 degrees C to plus 60 degrees C.

2. Adjust to turn lights ON at 2 plus-or-minus 1 foot-candles, unless otherwise specified. ON to OFF ratio: One to three.

3. Rating: 1,800VA at 120 volts or 277 volts, 60 Hertz, as shown.

4. Contacts

   a. For control of outdoor lights: SPST, NC contact.

   b. For control of tunnel lights at portals: SPST, NO contact

5. Cells: Hermetically sealed.

6. Enclosure: Weatherproof and tamper proof aluminum or non-metallic enclosure equipped with locking receptacles when mounted on fixture or designed for mounting on outlet box as shown and as necessary.

7. At tunnel portal, set photoelectric control to turn on selected lights at dawn and turn off lights at dusk, as shown.

H. Limit Switches

1. NEMA ICS 2, industrial-control.

2. Suitable for mounting in folding-gate cabinet. Switch contacts closed when cabinet door is fully closed and latched. Switch contacts opened when respective cabinet door is not fully closed.

3. Voltage rating: 120 volts AC.

4. Current rating: 10 amperes continuous.

5. Enclosure: NEMA 250, Type 13.

6. Actuator: Lever-operated and adjustable, with spring return.

7. Mounting: Plug-in type with receptacle tapped for conduit size as shown.

8. Contacts: Single-pole double-throw; one NO, one NC; snap action.

I. Time Switch

1. Seven-day and 24-hour calibration for each day time switch, listed per referenced UL or ITS directory, heavy-duty type suitable for controlling type of lighting fixtures shown.

2. Type: As shown, with contacts capable of switching continuous load of 20 or 40 amperes per pole at 277 volts as necessary.

3. Seven-day, 24-hour dial with day and night zones and 24-hour calibration for each hour clearly marked.

4. Providing up to four automatic ON/OFF operations each day.

5. Removable ON/OFF trippers designed for minimum ON period of 1 hour and minimum 2-hour period between one OFF operation and next ON operation.

6. Provision for manual ON and OFF operation of switch by hand without disturbing weekly preset schedule.

7. Provision for omitting operation of switch on selected days.

8. Spring-driven reserve power suitable for operation of switch for 16 hours minimum after failure of power. On restoration of power, switch transfers to synchronous motor drive and automatically rewinds spring.

9. Terminals designed to accommodate up to 8 AWG conductor cable.

10. Operation at 480/277Y or 208Y/120 volts, 60 Hertz as shown and within temperature range of zero degree F to plus 140 degrees F.

11. Enclosure

    a. NEMA 250, Type 1, steel, surface-mounted.

    b. Hinged flush front door with catches and spring-loaded door pull.

    c. Finish: Metallic surfaces cleaned and degreased, primed with zinc primer and finished with one coat of light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, 2 mils.

J. Occupancy Sensor

1. UL 508, passive infra-red motion detector designed for wall mounting over single-gang outlet box, minimum radio frequency interference and use with incandescent and fluorescent lighting fixtures and electronic ballasts.

2. Voltage rating: 120-277 volts AC.

3. Switching capacity

    a. 120-volt operation: 800 watts minimum.

    b. 277-volt operation: 1,500 watts minimum.

4. Coverage area: 1,000 square feet.

5. Detection zone

    a. Horizontal: 180 degrees.

b. Vertical: 5 degrees.

6. Ambient light sensing: Photocell for preventing operation of lights at ambient light levels above an adjustable setting.

7. Adjustments: Adjustable settings for time delay, sensitivity and light level concealed by tamper proof cover. Time delay adjustable from 10 seconds to 15 minutes after motion stops.

8. Operating mode: OFF/AUTO.

9. Detection indicator: LED.

**PART 3 – EXECUTION**

3.1 INSTALLATION

A. Install switches, limit switches, occupancy sensors, receptacles, automatic transfer switches, lighting contactor, photoelectric controls and time switches as shown and in accordance with referenced codes and standards in Article 1.2, and manufacturer's instructions.

B. Install cover plate on switch and receptacle.

C. Install cover plate with gasketed spring-loaded cover, on each receptacle in outdoor and underground locations except electrical rooms.

D. Ground disconnects switch, time switches, automatic transfer switches, receptacles, snap switches, photoelectric controls, and lighting-contactor enclosures in accordance with Section 16060, GROUNDING AND BONDING.

E. Make power cable connections to snap switches, plugs, time switches, occupancy sensors, photoelectric controls, receptacles, automatic transfer switches, and lighting contactors by means of integral mechanical connectors. If such items are not furnished with integral mechanical connectors, make connections using compression connectors in accordance with Section 16125, WIRE CONNECTION ACCESSORIES.

F. Make power cable connections to snap switches and receptacles using their side screw wiring connection terminals.

G. Apply matching touch-up paint as necessary.

3.2 FIELD QUALITY CONTROL

A. Furnish necessary test equipment and perform the following in the presence of the Contracting Officer Representative, in accordance with approved procedures:

1. Test time switches, receptacles, and contactors for connection in accordance with wiring diagram.

2. Test equipment enclosure for continuity to grounding system.

3. Check tightness of cable connections of snap switches, receptacles, time switches, occupancy sensors, disconnect switches, automatic transfer switches, lighting contactors, photoelectric controls, and limit switches.

4. Test operations of circuits and controls of switches, occupancy sensors, receptacles, and contactors.

5. Automatic transfer switches

a. Test switches for connection in accordance with wiring diagrams.

b. Calibrate and set voltage-sensing device for each source and time delay for transfer and retransfer as follows and as approved:

(1) Automatic transfer switches for fan shafts and drainage pumping stations: Time delay setting for transfer equal to total of 30 seconds for each connected motor or additional time as required.

(2) Time delay setting for retransfers equal to or greater than time delay setting for transfer.

c. Perform automatic transfer of load in accordance with the following requirements:

(1) With power available on both the normal and alternate sources, initiate automatic transfer from the normal source to the alternate source by opening the disconnect switch or circuit breaker on the line side of the automatic transfer switch for the normal source. Check that the switch position changes to the alternate source and remains connected to the alternate source.

(2) With power available on the alternate source and the switch connected to the alternate source, initiate automatic transfer to the normal source by closing the disconnect switch or circuit breaker on the line side of the automatic transfer switch for the normal source. Check that the switch position changes to the normal source and remains connected to the normal source.

(3) If testing indicates failure to comply with specified requirements, modify settings for the automatic transfer switch so that the specified requirements are met. Conduct additional tests witnessed by the Contracting Officer Representative to prove compliance with specified requirements.

B. Submit certified test reports for compliance with field quality control requirements.

END OF SECTION

# SECTION 16225
# MOTORS

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for providing motors.

1.2 RELATED REQUIREMENTS

A. Grounding and bonding: Section 16060, GROUNDING AND BONDING.

B. Wire connection accessories: Section 16125, WIRE CONNECTION ACCESSORIES.

C. Raceways, boxes and cabinets: Section 16130, RACEWAYS, BOXES, AND CABINETS.

1.3 REFERENCES

A. NEMA MG1

B. IEEE 85, 112

C. OSHA 1910.95

1.4 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each:

1. Shop Drawings

a. Outline dimensions.

b. Cross section showing internal construction and weight.

c. Connection diagram.

2. Certification.

3. Operation and Maintenance Manuals.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Ship each motor securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.

B. Store motors in secure and dry storage facility.

## PART 2 – PRODUCTS

2.1 EQUIPMENT

A. Motors

1. NEMA MG1, squirrel-cage, induction-type, unless otherwise shown.

2. Rating

   a. Horsepower: As shown.

   b. Voltage and frequency

      (1) Motors, 1/2 HP and smaller: 115-volt, single-phase, 60 Hertz.

      (2) Above 1/2 HP: 460-volt, three-phase, 60 Hertz, unless otherwise specified or shown.

      (3) For motors in air-conditioning units

         (a) For units up to and including 10,000 BTUH: 115-volt, single-phase, 60 Hertz.

         (b) For units from over 10,000 BTUH up to and including 36,000 BTUH: 208-volt, single-phase, 60 Hertz.

         (c) For units over 36,000 BTUH: 460-volt, three-phase, 60 Hertz.

   c. RPM: As shown.

   d. Time rating: Continuous, unless otherwise shown.

   e. Nominal full-load efficiency: Premium Efficiency when tested in accordance with NEMA MG1 and IEEE 112.

3. Design

   a. Single-phase motors: Design N, suitable for full-voltage across-the-line starting.

   b. Three-phase motors: Design B, unless otherwise shown, with the following additional requirements:

      (1) Up to and including 50-HP motors: Suitable for full-voltage across-the-line starting.

      (2) Above 50-HP motors: Suitable for reduced-voltage starting.

4. Service factor

   a. Motors, one HP and smaller: In accordance with NEMA MG1.

   b. Above one-HP up to and including 200-HP motors: 1.15.

   c. Above 200-HP motors: 1.00.

5. Insulation: Class and allowable temperature rise above average ambient temperature of 30 degrees C and maximum ambient temperature of 40 degrees C as follows:

   a. Integral-horsepower motors

      (1) Drip proof motors: Class B insulation with Class B temperature rise.

      (2) Totally enclosed motors: Class F insulation with Class B temperature rise, unless otherwise shown or specified.

   b. Fractional-horsepower motors: In accordance with NEMA MG1.

6. Noise level: NEMA MG1-12.49 but not to exceed requirements of OSHA 1910.95 when measured in accordance with IEEE 85.

7. Enclosure

   a. Drip proof, fully guarded; totally enclosed fan-cooled guarded; or totally enclosed air-over as specified.

   b. Heavy-duty steel or cast-iron frame.

   c. End bell

      (1) Up to 10 HP: With cast-iron or aluminum end bells.

      (2) 10 HP and above: With cast-iron end bells.

   d. Mounting: Foot mounted on pad or adjustable pad, if necessary or as otherwise shown.

   e. Provision for grounding.

   f. Finish: Red-oxide zinc-chromate primer with finish coat of light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, 2 mils.

   g. Totally enclosed air-over

      (1) Variation to totally enclosed fan-cooled machines with air flow for cooling supplied by fan specified elsewhere.

      (2) Fan/motor application factory-engineered for air flow shown or specified.

8. Conduit box

   a. Diagonally split, suitably gasketed.

   b. Type

      (1) Up to 10 HP: Steel, cast iron or aluminum with threaded or punched conduit holes.

      (2) 10 HP and above: Cast iron with threaded conduit holes.

   c. Size suitable to accommodate motor and line leads including taping.

   d. Capable of rotation in each 90-degree position.

9. Bearings

   a. Unless otherwise specified, average life 15 years, but not less than 3 years at continuous operation, with double shields.

   b. Integral-horsepower motors

      (1) Five HP and smaller: Sealed ball bearings or roller bearings.

      (2) Above 5 HP: Ball bearings or roller bearings with grease fittings and pressure-relief fittings for in-service lubrication.

   c. Fractional-horsepower motors

      (1) 1/6 HP and larger: Sealed ball bearings.

      (2) Below 1/6 HP: Sealed ball bearings or sleeve.

10. Motors for hermetically sealed and semi-hermetically sealed compressors: NEMA MG1, 18.076 through 18.093.

11. Motors for close-coupled pumps: Stainless-steel shaft in accordance with ASTM A582, Type 303.

12. Provide nameplate on each motor in accordance with NEMA MG1-10.37.

**PART 3 – EXECUTION**

3.1 INSTALLATION

A. Install motors where shown and in accordance with the NEC.

B. Install conduit in accordance with Section 16130, RACEWAYS, BOXES, AND CABINETS.

C. Connect power cable as shown and in accordance with Section 16125, WIRE CONNECTION ACCESSORIES.

D. Ground motor enclosure in accordance with Section 16060, GROUNDING AND BONDING.

3.2 FIELD QUALITY CONTROL

A. Furnish necessary equipment and perform the following tests:

1. Check and test wiring connections in accordance with wiring diagram.

2. Test to ensure that insulation resistance of motor winding is 10 megohms minimum.

3. Test motor enclosure for continuity to grounding system.

4. Test motors for proper operation with their associated controls.

B. Submit certified test reports.

END OF SECTION

# SECTION 16425

# MOTOR STARTERS AND CONTROL CENTERS

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for providing motor starters and control centers.

1.2 RELATED REQUIREMENTS

A. Grounding and bonding: Section 16060, GROUNDING AND BONDING.

B. Wire connection accessories: Section 16125, WIRE CONNECTION ACCESSORIES.

C. Raceways, boxes and cabinets: Section 16130, RACEWAYS, BOXES, AND CABINETS.

D. Motors: Section 16225, MOTORS.

E. Unit substation: Section 16360.

F. Circuit breakers, panel boards and load centers: Section 16440, CIRCUIT BREAKERS, PANEL BOARDS, AND LOAD CENTERS.

1.3 REFERENCES

A. Comply with codes and regulations of Jurisdictional Authorities.

B. NEC.

C. NEMA AB1, ICS-2, ICS-2.3, 250.

D. ANSI: Z55.1.

E. ASTM: A47, A653, B187.

F. UL: 845, Electrical Construction Materials Directory

G. ITS: Directory of ITS Listed Products.

1.4 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each:

1. Shop Drawings

a. Interconnection wiring diagrams.

2. Certification.

3. Operation and Maintenance Manuals.

4. Short-circuit calculations and coordination study in accordance with Section 16360.

1.5 QUALITY ASSURANCE

A. The following items to be listed or labeled in accordance with referenced UL or ETL directory:

1. Motor starter.

2. Combination starters.

3. Motor circuit protectors.

4. Motor control centers.

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.

B. Store motor starters and control centers in secure and dry storage facility.

**PART 2 – PRODUCTS**

2.1 PRODUCTS AND MATERIALS

A. General Requirements

1. Interchangeability: Equipment of same type, size, rating, functional characteristics, and make is to be interchangeable.

2. NEMA ICS-2, AC general-purpose, Class A.

3. Rating: Continuous-current rating suitable for associated motor as shown.

4. Type

a. Up to and including 1/2 HP: Manual starter operable on 120-volt, single-phase, 60 Hertz supply unless otherwise shown.

b. From above 1/2 HP up to and including 50 HP: Across-the-line magnetic starter operable on 480-volt, three-phase, and 60 Hertz supply.

c. Above 50 HP: Closed-transition autotransformer starter operable on 480-volt, three-phase, 60 Hertz supply.

5. Provide ground-fault protection with 5-ampere pick-up in each motor starter for fans in fan shafts and pumps in drainage-pumping stations.

6. Enclosure

a. Type

(1) For aboveground indoor locations and electrical rooms: NEMA 250, Type 1.

(2) For tunnel areas and underground locations except electrical rooms: NEMA 250, Type 12.

(3) For outdoor locations: NEMA 250, Type 3R.

b. Materials:

(1) Zinc-coated steel sheet: ASTM A653, coating designation G90, minimum thickness 14 gauge.

(2) Malleable iron: ASTM A47.

c. Finish: Metallic surface cleaned, degreased, primed with zinc primer and finished with light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, 2 mils.

7. Nameplate

    a. Nameplate provided on each motor starter and control center in accordance with NEMA ICS, showing manufacturer's name and brand designation, the referenced standard, type, class and rating as applicable.

    b. Additional functional nameplates for each component as follows:

        (1) Three-ply, laminated phenolic plates engraved through black face to white core and attached by means of stainless-steel rivets or screws.

        (2) Lettering to be vertical gothic using a round or square cutter. V-shaped groove not acceptable.

        (3) Each starter labeled with 1-inch wide nameplate showing starter's designation and function in 1/2-inch high characters.

B. Manual Starters: Quick-make/quick-break toggle mechanism, manual-reset thermal-overload device, position indicator showing ON/OFF/TRIPPED positions, red indicating light showing closed position.

C. Across-The-Line Magnetic Starter

1. Reversing or no reversing as shown.

2. NEMA size: As shown as, not smaller than NEMA 1.

3. 480-volt primary to 120-volt secondary control transformer with fuse in the primary circuit

4. Manual-reset overload relay, one per phase, with the following additional requirements:

    a. In starter for motors in fan shafts: Magnetic-type sensitive to current.

    b. In starters for motors in other locations: Thermal-type.

5. Two NO contacts with provision for addition of two NO or NC contacts.

6. No reversing-type: START/STOP pushbutton mounted on door.

7. Reversing-type: FORWARD/REVERSE/STOP pushbutton mounted on door.

8. HAND/OFF/AUTO selector switch provided when specified.

D. Autotransformer Starter

1. Reversing or no reversing closed-transition type as shown.

2. NEMA size: As shown.

3. Adjustable taps for 50, 65, and 80 percent of line voltage.

4. 480-volt primary to 120-volt secondary control transformer with fuse in primary circuit.

5. Manual-reset overload relay, one per phase.

    a. In starter for motors in fan shafts: Magnetic-type sensitive to current.

    b. In starters for motors in other locations: Thermal-type.

6. One pneumatic adjustable timing relay.

7. Two NO contacts with provision for addition of two NO or NC contacts.
8. No reversing-type: START/STOP pushbutton mounted on door.
9. Reversing-type: FORWARD/REVERSE/STOP pushbutton mounted on door.
10. HAND/OFF/AUTO selector switch provided when specified.

E. Motor Circuit Protectors (MCP)

1. NEMA AB1, molded-case, quick-make/quick-break, mechanically trip-free switching mechanism with adjustable magnetic trip for instantaneous short-circuit protection.
2. Rating
   a. Number of poles: Three.
   b. Continuous-current rating: As shown, not less than full-load current of motor.
   c. Voltage: 480-volt, three-phase, 60 Hertz.
   d. Interrupting rating: As shown.
   e. Trip range: As necessary to provide maximum protection to associated motor.
3. Where shown or necessary, individually removable current limiter, internally mounted on load side of MCP, with the following additional requirements:
   a. Limiter current rating and time-current limiting characteristics coordinated with time-current characteristics of MCP to provide the following:
      (1) Interruption by MCP under fault-current level up to interrupting capacity of MCP.
      (2) Interruption by current limiter in conjunction with the MCP of fault-current level above interrupting capacity of MCP.
      (3) Where necessary to protect associated motor starter. Limit fault-current below withstand capability of the starter.
      (4) Where necessary to protect associated motor-circuit conductors. Limit fault-current below withstand capability of cable insulation.
   b. Current-limiter housing interlocked with MCP tripping mechanism so that breaker will trip upon removal of cover.
   c. Equipped with common trip mechanism for tripping all poles simultaneously on blowing of current limiter to prevent single phasing.
   d. Capable of interrupting minimum fault-current up to 100,000 rms symmetrical amperes at 480 volts AC.

F. Combination Starter

1. NEMA ICS-2, rated 480 volts, three-phase, 60 Hertz.
2. Motor starter: Across-the-line magnetic or autotransformer starter as shown and specified.
3. One 480-volt, three-pole MCP.

4. Externally mounted operating handle with position indicator showing ON/OFF/TRIPPED condition of MCP. Operating handle interlocked for preventing opening and closing of door when MCP is in ON position. Defeater provided to bypass interlock. Provision for padlocking in OFF position.

G. Motor Control Centers

1. NEMA ICS-2.3, Class 1, Type B, rated 480-volt, three-phase, 60 Hertz, totally enclosed, deadfront, free-standing, modular assembly having vertical and horizontal buses, wireways, compartments equipped with circuit breakers, MCP and starters as shown.

2. Enclosure: Modular assembly allowing maximum of six compartment units in one vertical assembly and units' layout in any combination without structural interference, with the following additional requirements:

   a. Type

      (1) Above ground indoor locations and electrical rooms: NEMA 250, Type 1.

      (2) Tunnel areas and underground, except electrical rooms: NEMA 250, Type 12.

      (3) Outdoor locations: NEMA 250, Type 3R.

   b. Each unit compartment provided with individual door having concealed hinges. Unit door mechanically interlocked with unit circuit breaker to prevent opening or closing when the circuit breaker is in the ON position. Defeater provided to bypass interlock. Provision for padlocking in OFF position.

   c. Horizontal wireway with removable cover plate provided at top and bottom for wiring between sections, incoming conduit, and cable, motor and control wiring. Top trough separated by barrier from main horizontal bus.

   d. Vertical wireway, with its own door, provided adjacent to each vertical assembly and accessible to two adjacent vertical assemblies when applicable.

   e. Reinforced with adequate steel framework to form rigid structure with smooth outer surface free of burrs, ridges, or other blemishes.

   f. Zinc-coated steel sheet: ASTM A653 coating designation G90, minimum thickness 14 gauge

   g. Finish: Metallic surface cleaned, degreased, primed with zinc primer and finished with light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, 2 mils.

3. Horizontal and vertical buses: Main horizontal buses provided at top of structure. Vertical buses for feeding power to each compartment provided in each vertical assembly and securely bolted to main buses.

   a. Busbar: ASTM B187, 98-percent-conductivity copper, contact surfaces tin-plated, fully insulated by extruded sleeve or wound tape.

   b. Each horizontal and vertical bus rated for a minimum of 600 amperes and 300 amperes, respectively, with current density not to exceed 1,000 amperes psi or to meet ANSI temperature of 50-degree rise unless otherwise shown.

   c. Each bus rigidly held by bus supports, which have high-dielectric qualities, are moisture-resistant, non-carbonizing and no tracking and has vertical creepage surfaces to prevent faults due to buildup of conductive dirt.

d. Bus assembly braced to withstand short-circuits rating of 22,000 symmetrical amperes, rms, or available short circuit determined by short-circuit calculations, whichever is greater.

e. Unit guides provided in unit compartment for aligning starter stubs.

f. Continuous bare-copper ground bus, 1/4-inch by 2-inch cross-section, provided throughout length of control center.

4. Motor starter: Across-the-line magnetic or autotransformer starter, as shown and specified, with tin-plated stub assembly for connecting to vertical buses in unit compartment.

5. Circuit breaker

a. Main circuit breaker: One 480-volt, three-pole, rating as shown and in accordance with Section 16440, CIRCUIT BREAKERS, PANEL BOARDS, AND LOAD CENTERS.

b. Branch circuit breaker: One 480-volt, three-pole MCP for each unit compartment.

6. Indicator light: One red light mounted on each unit compartment showing ON position of circuit breaker.

7. Nameplate: As specified under General Requirements for motor starters, with the following additional requirement:

a. Each motor control center labeled with 1-1/2 inch wide nameplate showing designation in 1-inch high characters.

b. Each compartment labeled with 1-inch wide nameplate showing function and number of the motor controlled in 1/2-inch high characters.

**PART 3 – EXECUTION**

3.1 INSTALLATION

A. Embed iron sills for anchoring motor control center flush with raised concrete pad as shown.

B. Install motor starters and control centers as shown in accordance with manufacturer's recommendations.

C. Install conduit in accordance with Section 16130, RACEWAYS, BOXES, AND CABINETS and the NEC.

D. Connect power cable and control wire as recommended by manufacturers and as follows:

1. Make power-cable and control-cable connections to manual starters, across-the-line magnetic starters and autotransformer starters by means of integral mechanical connectors. If such items are not furnished with integral mechanical connectors, make connections using compression connectors in accordance with Section 16125, WIRE CONNECTION ACCESSORIES.

E. Install motor starters and control centers as shown and in accordance with the NEC and Section 16225, MOTORS.

F. Ground motor starter, complete motor control center in accordance with Section 16060, GROUNDING AND BONDING.

G. Apply touch-up paint as necessary.

3.2 TESTING

A. Furnish necessary equipment and perform the following tests:

1. Test circuits for connections in accordance with wiring diagram.

2. Test to ensure that insulation resistance to ground of non-grounded conductor is in accordance with Section 16060, GROUNDING AND BONDING.

3. Test equipment enclosures for continuity to grounding system.

4. Test operation of circuits and controls.

B. Submit certified test reports.

END SECTION

# SECTION 16525

# LIGHTING FIXTURES AND MOUNTING POLES

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for providing lighting fixtures and mounting poles.

1.2 RELATED REQUIREMENTS

A. Grading, excavation and backfilling: Section 02320.

B. Concrete formwork: Section 03100

C. Concrete reinforcement: Section 03200.

D. Cast-in-place structural concrete: Section 03300.

E. Field painting: Section 09920.

F. Grounding and bonding: Section 16060 GROUNDING AND BONDING.

G. Wire, cable and busways: Section 16120, WIRE, CABLE, AND BUSWAYS.

H. Wire connection accessories: Section 16125, WIRE CONNECTION ACCESSORIES.

I. Raceways, boxes and cabinets: Section 16130, RACEWAYS, BOXES, AND CABINETS.

J. Wiring and control devices: Section 16145, WIRING CONTROL DEVICES.

1.3 REFERENCES

A. Comply with codes and regulations of Jurisdictional Authorities.

B. NEC.

C. UL: 496, 542, 1029, 1570, 1571, 1572, Electrical Construction Materials Directory.

D. FS: FF-B-588, FF-P-395, FF-S-325C.

E. MS: MIL-C-450.

F. FED STD: 595.

G. PEI: 1001.

H. SSPC: SP-8, SP-10.

I. ASTM: A53, A167, A276, A123, A507, A575, B26, B85, B117, B136, B137, B209, B221, B244, D635, D1056, D1400, D2240.

J. AASHTO: M314, LTS-3.

K. ITS: Directory of ITS Listed Products.

L. AA: Standard finishes as designated by the Aluminum Association and referenced in NAAMM Metal Finishes Manual.

M. ANSI/IEEE: C62.41.

N. IEEE Publication 587.

O. ANSI Standards.

P. FCC Rules and Regulations, Part 15, Part 18.

Q. NEMA 1

R. AISI.

S. IES: RP-20

1.4 SUBMITTALS

A. Submit the following for approval in accordance with Section 01330, SUBMITTAL PROCEDURES, and with the additional requirements as specified for each:

1. Shop Drawings

a. Include photometric curves.

2. Samples: One of each type of fixture.

3. Certification

a. Verification that each fixture is in compliance with applicable codes, regulations, reference standards and specifications for the location at which it is to be used. Indicate requirements that each fixture meets.

b. Calculations: Submit calculations by a professional engineer registered in the jurisdiction where material is to be installed certifying that assemblies of foundation, anchor bolts, pole, arms and luminaire will withstand specified wind pressure, wind speed, stress, deflection, vibration, and fatigue.

1.5 QUALITY ASSURANCE

A. Each lighting fixture to be labeled or listed in accordance with referenced UL or ITS directory.

1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.

B. Store lighting fixtures and mounting poles in secure and dry storage facility.

1.7 WARRANTY

A. Globes and Diffusers: In addition to warranty requirements of the General Provisions, furnish warranty against discoloration and distortion for a total of 4 years.

B. Lamps: Warrant the life of lamps for periods specified.

**PART 2 – PRODUCTS**

2.1 PRODUCTS AND MATERIALS

A. General Requirements

1. Interchangeability: Components of same type, size, rating, functional characteristics, and make shall be interchangeable.

2. In accordance with UL 1570, UL 1571 and UL 1572.
3. Materials
    a. Steel
        (1) Sheet: ASTM A507, 22-gauge minimum.
        (2) Bar: ASTM A575.
    b. Steel pipe: ASTM A53, Type S.
    c. Stainless steel
        (1) Sheet: ASTM A167, 22-gauge minimum.
        (2) Bar: ASTM A276, Type 316.
        (3) Finish: AISI Alloy S30400, NAAMM Finish No. 4, unless otherwise shown.
    d. Aluminum: Alloy as recommended by manufacturer, unless otherwise shown or specified.
        (1) Sheet and plate: ASTM B209.
        (2) Extrusion: ASTM B221, 0.109-inch minimum thickness, unless otherwise shown.
        (3) Cast
            (a) Die cast: ASTM B85, 0.1875-inch minimum thickness, unless otherwise shown.
            (b) Sand cast: ASTM B26, 0.1875-inch minimum thickness, unless otherwise shown.
            (c) Color-anodized cast: Kalcolor Casting Alloy No. 2 or approved equal.
4. Lamps
    a. In accordance with applicable ANSI Standards.
    b. Incandescent
        (1) Wattage: As shown or specified.
        (2) Finish: Inside frosted unless otherwise shown.
        (3) Base
            (a) Up to 200 watts: Medium screw base
            (b) Above 200 watts: Mogul screw base.
        (4) Operating voltage: 120 volts, 60 Hertz.
        (5) Rated life: 2,500 hours.
        (6) Bulb size: As shown.
    c. Mercury vapor
        (1) Watt rating: As shown.
        (2) Color: Deluxe white.

(3) Finish: As shown.

(4) Base

(a) Up to 100 watts: Medium screw base.

(b) Above 100 watts: Mogul screw base.

(5) Rated life: 24,000 hours.

(6) Bulb size: As shown.

d. Fluorescent

(1) Wattage and size: As shown or specified.

(2) Color: Warm white.

(3) Type

(a) PL7 compact, PL13 compact.

(b) F6T5/CW and F20T12WW, Preheat start.

(c) F32T8/WW, F48T12/WW/SHO, F72T12/WW/SHO, and F96T12/WW/SHO: Rapid start.

(4) Rated life

(a) Super-high output (SHO), very-high output (VHO) and high output (HO) lamps: 12,000 hours.

(b) F32T8/WW: 20,000 hours.

(c) PL compact lamps: 10,000 hours.

(5) Base

(a) Super-high output (SHO), very-high output (VHO) and high output (HO) lamps: Recessed double contact.

(b) F32T8/WW: Medium bi-pin.

(c) PL7 medium.

e. Tungsten-halogen

(1) Wattage: As shown.

(2) Size: T-3.

(3) Base: Recessed single contact.

(4) Rated life: 4,000 hrs.

(5) Operating voltage

(a) 1,500-watt lamps: 277 volts, 60 Hertz.

(b) All other lamps: 120 volts, 60 Hertz.

f. Metal-halide

(1) Wattage: As shown.

(2) Size: As shown.

(3) Color: Clear unless otherwise noted.

(4) Lamp operating position: As shown.

(5) Base: Mogul.

(6) Rated life:

(a) 175 watt: 7,500 hours.

(b) 400 watt: 15,000 hours.

(c) 1,000 watt: 10,000 hours.

g. High-pressure sodium

(1) Wattage: As shown.

(2) Size: As shown.

(3) Coating: Clear, unless otherwise shown or specified.

(4) Base: Medium or mogul.

(5) Rated life: 24,000 hours.

5. Lampholders

a. Incandescent, mercury vapor, metal halide and high-pressure sodium

(1) In accordance with UL 496.

(2) Black or white thermosetting phenolic compound, glazed-porcelain or neoprene base and body as shown. Neoprene unit molded in one-piece, weatherproof, oil-resistant, with vibration-absorbing socket construction.

(3) Incandescent: Rated 660 watts, 250 volts for medium screw base.

(4) Mercury vapor, high-pressure sodium and metal halide

(a) Rated 660 watts, 600 volts: Medium screw base.

(b) Rated 1,500 watts, 600 volts: Mogul screw base.

(5) Provide mechanical self-retaining neoprene gasket for dust and moisture proof seal between lamp and lampholder.

(6) Provide vibration proof feature to prevent incandescent lamp from loosening in lampholder in S-1 fixture

b. Fluorescent

(1) In accordance with UL 542.

(2) Rated 660 watts, 600 volts.

(3) Integral starter holder for preheat-type lamps, with starter.

(4) White, thermosetting phenolic-compound base and body, silver-plated phosphorous-bronze contacts, self-aligning neoprene gasket face.

c. Tungsten-halogen: Porcelain with silver-plated contacts, to suit RSC lamp base.

6. Ballasts

a. Mercury-vapor lamps, high-pressure sodium lamps and metal-halide lamps

(1) UL 1029, high-power-factor type.

(2) Operable on 120-volt or 277-volt, 60 Hertz as shown or necessary, type and rating suitable for associated lamp.

(3) Capable of starting lamp at ambient temperature of minus 20 degrees F and above.

(4) Equip with individual fuse protection installed in ballast compartment of fixture.

b. Fluorescent lamps

(1) FCC part 15 subpart J, UL listed Class P.

(2) Operable on 120-volt or 277-volt, 60 Hertz, as shown or necessary, type and load rating suitable for associated lamps.

(3) Capable of starting lamps at ambient temperature as follows:

(a) F32T8/WW lamps: Zero degree F.

(b) F48T12/WW/SHO, F72T12/WW/SHO, and F96T12/ WW/SHO lamps: Minus 20 degrees F.

(4) Sound rating

(a) For use with F32T8/WW lamps installed in office areas: A.

(b) For use with F32T8/WW lamps installed in ancillary areas: B or better.

(c) For use with F48T12/WW/SHO, F72T12/WW/SHO, and F96T12/WW/SHO lamps: D or better.

(5) Maximum utilization of two-lamp ballasts in public-area lighting fixtures.

(6) Equipped with individual fuse protection, installed in the fixture wiring channel.

7. Fixture body and housing: Shape, size and material as shown.

8. Reflector: Shape, size and material as shown. Aluminum or stainless steel polished to mirror finish unless otherwise shown. Minimum thickness 22 gauge unless otherwise shown.

9. Diffusers

a. Shape and size as shown, one-piece molded or extruded clear virgin acrylic or polycarbonate plastic having the following properties:

(1) Interior diffusing with smooth exterior surface.

(2) Self-extinguishing, in accordance with ASTM D635.

(3) No material color change when used with 4500 K fluorescent lamp.

(4) No apparent yellowing after 500 hours exposure to fluorescent-lamp source under conditions similar to those existing in the lighting fixture.

(5) No alteration to optical properties of the fixture when finished diffuser treated with anti-static wax.

b. Formed by carefully controlled processes so that the finished piece retains its design contours and dimensions at normal operating temperature.

c. Resistance to shrinking, warping, crazing, cracking, or discoloring, either in service or when stored in the manufacturer's standard shipping containers under normal conditions.

10. Globes

a. Clear seamless polycarbonate or high-impact heat-resistant glass as shown.

b. Shape and size: As shown.

c. Minimum thickness: 0.125 inches, surface free from visible mold seam.

d. Reduction in strength: 10-percent maximum after 5 years.

e. Maximum haze: 2 percent.

f. Minimum light transmittance: 88 percent.

11. Lenses

a. Plastic lenses: Clear polycarbonate as shown, minimum thickness 0.06 inch.

b. Glass lenses: 1/4-inch tempered glass, laminated glass, or 1/8-inch double-strength clear glass as shown, capable of absorbing ultraviolet rays when used with mercury-vapor or metal-halide lamps.

c. Refracted lenses: Heat-resistant, annealed, clear borosilicate glass, with the following additional requirements:

(1) Initial lumen distribution on horizontal plane evenly from zero to 90 degrees: 55 to 60 percent.

(2) Minimum efficiency: 85 percent.

12. Fixture wire: Section 16120, WIRE, CABLE, AND BUSWAYS.

13. Gasket

a. Keyed gasket: One-piece, extruded solid neoprene having Type A Durometer hardness of 30 plus or minuses 5 when tested in accordance with ASTM D2240.

b. Self-retaining gasket

(1) One-piece, closed-cell sponge neoprene, soft, or medium density.

(2) Resistant to aging, heat, ultra-violet light, water, oil, weathering and setting as determined by ASTM D1056.

(3) Cemented to component with resilient neoprene sealing compound compatible with finish. Adhesive not applied to diffuser.

c. Silicone gasket equal to neoprene, at Contractor's option.

14. Hardware

a. Latches, catches, release mechanisms, hinges, screws, bolts, studs, nuts, rivets, washers, and springs. Heavy-duty stainless steel or bronze, as shown.

b. Latches and catches: Captive-type.

c. Operating hardware: Self-retaining type.

15. Construction

a. Fixture body, reflectors, wiring channels, end caps and castings formed so as to prevent buckling or distortion.

b. Minimum of two wire clips provided in wiring channel to support wiring. Self-cleaning air filter provided on breather ports.

c. Seams and joints continuously welded and ground smooth.

d. When aluminum will be in contact with dissimilar metal, separate contact surfaces with gasket, non-absorptive tape, or coating to prevent corrosion.

16. Finish

a. Baked enamel: Non-specular finish consisting of six-stage hot-cleaning wash, phosphate coat, prime coat, and finish coat of sprayed white or other color acrylic enamel as shown, baked at 350 degrees F for a minimum of 30 minutes, with the following additional requirements:

(1) Dry-film thickness (DFT) per ASTM D1400: 1.25 mils minimum.

(2) Undercutting of enamel film from scored line after exposing to 10-percent salt spray for 1,500 hours, in accordance with ASTM B117: 0.067-inch maximum.

(3) Baked white enamel after 100 hours exposure to fadeometer: 86-percent minimum reflectance factors, no appreciable visual color change.

(4) Bronze color: FED STD 595, Color No. 20040.

b. Porcelain enamel: Opaque, fused vitreous surface finish, 88-percent average reflectance factor, in accordance with the following standards:

(1) On steel: PEI 1001.

(2) On aluminum alloy: PEI 1001.

c. Specular anodized coating: 14-stage process for permanently sealed specular or semispecular finish, as shown, in accordance with patented electrolytic process, Alzak, or approved equal. When shown dark-bronze color, match Duranodic 313 Dark Bronze.

d. Clear anodic coating: AA-M22C22-A41, minimum coating thickness 0.8 mil, coating weight 35 milligrams per square inch, hot-water seal overall, tested in accordance with the following requirements:

(1) Coating weight: ASTM B137.

(2) Coating thickness: ASTM B244.

(3) Sealing test: ASTM B136.

(4) Undercutting of anodic film from scored line after exposing to 10-percent salt spray for 1,500 hours, in accordance with ASTM B117: 0.067-inch maximum.

e. Color-anodized finish: NAAMM AA-M22-C22A42, minimum coating thickness 0.8 mil, coating weight 35 milligrams per square inch, hot-water seal overall, tested in accordance with the following requirements:

(1) Coating weight: ASTM B137.

(2) Coating thickness: ASTM B244.

(3) Sealing test: ASTM B136.

(4) Color: Dark Bronze. Kaiser Aluminum Color, Statuary Bronze; Alcoa Color, Dark Bronze, Duranodic 313.

f. Zinc coating: ASTM A123.

g. Factory-painting: Prepare surfaces by pickling in accordance with SSPC SP-8. Apply coating of 7.0-mil total DFT as follows:

(1) First coat: Inorganic zinc-silicate primer, 2.5-mil DFT.

(2) Second coat: High-build epoxy primer, 3.0-mil DFT.

(3) Third coat: Aliphatic polyurethane, 1.5-mil DFT, FED STD 595, Color No. 20040.

h. Field painting: Section 09920.

i. Electrostatic-powder coating: Prepare surfaces by sandblast cleaning complying with SSPC SP-10 near-white blast cleaning, applying coating promptly after cleaning. Ground material to be coated. Apply coating as electrostatically-charged dry powder using electrostatic spray gun to produce DFT of 6 mils plus or minus 2 mils. Cure by heat treatment.

17. Mark each fixture and its components in accordance with applicable reference standard.

18. Conduit: Section 16130, RACEWAYS, BOXES, AND CABINEST.

19. Connectors: Section 16125, WIRE CONNECTION ACCESSORIES.

20. Fasteners: Size and type shown or best suited to use.

a. Expansion anchors: FS FF-S-325C, Group II, Type 3, Class 1, stainless steel, Type 303.

b. Toggle bolts: FS FF-B-588.

c. Powder-actuated: FS FF-P-395.

d. Finish: Where exposed, custom finish exposed parts to match surface being fastened.

21. Anchor bolts, nuts and washers

a. AASHTO M314, hot-dip galvanized.

b. Bolts hooked, unless otherwise shown or recommended by manufacturer of pole or structure being anchored.

c. Two nuts and one washer for each anchor bolt for plumbing pole or leveling structure.

d. Finish: Where exposed, custom finish exposed parts to match surface being fastened.

22. Mounting poles

a. Steel or aluminum, straight or tapered as shown. Complete assembly of anchor bolts, pole, arms and luminaire designed to withstand wind pressure (P) developed by wind speed (V) of 80 MPH in accordance with AASHTO LTS-3. Pole assembly to fully comply with AASHTO requirements for permissible stresses, deflection, vibration, and fatigue. Ratio of deflection to pole height under action of applicable static loading not to exceed 1/60.*i

OR

b. Steel, straight or tapered as shown. Complete assembly of anchor bolts, pole, arms and luminaire designed to withstand wind pressure (P) developed by wind speed (V) of 80 MPH in accordance with AASHTO LTS-3. Pole assembly to fully comply with AASHTO requirements for permissible stresses, deflection, vibration, and fatigue. Ratio of deflection to pole height under action of applicable static loading not to exceed 1/60.*ii

c. Size and shape: As shown.

d. Base assembly: Steel base plate, designed to withstand full-bending movement of shaft and welded to shaft; anchor bolts; and base cover.

e. Handhole size: As shown, with 12-gauge steel sheet coverplate.

f. Polygonal-shaped poles fabricated with sharp bends.

g. Longitudinally welded with welds continuous and ground smooth.

23. Grout: Section 03300, nonshrink. Where recommended by manufacturer, prime surfaces to be grouted.

24. Concrete base, including forms and reinforcement: Division 3, Sections 03100, 03200, and 03300.

25. Bituminous coating: MS MIL-C-450.

26. Photoelectric control: Section 16145, WIRE CONTROL DEVICES.

2.2 LIGHTING FIXTURES

A. Tunnel and Ancillary-Space Lighting Fixtures: Types as shown and as follows:

1. Type 1 fixture

a. Open, industrial-type, fluorescent.

b. Lamps: Two 32-watt F32T8/WW.

c. Body: Aluminum or 20-gauge steel channel-shaped body, end plates, cover and reflector. Knockouts in body and end plates as shown. Attach end plates to body with noncorrosive screws. Double-strength construction for steel channel.

d. Finish

(1) Channel, end plates, and cover

(a) Steel: White baked enamel.

(b) Aluminum: Clear anodic coating.

(2) Reflector: White baked enamel for aluminum and steel.

2. Type 2 fixture: Same as Type 1, except fixture equipped with one-piece acrylic-plastic diffuser in extruded aluminum or steel frame; with octolens surface.

3. Type 3 fixture

a. Open, strip-type, fluorescent.

b. Lamps: Two 20-watt F20T12/WW.

c. Body: Aluminum or 20-gauge steel channel, end plates and cover. Knockouts in body and end plates as shown. End plates attached to body with noncorrosive screws. Double-strength construction for steel channel.

d. Finish

(1) Steel: White baked enamel, interior and exterior.

(2) Aluminum: Clear anodic coating.

4. Type 4 fixture

a. Enclosed, watertight, fluorescent, for mounting on channel inserts.

b. Lamp: One 32-watt F32T8/WW.

c. Enclosure

(1) Body: Extruded-aluminum housing with die-cast aluminum end caps, flanged to provide solid seat for gasket between body and door frame.

(2) Door frame: Extruded aluminum, minimum of three hinges riveted to door and housing, 0.2-inch diameter stainless-steel hinge pins and minimum of three door-fastening screws.

(3) Door-fastening screws: Quick-turn slotted, pan-head, captive, corrosion-resistant, location to provide uniform pressure on door gaskets.

(4) Diffuser: Clear, inside-ribbed polycarbonate plastic.

(5) Reflector: Aluminum, three-part, with portion concealing ballast flush-hinged to permit wiring connections and ballast replacement.

d. Finish

(1) Enclosure: Clear anodic coating.

(2) Reflector: White baked enamel.

5. Type 4A fixture: Two tandem-mounted Type 4 fixtures, with two lamp ballasts, as shown.

6. Type 5 fixture

a. Enclosed fluorescent fixture.

b. Lamp: One 32-watt F32T8/WW.

c. Enclosure: Steel housing and end plates. Knockouts where shown. End plates attached to housing with noncorrosive screws. Diffuser: Clear acrylic plastic.

d. Finish

(1) Enclosure: White baked enamel.

(2) Reflector: White baked enamel.

7. Type 6A fixture

a. Enclosed, vapor-tight, compact fluorescent, for pendant mounting.

b. Housing: Cast aluminum, with threaded hub for 3/4-inch conduit, and cast-aluminum guard.

c. Globe: Clear glass with high-impact resistance.

d. Finish: Clear anodic coating.

e. Fluorescent lamp: One PL13 compact.

8. Type 6B fixture: Same as Type 6A, except for mounting on outlet box.

9. Type 6C fixture: Same as Type 6A, except bracket-type for mounting on wall.

10. Type 6D fixture: Same as Type 6C, except complete with outlet box.

11. Type 7A fixture

a. Enclosed, vapor-tight, high-pressure sodium for ceiling mounting.

b. Housing: Cast aluminum, with ballast compartment cast aluminum, guard.

c. Globe: Clear glass with high-impact resistance.

d. Finish: Two coats of gray epoxy enamel.

e. Lamp: One 50-watt, clear, BT-25, high-pressure sodium.

12. Type 7B fixture: Same as 7A, except wall-mounted.

13. Type 7C fixture: Same as 7A, except pendant-mounted. Center topped and integrally counter-weighted so fixture hangs plumb.

14. Type 8 Fixture

a. Enclosed, weatherproof high-pressure sodium for wall mounting, UL-listed "Suitable for Outdoor and Wet Locations".

b. Housing: Die-cast aluminum luminaire, integral ballast housing and grid guard, with tamper-resistant stainless-steel hardware.

c. Refractor: Pressed, clear, prismatic, single-piece, thermal/shock-resistant, borosilicate glass or polycarbonate.

d. Finish: Electrostatic powder-coated, FED STD 595 Color No. 20040.

e. Lamp: One clear, high-pressure sodium, wattage as shown.

15. Type 9 Fixture: Emergency trip station light

    a. Enclosed and gasketted weatherproof, mercury-vapor fixture mounted on steel channel and tube as shown, UL-listed as Suitable for Outdoor and Wet Locations.

    b. Housing: Die-cast copper-free aluminum luminaire with 90-degree arm for wall mounting, integral ballast housing, grid guard and threaded globe seat, with tamper-resistant stainless steel hardware.

    c. Globe: Thermal shock-resistant and impact-resistant blue, tempered glass with threads to ensure secure fit to housing.

    d. Finish: Natural.

    e. Lamp: Mercury-vapor, 40-watt B-17.

    f. Ballast: H45 type, Class H insulated, capable of starting 40-watt mercury-vapor lamp at ambient temperature of minus 20 degrees F and above, suitable for remote mounting.

    g. Remote ballast enclosure: Fiberglass or aluminum with polyester powder paint finish, front access, weathertight construction, 3/4-inch conduit entry and exit knockouts, with mounting lugs suitable for mounting on channel inserts or on wall as shown.

    h. Source: Hubbell catalog number VMWX-5050C-R, or approved equal.

16. Type X fixture

    a. Exit sign for top, side, back or pendant-mounting, as shown. With directional arrows where shown. Color of lettering and arrows to comply with jurisdictional requirements.

    b. Lamps: Ultra-long-life light-emitting diodes (LED) mounted on a circuit board to operate on 120 V or 277 V, single phase, 60-Hz supply. Have LEDs protected by a clear panel and special optical diffuser.

    c. Housing: Die-cast aluminum, 0.125-inch minimum wall thickness. Concealed hinges and latching mechanism.

    d. Door: Die-cast aluminum, 0.125-inch minimum thickness; open-face with phosphorescent-glass panel and 6-inch high letters; color of letters and field as required by the Jurisdictional Authority, using fired-on ceramic colors.

    e. Finish: Clear-satin anodic coating, unless otherwise shown.

B. Station Kiosk Lighting

1. Lighting Fixtures; Station Kiosk: UL 1570, and the following additional requirements:

    a. Type K-4 lighting fixture: Open compact fluorescent downlight fixture, Prescolite Catalog Number CFR813EBDM-B572-MTR-120V/208V/240V/277V - RIF1 or approved equal, for recess mounting in the ceiling of the kiosk with the following additional requirements

        (1) Two 13-watt compact fluorescent twin tube lamps with four-pin 2GX7 lamp base compatible with fixture lampholder and suitable for dimming application using electronic ballast.

        (2) Encased and potted Class P electronic ballast capable of producing flicker-free light output range from 5 percent to 100 percent of rated output.

        (3) Clear Alzak reflector with lower black baffle to provide 50-degree optical cutoff and maximum spacing to mounting height ratio of 1:1.

(4) Diecast aluminum trim ring with baked enamel finish, FS 595, Color No. 36586.

(5) Dimensions

(a) Nominal aperture size: 8 inches.

(b) Maximum height: 8 inches.

(c) Maximum overall dimensions of housing, including accessories, in vertical view above ceiling plane: 16 inches by 20 inches.

(6) Integral junction box approved for 90 degrees C through wiring.

(7) Suitable for damp location.

(8) Radio interference filter for suppressing radio interference noise.

(9) Lighting fixture, dimming ballast, and associated controls designed and manufactured for compatibility by a single manufacturer.

b. Ballast: Dimming compact fluorescent electronic ballast, Prescolite Model No. PUV-20RSD or approved equal, for mounting on the housing of the Type K-4 lighting fixture and with the following additional requirements:

(1) Capable of operating four-pin, 13-watt compact fluorescent lamps with circuitry that constantly monitors lamp conditions to provide constant light output regardless of voltage fluctuations.

(2) Equipped with a soft start/rapid start function, which preheats cathode filaments and then ignites the lamp for maximum lamp life.

(3) Capable of dimming continuously from 100 percent to 5 percent of rated light output.

(4) Capable of maintaining full filament heat throughout the dimming range for long lamp life.

(5) Dimming circuitry UL Class 2 and fully isolated from ballast input power.

(6) Compatible with low voltage (2.5 to 12 volts DC) dimming systems.

(7) Compatible with phase controlled dimmers by utilizing a dimming interface box to provide the interface between the phase controlled AC output and the 2.5 to 12 volts DC signal required by the ballast.

(8) Equipped with push-in wire connections suitable for No.18 AWG solid copper wire.

(9) Input voltage universal and suitable for operation on 120-volt system.

(10) Maximum lamp current crest factor of 1.414.

(11) Power factor of 0.95 or higher.

(12) Input current total harmonic distortion not to exceed 10 percent.

(13) Operating frequency exceeding 30 kilohertz.

(14) Maximum control input current of 2 milliamperes at 12 volts DC output.

(15) Sound level not exceeding Class A ambient noise levels.

(16) Minimum starting temperature of 0 degree F.

(17) Capable of withstanding line transients as defined in IEEE Publication 587, Category A, ANSI/IEEE C62.41, Category A.

(18) Capable of maintaining cathode filament voltage within ANSI standards.

(19) Meet requirements of FCC Rules and Regulations, Part 18.

(20) UL-listed, Class P, Type 1 Outdoor.

2. Lighting Control System; Station Kiosk: Lighting control system consisting of dimming interface box and dimmer switch as follows:

   a. Dimming interface box: Dimming interface box, Prescolite Model No. CIB or approved equal, to provide the interface between electronic dimming ballasts and the phase controlled wallbox dimmer and with the following additional requirements:

      (1) Compatible with fluorescent wallbox dimmers and with lamp types used with electronic dimming ballasts.

      (2) Dimming interface box to convert the dimmed (phase controlled) ac output from a wallbox dimmer to the 2.5 to 12 volts DC signal required by the electronic ballast. Lowest dimming level shall correspond to a 3 volts DC signal and maximum light output shall correspond to a 12 volts DC signal.

      (3) DC control output to be isolated from the switched AC and dimmed AC inputs and protected internally from short circuits.

      (4) Capable of operating from one to 100 electronic dimming ballasts.

      (5) Input voltage autoranging and suitable for operation on 120-volt system.

      (6) Constructed in a steel NEMA 1 enclosure with nominal 6-inch by 8-inch by 4-inch dimensions.

      (7) UL-listed.

   b. Dimmer switch: Commercial grade linear slide, phase controlled wallbox dimmer, Prescolite Model No. P6F-BR or approved equal, to provide the dimmed/phase controlled ac output to the dimming interface box and with the following additional requirements:

      (1) Single pole, 120 volts for controlling up to twelve fluorescent lamps.

      (2) Vertical slide intensity control with on/off illuminated switch.

      (3) Soft start electronic circuit with voltage compensation to minimize flicker resulting from line voltage fluctuations.

      (4) Toroidal radio frequency interference (RFI) filters to minimize radio and intercom interferences.

      (5) Adjustable low-end trim to permit user to determine minimum light level based on particular ballast and lamp combinations.

      (6) Cover finished with brown or bronze color.

      (7) UL-listed.

C. Parking Structure Lighting Fixtures: The low glare fixture shall comply with the latest IES Specifications, RP-20 (Lighting for Parking Facilities). The electrical components will carry a 5-year minimum warranty, with other components covered by a 2-year warranty.

1. Housing: A die cast housing integrating the high power factor ballast and wiring splices. The wiring shall be rated for 90 degrees C.

2. Ballast: High power factor with multitap power feature 120/277 V, 60 HZ. UL listed and capable for starting at minus 20 degrees F

3. Lamp: 150 W, High Pressure Sodium, Medium base, clear. Average life of 24,000 hours.

4. Fixture shall be fused, totally sealed and UL listed for wet location.

D. Other Lighting Fixtures: Types as shown, with materials and finishes shown and specified.

**PART 3 – EXECUTION**

3.1 INSTALLATION

A. Install lighting fixtures of types shown at locations shown as follows:

1. Mount fixtures rigidly in place. Use expansion anchors and machine screws for concrete surfaces and toggle bolts for hollow concrete-masonry surfaces. Use appropriate fasteners for attachment to other surfaces. Support lighting fixtures independent of suspended acoustical-panel ceiling systems.

2. Where aluminum contacts concrete or dissimilar metal, separate contact surfaces with gasket, non-absorptive tape, or bituminous coating to prevent corrosion. Use stainless-steel fasteners.

3. Mount fixtures plumb, level, and in straight lines. Install stems of suspended fixtures plumb. Group-mounted fluorescent fixtures to appear as one unit.

4. Install 12-inch minimum length of liquid-tight flexible conduit for connection between fixture and outlet box unless otherwise shown in accordance with Section 16130, RACEWAYS, BOXES, AND CABINETS. Use fixture wire from outlet box in branch circuit to lighting fixture in accordance with Section 16120, WIRE, CABLE, AND BUSWAYS, and connect fixtures to branch circuit in accordance with Section 16125, WIRE CONNECTION ACCESSORIES.

5. Install chase nipple where fluorescent fixtures are installed in continuous groups. Clean lamps, diffusers, globes, reflectors, and exposed-to-view surfaces of fixtures after aiming and adjusting has been approved.

B. Installation of Pole-Mounted Fixtures

1. Prepare and compact that earth foundation for mounting in accordance with Section 02320. Form and reinforce concrete base as shown and in accordance with Sections 03100 and 03200. Mix and place concrete in accordance with Section 03300. Use finish Number 2 for exposed surfaces. Use templates for setting anchor bolts.

2. Install mounting pole of type shown at location shown. Use double nuts to erect poles plumb. Pack void between concrete base and pole with grout in accordance with Section 03300.

3. Install conductors in accordance with Section 16120, WIRE, CABLE, AND BUSWAYS, leaving 3-foot minimum lengths of conductors for fixture connections; tape or otherwise secure in place pending final connection.

4. Install lighting fixtures in accordance with approved Shop Drawings.

5. Connect wiring using connectors in accordance with Section 16125, WIRE CONNECTION ACCESSORIES. Tape connections.

6. Install photoelectric controls as shown or in accordance with fixture manufacturer's instructions and in accordance with Section 16145, WIRE AND CONTROL DEVICES.

7. Ground lighting fixtures and mounting poles in accordance with NEC and Section 16060, GROUNDING AND BONDING.

8. Apply touch-up paint where necessary in accordance with Section 09920.

3.2 FIELD QUALITY CONTROL

A. Ensure that earth foundation for mounting poles is prepared and compacted in accordance with Section 02320.

B. Testing

1. Furnish necessary personnel and equipment and perform tests and adjustments in the presence of the Engineer. Schedule adjustment of exterior installations to occur during hours of darkness.

2. Test lighting circuits for continuity and operation.

3. Test fixtures and mounting poles for continuity of grounding system.

4. Aim and adjust fixtures to provide distribution pattern approximately as shown and as approved.

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

ENDNOTES:

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*i. Use first version of 2.1 A.22.a. modification for all contracts requiring lighting fixture mounting poles for S&I yards.

END OF SECTION

# SECTION 16705

# COMMUNICATIONS STANDARD SPECIFICATIONS - EQUIPMENT AND MATERIAL

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for Communications equipment and materials.

B. These Specifications shall apply to all equipment and materials furnished, unless otherwise specified elsewhere in this Contract (i.e. conflicting Specification requirements found in other Specification sections or on Contract Drawings take precedence over Standard Specifications in this section).

1.2 RELATED REQUIREMENTS

A. Section 16706 - Communications System Submittals & Services.

B. Section 16710 - Communications Grounding.

C. Section 16721 - Communications Telephone System.

D. Section 16723 - Communications Garage Emergency Telephone System.

E. Section 16727 - Communications Passenger Emergency Reporting System.

F. Section 16731 - Communications Fire and Intrusion Alarm System.

G. Section 16733 - Communications Kiosk System.

H. Section 16771 - Communications Carrier Transmission System.

I. Section 16776 - Communications Fiber Optics System.

J. Section 16791 - Communications Mobile Radio System.

K. Section 16820 - Communications Public Address System.

L. Section 16821 - Communications Automatic Public Address Announcement System.

M. Section 16851 - Communications Passenger Station Closed Circuit Television System.

N. Section 16852 - Communications Parking Garage Closed Circuit Television System.

1.3 REFERENCES

A. Federal Communications Commission (FCC) (Specifically Parts 15, 90, and other applicable regulations).

B. National Electrical Code (NEC).

C. Underwriters Laboratories (UL).

D. American National Standards Institute (ANSI).

E. Rural Electrification Administration (REA).

F. Insulated Cable Engineers Association (ICEA).

G. Electronic Industries Alliance (EIA).

H. National Electrical Manufacturers Association (NEMA).

I. Institute of Electrical and Electronic Engineers Association, Inc. (IEEE).

J. Association of American Railroads (AAR).

K. WMATA General Provisions and Standards Specifications for Construction Projects.

1.4 SUBMITTALS

A. Submit under provisions of Section 16706.

**PART 2 – PRODUCTS**

2.1 EQUIPMENT RACKS

A. Construction: Open Frame, Aluminum 3-Inch by 1.410 Channel, 1/4 Inch thick.

B. Panel Mounting Size: Standard 19-inch or 23-inch panels.

C. Finish: Baked Enamel.

D. Color: ANSI 61 Gray.

E. Hole Spacing: Standard EIA 1.75-inch vertical rack mounting spaces.

F. Hole Size: No. 12 to 24.

G. Base Width: 20.25 inches for 19-inch panels and 24.25 inches for 23-inch.

H. Base Depth: 15 inches.

I. Base Mounting Holes: Front-to-back centers of 12.5 inches and side-to-side centers of 16.0 inches and 20.0 inches.

J. Rack Height: Maximum 7.5 feet.

K. Equipment racks shall have a ground bus bar, bolt mounted near the top of the rack, consisting of a 6.0-inch by 0.25-inch by 0.5-inch copper bar drilled and tapped for six connections. The ground bus bar shall be electrically connected to the equipment rack.

2.2 EQUIPMENT CABINETS

A. Construction: Assembled frame with a flush frame base, suitable side panels and top panel, a front door and a rear door.

B. Assembled frame: Zinc plated 14-gauge steel and shall have the required front-to-back stiffeners to distribute the equipment load.

C. Base: Zinc plated 14-gauge steel or greater.

D. Panel Mounting Rails: Drilled and tapped in accordance with EIA Standard RS-310-C.

E. Front Door and Rear Door: 16-gauge steel with a lockable handle.

F. Ventilation: Louvers front door and/or the rear.

G. Finish: Baked enamel/acrylic, gray color.

H. Cabinet Height: Maximum 7.5 feet.

I. Equipment cabinets shall have a ground bus bar, bolt mounted near the top of the rack, consisting of a 6.0-inch by 0.25-inch by 0.5-inch copper bar drilled and tapped for six connections. The ground bus bar shall be electrically connected to the equipment cabinet.

## 2.3 DISTRIBUTION FRAMES

A. All systems distribution frames, including the Main Distribution Frame (MDF)/Protector Cabinet, shall consist of the required multisection cable terminal housings, top and bottom assemblies for each housing, a hinged end section at both ends of the distribution frame, a lift-out door for each housing, and a fungus resistant solid plywood backboard in each housing. Each housing of the distribution frame shall contain four distribution rings to permit neat installation of wires and cables within the housing.

B. Finish: Baked enamel gray color.

C. Multisection cable terminal housings shall have a ground bus bar installed near the bottom on the plywood backboard, consisting of a 6.0-inch by 0.25-inch by 0.5-inch copper bar. The ground bus bar shall be drilled and tapped for the required ground connections within the housing. The ground bus bar shall be electrically isolated from the distribution frame enclosures.

## 2.4 JUNCTION BOXES

A. Junction boxes shall be constructed of 12-gauge sheet steel, except for sizes 24-inch by 36-inch and smaller, which shall be constructed of 14-gauge sheet steel. Boxes shall have all seams welded. The boxes shall be finished to be a NEMA Type 4 rating with the door/cover gasket with an oil resistant gasket material and adhesive. Boxes shall be either galvanized and painted with ANSI 61 gray paint after priming or shall be a phosphatized surface with ANSI 61 gray polyester powder coating applied. Associated hardware shall be constructed of stainless steel. Junction boxes shall be sized to provide ample space for terminating the wires and cables installed at each location, including terminal blocks and considering the minimum bending radii of cables. Junction boxes exposed to the weather shall have all wire entrances protected from weather and dust with a pliable sealing compound, and shall be equipped with a drain plug.

B. Junction boxes shall be furnished and installed complete with terminals, fittings, mounting brackets, cable supports and all other necessary hardware. All conductors within a junction box (including spares) shall be terminated on terminal blocks. Junction boxes to be used only for the pulling of cable do not require terminals.

C. Where the Contractor furnishes and installs junction boxes as means of terminating cables, cable supports shall be provided in the boxes.

D. The Contractor may request a waiver to use outlet boxes in lieu of junction boxes for specific application(s) in specific locations. The request must be approved by the Authority prior to the purchase of material or the beginning of installation.

## 2.5 CONDUIT PLANT

A. All conduit, except as noted, shall be intermediate metal conduit (IMC). The rigid metal conduit shall conform to UL Standard Number 6, Rigid Metal Conduit and National Electric Code Article 345 Intermediate Metal Conduit. The exterior surface shall be thoroughly and evenly coated with metallic zinc applied directly to the surface of the steel (electroplated zinc coating). The conduit furnished shall be supplied in nominal 10-foot lengths, threaded on each end with one coupling attached. The intermediate metal conduit, elbows, coupling, and fittings shall be protected by corrosion protection when subject to severe corrosive influences. Conduit fittings selected for removable covers shall be complete with gaskets and blank covers.

B. Flexible conduit shall be provided only where specifically required by these Specifications or where, at the request of the Contractor, its use has been approved by the Contracting Officer Representative and allowed by the National Electrical Code. The flexible conduit shall be constructed of interlocking spiral strip steel of the best quality. The flexible conduit shall be thoroughly annealed and fully coated with metallic zinc. The flexible conduit shall conform to Underwriters Laboratories standards and Federal Specification WW-C-5568. The flexible conduit shall have an extruded liquid-tight neoprene jacket in those locations where the conduit will be exposed to a wet environment, or required by the Contracting Officer Representative for an approved installation. Appropriate type and sized connectors, couplings and fittings supplied or recommended by the manufacturer for the specific flexible conduits shall be provided.

C. Rigid non-metallic conduit shall be provided only where specifically required by these Specifications or where, at the request of the Contractor, its use has been approved by the Contracting Officer Representative and allowed by the National Electrical Code. Unless otherwise specified, the rigid non-metallic conduit shall be classified as heavy wall type construction. Appropriate type and sized connectors, couplings and fittings supplied or recommended by the manufacturer for the rigid non-metallic conduit shall be provided.

D. The Contractor shall furnish systems and facilities and select equipment with features that will allow for the utilization of cables sized to fit existing conduit (if any), or the Contractor will be required to furnish and install suitable conduit to Authority standards to accommodate the communications cables required.

## 2.6 CABLE TRAYS

A. Cable trays shall be prefabricated aluminum, open ladder type, approximately 3 inches in depth and shall conform to NEMA Standard VE-l. The width of cable trays shall be determined by the Contractor, but shall be a minimum of 6 inches. Cable tray bottoms shall have rungs on 4-inch centers. Where applicable, a cantilevered single "wall support" type of tray shall be used.

B. The cable trays shall support 100 pounds per linear-foot load, with a maximum mid-span deflection of 0.25 inch when considered as a simple beam with supports on 8-foot centers.

C. Appropriate type and size curved sections, cross sections, tee sections, fittings, accessories, and supports shall be furnished in accordance with the manufacturer's recommendations.

## 2.7 CABLE LADDERS

A. Cable ladders shall be prefabricated aluminum, open ladder type, approximately 3 inches in depth and shall conform to NEMA Standard VE-1. The width of cable ladders shall be determined by the Contractor to support cables in cable vault or mounted on wall when conduit is not available or conduit is not suitable for installation.

## 2.8 HARDWARE

A. Unless otherwise specified, all mounting hardware shall be galvanized. Appropriate type mounting hardware shall be provided for the corresponding supporting surfaces.

B. Unless otherwise specified, brackets for the mounting and supporting of equipment and material in passenger station areas, yard buildings and other facility buildings shall be painted. Unless otherwise specified, brackets installed in tunnel or outdoor areas shall be galvanized after fabrication in accordance with ASTM A386.

C. All bolts, nuts and washers for mounting and supporting of equipment within equipment enclosures shall be cadmium plated.

2.9 PAINTING

A. Equipment furnished and installed by the Contractor other than galvanized, copper, plastic, and electrical contact surfaces shall be factory painted internally and externally, except as otherwise specified.

B. Paint colors shall be selected to match existing equipment, where applicable, and shall be subject to the approval of the Contracting Officer Representative.

2.10 SPECIAL REQUIREMENTS FOR STAINLESS STEEL CORROSION RESISTANT HARDWARE

A. Except as otherwise specified, equipment enclosures, cabinets, boxes, and hardware of all types in tunnels, tunnel crossovers, along the surface right-of-way, and in all ancillary structures that are open to tunnels (vent shafts, fan shafts, and pumping stations - excluding rooms within these areas that are heated/air conditioned) shall consist of stainless steel 304 material. Also, except as otherwise specified, equipment enclosures, cabinets, boxes and hardware of all types; in platform plenums (and including track side walls and under-platform slab and extensions into service rooms); along station train room safety walks, in stairways, corridors, and plenums that are not heated/air conditioned; and in all shafts to the surface and dome reliefs, escalator well ways, elevator pits and surface elevator shafts, shall consist of stainless steel 304 material.

B. Exceptions: Galvanized conduit may be used with stainless steel 304 mounting hardware. Gray colored fiberglass boxes may be utilized for Emergency Trip Station (ETS) Telephones (Ref. Article 3.7 for product specifications). Non-metallic mounting hardware may be utilized for tunnel and passenger station Mobile Radio System (MRS) antenna cable mounting (Ref. Article 3.13 for product specifications). Electronic equipment connectors, and other relatively small sized specialty items, that are not available in Stainless Steel 304 material, may be allowed by the Contracting Officer Representative as exceptions (Ref. Article 3.1, Request for Approval Of Minor Technical Specification Deviation).

C. Unless otherwise specified, dull “powder gray” colored Original Equipment Manufacturer (OEM) factory painted exterior surfaces of stainless steel 304 equipment enclosures, cabinets, and boxes shall be utilized in areas where surface glare may be visible to rail car operators, or neatly apply dull colored epoxy paint to surfaces to avoid glare. McMaster-Carr Supply Company (New Brunswick, NJ) Catalog No. 7892T78 (from Cat. #98) gray primer (or approved equal) shall be utilized for the Contractor-applied paint.

D. Definition: “Hardware” includes bolts, screws, clamping devices, anchoring devices, threaded rods, nuts, washers, hangers, and covers/wall plates. “Boxes” includes junction boxes, outlet boxes; disconnect switch boxes, circuit breaker boxes, and terminal boxes. “Cabinets” includes terminal cabinets, equipment cabinets, MDF cabinets, and power distribution panel boards. (Note: definitions include but are not limited to the items listed herein.)

2.11 ELECTRICAL

A. All electrical and electronic components furnished shall be:

1. New and free of manufacturing defects.

2. Free of storage and handling damages.

3. Clearly and permanently labeled with value or identification type.

4. Rated to operate at power, voltage, and current levels exceeding, by at least 20 percent, those which the components will be subject to in service, unless otherwise noted.

5. Commercially available.

6. Capable of operating in the environment specified in these Specifications.

7. Identical, if performing the same function.

8. Selected with tolerance limits such that the equipment fabricated from the components shall not malfunction over the specified system/facility or equipment operating range.

B. The selection of the electrical and electronic components shall be such as to provide maximum convenience and safety to personnel in installing, operating, and interchanging a complete assembly or component part. Provisions shall be made to prevent personnel from accidentally coming into contact with hazardous voltages. Components shall be selected to prevent reversed assembly or installation of connectors and cables. Cables shall be suitably identified with their mating connections.

C. Deviations from these requirements and the requirements detailed herein, including those inherent in standard production equipment, shall be subject to the approval of the Contracting Officer Representative.

2.12 TRANSISTORS AND DIODES

A. All transistors and diodes shall carry a Joint Electronic Device Engineering Council (JEDEC) number, shall be available from at least two manufacturers, and shall be silicon. Specially selected transistors and diodes within a type number shall not be permitted.

B. Resistors shall have a maximum tolerance of plus or minus 5 percent and shall be rated to dissipate a minimum of 1.5 times the maximum power they will be required to dissipate in operation.

C. Zener diodes used for voltage regulation or reference levels shall be of such rating that they will not be damaged if the entire load is removed abruptly, and shall have a Zener voltage tolerance of plus or minus 5 percent or better.

D. Zener diodes used for transient protection shall be of such a rating that they will not be damaged in performing their function within all actual conditions encountered in the operating system/facility.

2.13 CAPACITORS

A. Wet electrolytic capacitors shall not be used. Only dry electrolytic capacitors shall be provided.

B. Capacitors shall have a maximum tolerance of plus or minus 10 percent and shall be rated for at least 1.5 times the maximum peak voltage they will be subjected to in operation.

2.14 OTHER SEMICONDUCTORS

A. All other semiconductors shall carry a Joint Electronic Device Engineering Council (JEDEC) number and shall be available from at least two manufacturers. All other semiconductors shall be of the silicon type, unless otherwise approved, in writing, by the Contracting Officer Representative.

2.15 INTEGRATED CIRCUITS

A. All integrated circuits (ICs) shall be available from at least two manufacturers. Take all necessary precautions to ensure that no system or facility using ICs shall malfunction in any fashion due to internally or externally generated noise or cross-talk.

B. Integrated circuits shall not be damaged by the failure or partial failure of any one or any combination of the various supply voltages. Integrated circuits shall not be damaged by overvoltage of 1.4 times the normal supply voltage, or by short circuits on their inputs and outputs.

## 2.16 TRANSFORMERS

A. All transformers provided shall be of air-cooled, dry type, unless otherwise approved by the Contracting Officer Representative.

B. Unless otherwise specified, all transformers shall have minimum interwinding and winding to core breakdown voltage of 600 Vdc. Transformers used in electronic circuitry are an exception.

C. Unless otherwise specified, all transformers shall conform to the following requirements:

1. Core laminations shall be grain oriented silicon steel. Maximum flux densities shall be substantially below saturation level. The core volume shall allow efficient transformer operation at 10 percent above the highest tap voltage. All laminations must be core plated or annealed, free of burrs and firmly butted. The core laminations shall be tightly clamped and compressed to provide quiet operation. Transformers shall not emit audible noise in excess of 50 dB referenced to 0.0002 dynes per sq. cm., at a distance of 3 feet, while operating at rated voltage and load.

2. Coil conductors shall be continuous with terminations brazed or welded without auxiliary flux material. The entire core and coil assembly shall be pre-dried by heat, impregnated with varnish or other approved compound, and cured at a minimum of 350 degrees F to reduce hotspots and seal out moisture. Coils shall be protected with an outer layer of glass tape or similar quality insulation.

D. Unless otherwise specified, all transformers provided shall be equipped with suitably insulated screw terminals for all primary and secondary lead wires. Transformers used in electronic circuitry and video isolation transformers are an exception. Appropriate type video connectors shall be provided for the input and output leads of video isolation transformers.

## 2.17 POWER SUPPLIES

A. Unless otherwise specified, all power supplies shall have the characteristics and meet the requirements listed herein.

B. Power supplies shall be for continuous duty and shall be rated at a minimum of 120 percent of maximum load at 50 degrees C.

C. Power supplies shall be selected for mounting in a standard 19-inch equipment rack and shall be housed in a metal panel-chassis combination with no exposed electrical connections or wires. Appropriate type terminals shall be provided on the rear of the chassis for the connections of all external input and output power leads. An appropriate sized power cord (internally connected) may be provided for the input power leads.

D. Power supplies shall be selected for natural convection cooling. No supplementary fans or other cooling devices will be allowed.

E. The power supplies shall not be damaged by a sustained input voltage varying from 0 to 150 percent of the rated input voltage. Power supplies shall have current limiting, which shall protect the power supplies from damage due to overload or short circuits. Overvoltage protection shall be contained on those power supplies driving solid-state circuitry.

F. Each power supply shall have an output voltmeter, an output ammeter, and a normally illuminated power light (lamp or LED) mounted on its front cover. All panel mounted indicating, adjusting, and protective devices, or openings for such devices, shall be legible and permanently labeled.

G. Each power supply shall be equipped with a failure alarm device, which shall detect any internal failure that will impair the ability of the power supply to deliver its full rated load. This device shall be normally energized by a small percentage of the rated load current of the power supply. Upon detection of a failure, the failure alarm device shall provide an independent contact closure for an

external alarm indication circuit. The contacts shall be wired to appropriate type terminals on the rear of the chassis. In addition, the failure alarm device shall extinguish the normally illuminated power light on the front cover, when a failure is detected.

H. Unless otherwise specified, all redundant power supplies shall be diode coupled to the loads with the corresponding main power supplies.

2.18 CONNECTORS

A. Connectors shall be provided on wires, multi-conductor cables, coaxial cables, and triaxial cables, when required to permit the connection to or removal of equipment items for maintenance, as determined by the Contracting Officer Representative. In-line connectors shall be provided only where specifically required by these Specifications or where, at the request of the Contractor, its use has been approved by the Contracting Officer Representative. Appropriate type and size connectors shall be provided for the joining, splicing, and terminating of all coaxial cables and triaxial cables.

B. Unless otherwise specified, connectors will not be required for the termination of wires and cables to those equipment items, which contain screw type terminals as the interface connection for wires and cables. Connectors shall not be provided in system distribution frames. Appropriate type mating connectors, recommended by the manufacturers, shall be provided for those equipment items requiring connectors for the interfacing of wires and cables. Appropriate type connector assemblies and mating connectors shall be provided to interface wires and cables to all equipment (including system control panels) in the Kiosk and yard consoles.

C. Appropriate type, size, and rated power connectors (plugs) shall be provided to interface equipment power cords and cables to ac power receptacle strips, ac power outlet assemblies, and ac outlets.

D. Unless otherwise specified, all multi-conductor cable connectors (including those provided for custom-made equipment and control panels) shall consist of a molded plastic connector block equipped to hold the required number of contacts, a protective shell (plastic or metal), a mechanical keying device, a device to grip the external wiring firmly in order to prevent strain on the contacts, and the required solderless contacts (pins or sockets). The pin and socket contacts shall be fabricated from commercial bronze or brass and have a minimum 0.00003-inch gold plating over nickel underplate. The pins and sockets shall be appropriately sized to interface the corresponding conductor sizes that are to be terminated to the connector. Connectors provided on equipment for the interfacing of wires and cables shall be firmly secured to the chassis.

E. All connector assemblies shall be easily connected and disconnected by hand. Tools used to apply connector contacts to wires and cable conductors shall be of the size and type recommended by the manufacturer of the connector.

F. Each connector shall be marked in such a manner that its mating half shall be distinctly identified as being related to each other, but to no other connector within the immediate area. These identification markings shall be applied in such a manner that they will not be obscured or worn off in normal use.

G. All conductors (including spares) within a cable that interfaces with a connector shall be terminated in the connector.

H. All in-line connectors installed in wires and cables located inside structures, within tunnel areas, and all connectors installed to equipment which are not located within rooms of passenger stations, ancillary buildings and yards shall be protected by silicon sealer coating, enclosed by heat shrinkable tubing (sleeves). This requirement shall be excluded for all connections with a weatherproof classification.

I. All in-line connections installed in manholes, hand-holes, cable troughs or cable trenches (direct burial) shall be enclosed in filler splice cases, utilizing products and methods approved by the Contracting Officer Representative.

J. In-line connection shall not be allowed in conduits, ducts, pipes and cable trays.

K. All locations of in-line connections shall be documented on As-Built drawings.

2.19 RELAYS, SWITCHES AND PUSHBUTTONS

A. All electromagnetic relays shall be plug-in type and secured to their corresponding socket to reduce the effects of shock and extreme vibration. Where applicable, retaining wire springs shall be provided with the relays. The contacts of the electromagnetic relays shall be palladium, silver, or gold plated, or shall be mercury-wetted. All contacts shall be bifurcated and shall have a wiping action. The coil and contacts of each electromagnetic relay shall be enclosed in a protective dust cover. Unless otherwise specified or required for a specific function within the associated circuitry, all double throw contacts shall be break-make type (Form "C").

B. All solid-state relays shall be completely encapsulated in a rugged epoxy case. A minimum of 2500-Vrms isolation shall be provided between the input and the output of all solid-state relays.

C. All relays shall be of the appropriate type (Vac or Vdc operation) and be of the required input control rating for their intended use. The contacts of the electromagnetic relays and the isolated outputs of the solid state relays shall have ratings that equal or exceed the corresponding connected load requirements (voltage and current).

D. Arc suppression circuits shall be provided for all relays used in electronic circuitry. Arc suppression may be built into the relays or provided on the printed circuit cards on which the relays are mounted. All time delay relays shall have solid-state timing circuits.

E. All switch and pushbutton contacts shall be palladium, silver or gold-plated. The contacts shall have a wiping action and shall be rated for their intended use. All switches and pushbuttons shall have a long life expectancy of more than 10,000 operations.

F. Unless otherwise specified, the types of switches (rocker and toggle), the operation of the pushbuttons and switches (momentary action and maintained action), and the configuration of the pushbuttons and switches on developed equipment shall be determined by the Contractor and approved by the Contracting Officer Representative. Unless otherwise specified, all pushbuttons and switches on developed equipment shall contain LEDs, if indicators are required. Mechanical interlocking shall be provided when required. Full guard bezel, which surrounds the button to help prevent accidental operation and barriers between pushbuttons and switches, shall be provided, upon request by the Authority.

G. All switches and pushbuttons on equipment shall be permanently labeled. Labeling of the switches and pushbuttons shall either be provided on the surface of the equipment to which they are mounted or provided on the switches and pushbuttons themselves. All graphics on pushbuttons and switches shall be hot stamped in a color that will contrast with the color of the buttons (lenses).

2.20 TEST POINTS

A. Test points shall be provided for each major function. Labeled test points on printed circuit boards and other plug-in modules shall be accessible while the device is in operation.

2.21 PRINTED CIRCUIT BOARDS

A. All printed circuit boards (cards) shall be constructed of fire-resistant glass epoxy material of NEMA quality FR4 or better. Cards shall have sufficient thickness to permit easy insertion and removal without buckling or breaking and shall be keyed to prevent incorrect interchange. All

circuits on the printed circuit boards shall be formed by etching. Conductor material shall be copper and shall be protected from exposure to air.

B. Boards shall be produced with plated through holes, for component mounting and connecting, and for interfacial connections. If all interconnecting circuitry is confined to one side of the board, the board may be produced with unsupported holes for mounting the components, which will be soldered to the pattern side of the board.

C. Printed circuit boards shall be coated with an approved moisture-proofing compound after assembly, except when this requirement is waived by the Contracting Officer Representative, due to non-availability from manufacturers of approved off-the-shelf dust protected equipment units.

D. Each printed circuit board shall be permanently and legibly marked with a unique number identifying that type of circuit board (i.e., model number). In addition, each printed circuit board shall be permanently and legibly marked with a unique serial number.

2.22 LED AND INDICATING LAMPS

A. All indicating lights (LEDs and lamps) shall have a life expectancy of 25,000 hours minimum. All indicating lights shall be operated between 85 percent and 95 percent of their rated voltage.

B. All indicating lights on equipment shall be permanently labeled. Labeling of the indicating lights shall either be provided on the surface of the equipment to which they are mounted or provided on their associated lenses. All graphics on the lenses shall be hot stamped in a color that will contrast with the color of the lenses.

C. Unless otherwise specified, all indicating lights (LEDs and lamps) shall be replaceable from the front of the light assemblies.

D. Unless otherwise specified, all numeric and alphanumeric displays shall be solid state LED display or liquid crystal display. Numeric characters shall be 7-segment type display and alphanumeric characters shall be l4-segment type display. However, a dot matrix display will be considered upon request by the Contractor. Unless otherwise specified, all character displays shall be a minimum of 1/2-inch. Appropriate filters and windows shall be provided.

2.23 METERS

A. Unless otherwise specified, traditional meter movements shall have a full-scale accuracy of plus or minus 2 percent.

B. All meters shall be of the appropriate type for their intended use; i.e., a meter with an ampere scale shall not be acceptable for the measurement of milli-amperes. All meters shall be legible and permanently labeled.

2.24 TERMINAL BLOCKS

A. All terminal blocks and terminal strips shall be rated for service at 300 volts minimum. All terminal blocks and terminal strips shall be of the appropriate current rating for corresponding terminated circuits. All terminals of the terminal blocks and terminal strips shall be sized to accept corresponding terminated wire and cable conductor sizes (gauges). Resistance of the terminals shall not exceed 0.0002 ohms.

B. Unless otherwise specified, terminal blocks and terminal strips provided in junction boxes, equipment enclosures, system distribution frames, equipment cabinets, and termination facilities shall be of the modular, feed-through type mounted to a metal channel or be of the single molded construction barrier type.

C. Unless otherwise specified, the modular, feed-thru type terminal blocks and terminal strips shall have pressure clamp contact terminals suitable for solid and stranded wire. Appropriate sized

(length) continuous mounting channel shall be provided for each terminal block and terminal strip. Appropriate accessories (end sections, channel clamps, partitions, and mounting hardware) shall be provided for each terminal block and terminal strip. Disconnect apparatus (without removing wires) shall be provided in the terminal assemblies of those terminal blocks and terminal strips, which are utilized in conjunction with protector block assemblies, or otherwise specified within these Specifications.

D. The barrier type terminal blocks and terminal strips shall be constructed of molded fire-retardant thermoplastic with double row terminals. The terminals shall consist of binding head screws, with the two screws associated with each terminal electrically connected with a brass strip. Appropriate mounting hardware shall be provided for each terminal block and terminal strip.

2.25 PROTECTOR BLOCKS

A. Unless otherwise specified, each protector block shall be selected for the termination of two pairs (four conductors). The base of each protector block shall be constructed of molded fire-retardant thermoplastic and shall be equipped with four binding posts and four related screw-in arrester units. The four binding posts shall be connected internally to the corresponding arrester units. Each binding post shall be equipped with two nuts and four beveled washers. A ground plate shall be provided on the face of the base of each protector block between the arrester units. The arrester units shall be 2-electrode gas type and provide 400 Vdc fail-short protection.

B. Multiple protector blocks (two pair type) shall be provided and installed adjacent to each other (vertical rows) for the termination of multi-conductor cables containing more than two pairs.

C. Appropriate length brass or copper mounting and ground bar assemblies shall be provided for the installation and grounding of the protector blocks. Each mounting and ground bar assembly shall have a minimum of two binding posts with appropriate nuts and washers for the termination of ground wires. Appropriate hardware shall be provided to secure and ground the protector blocks to the mounting and ground bar assemblies. Appropriate mounting hardware shall be provided to install the mounting and ground bar assemblies.

D. Unless otherwise specified, all wires and cables that enter/exit the Communications Equipment Rooms of passenger stations and yards to/from the WMATA right-of-way shall be terminated on protector blocks in the Communications Equipment Room. All wires and cables that enter/exit equipment within the WMATA right-of-way and enter/exit remote ancillary buildings shall be terminated on protector blocks at the equipment and in the remote ancillary buildings. All wires and cables that enter/exit yard buildings and other special buildings shall be terminated on protector blocks in the yard buildings and special buildings. All wires and cable conductors (including spares) shall be terminated on protector blocks at each location. Coaxial cables and triaxial cables are exceptions.

2.26 FUSES AND CIRCUIT BREAKERS

A. All equipment shall be protected by fuses or circuit breakers of the appropriate size. Fuses and circuit breakers shall be readily accessible, surface mounted, on all equipment. Fuse wire within the equipment shall not be acceptable.

2.27 WIRES AND CABLES

A. Only continuously extruded outer jackets free of polyvinylchloride (PVC) and PVC-based compounds shall be furnished on cables provided in these Specifications. Exceptions may be allowed by the Contracting Officer Representative when such cable is not commercially obtainable only from equipment manufacturers, and when appropriate to avoid potential electrical signal mismatching, or to otherwise improve system performance or reliability.

B. All single conductor wire and individual conductors of multi-conductor cables shall be copper and shall be insulated.

C. Multi-conductor cable shall be made by assembling individual or twisted pairs of insulated conductors into a tight cylindrical form. Individual conductors or twisted pairs in a cable having more than two wires shall be assembled helically and with adjacent layers wound in opposite directions. Twisted pairs shall consist of two individually insulated conductor cables with a length of lay as short as good construction will permit, but not longer than 10 inches. Where more than one twisted pair is included, length of lay of adjacent pairs shall differ by at least 1/2 inch.

D. Unless otherwise specified, all multi-conductor cables installed within the WMATA right-of-way shall contain a metallic shield and a corrugated metallic tape armor. The shield and armor shall be separated by an inner jacket.

E. Multi-conductor cables containing more than two conductors shall contain 20 percent spare conductors, or two spare conductors (two spare pairs if composed of twisted pairs), whichever is greater.

2.28 HOOK-UP-WIRE

A. All wiring within electronic equipment selected, or wired by the Contractor shall have passed the Underwriters Laboratories VW-l Vertical Flame Test. The wire size shall be commensurate with the application.

B. All wires within electronic subassemblies and assemblies shall be identified by adequate color-coding, in accordance with best commercial practices.

2.29 GROUNDING

A. Communications systems and facilities, equipment and cables shall be grounded using a single-point grounding scheme. Each Communications Equipment Room will have a separate isolated ground bus bar, provided by others, designated as "communications ground."

B. Unless otherwise specified, the shields of all single shielded communications cables, the shields of multi-conductor cables that have individually shielded pairs, and the inner shield of all double shielded communications cables and communications cables with separate shield and armor, shall be grounded only at a single point and only to the "communications ground." These shields shall be electrically continuous throughout the cable length by bonding across all splices and terminations in equipment enclosures and junction boxes.

C. The outer shield of all double shielded communications cables and the armor of all communications cables with separate shield and armor shall be grounded only at a single point in each cable section. The single point ground shall be located at the end of the cable section nearest to the associated Communications Equipment Room. Cable sections originating at Communications Equipment Rooms shall have the outer shield or armor grounded to the "communications ground."

D. The Contract Drawings show details of the cable grounding scheme.

E. Equipment racks and equipment cabinets shall be electrically isolated from the building structure, adjacent equipment racks and equipment cabinets. Minimum resistance between adjacent equipment racks and equipment cabinets, and between equipment racks and equipment cabinets and the building structure, shall be 10 megohms. Each equipment rack and equipment cabinet shall be individually wired to the communications ground, via the copper ground bus bar on the equipment rack and equipment cabinet, by a No. 6 AWG, stranded, insulated wire, Type XHHW.

F. Each copper ground bus bar in the multi-section cable terminal housings of the MDF/Protector Cabinet and the systems distribution frames shall be wired to the communications ground by a No. 6 AWG, stranded, insulated wire, Type XHHW.

G. All power conductors shall be electrically insulated from equipment racks and equipment cabinets, and power ground shall be separate and isolated from communications ground. Conduit

containing power conductors running from ac distribution boxes to equipment racks, equipment cabinets, AC receptacle boxes on equipment racks and equipment cabinets shall be insulated from the equipment cabinet or equipment rack by means of short lengths of non-conducting conduit.

**PART 3 – EXECUTION**

3.1 INSTALLATION

A. Adjacent equipment racks and equipment cabinets shall have a 0.25-inch separation between upright members. They shall be mechanically secured to each other by 0.25-inch nylon bolts and spacers.

B. Adjacent equipment racks and equipment cabinets shall use rigid non-metallic conduit for interconnecting wiring.

END OF SECTION

# SECTION 16710

# COMMUNICATIONS GROUNDING

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for hardware and installation methods that the Contractor shall use to ensure the installation of a competent grounding system that will avoid/minimize ground-loops and Electromagnetic Interference (EMI) problems in the operation of the communications systems. In addition to the methods detailed in this Section, the Contractor shall ensure that its crews adhere to all generally accepted installation practices that are meant to minimize interference between communications systems.

B. Equipment and Rack Grounding.

C. Cable Shield Grounding.

1.2 RELATED REQUIREMENTS

A. Section 16705, COMMUNICATIONS STANDARD SPECIFICATIONS - EQUIPMENT AND MATERIAL.

B. Section 16706 - Communications System Submittals & Services

C. Section 16721 -Communications -Telephone System.

D. Section 16723 -Communications -Garage Emergency Telephone System.

E. Section 16727 -Communications -Passenger Emergency Reporting System.

F. Section 16731 -Communications -Fire and Intrusion Alarm System.

G. Section 16733 -Communications -Kiosk System.

H. Section 16771 -Communications - Carrier Transmission System.

I. Section 16776 -Communications - Fiber Optics System.

J. Section 16791 -Communications - Mobile Radio System.

K. Section 16820 -Communications - Public Address System.

L. Section 16821 -Communications - Automatic Public Address Announcement System.

M. Section 16851 -Communications - Closed Circuit Television System.

1.3 REFERENCES

A. NFPA 130 - Standard for Fixed Guideway Transit Systems

1.4 SUBMITTALS

A. Submit under provisions of Section 16706.

B. Shop Drawings: Indicate electrical system wiring diagram.

**PART 2 – PRODUCTS**

NOT USED

**PART 3 – EXECUTION**

3.1 INSTALLATION

A. Ground Communication system and facilities, equipment, and cables using a single-point grounding scheme. Each Communication Equipment Room shall have a separate isolated ground bus bar designated as “communications ground.”

B. Unless otherwise specified, ground the shields of all single shielded communications cables, the shields of multi-conductor cables that have individual shielded pairs, and the inner shield of all double shielded communications cables and communications cables with separate shield and armor only at a single point and only to the “communications ground.” These shields shall be electrically continuous throughout the cable length by bonding across all splices and terminations in equipment enclosures and junction boxes.

C. Ground the outer shield of all double-shielded communications cables and the armor of all communications cables with separate shield and armor only at a single point in each cable section. Locate the single point ground at the end of the cable section nearest to the associated Communications Equipment Room. Ground outer shield or armor Cable sections originating at Communications Equipment Rooms to the "communications ground."

D. Electrically isolate equipment racks and equipment cabinets from the building structure, adjacent equipment racks, and equipment cabinets. Minimum resistance between adjacent equipment racks and equipment cabinets and between equipment racks and equipment cabinets and the building structure, shall be 10 megohms. Individually wire each equipment rack and equipment cabinet to the communications ground, via the copper ground bus bar on the equipment rack and equipment cabinet, by a No. 6 AWG, stranded, insulated wire, Type XHHW.

E. Wire each copper ground bus bar in the multi-section cable terminal housings of the Main Distribution Frame (MDF)/ MDF/Protector Cabinet and the systems distribution frames to the communications ground by a No. 6 AWG, stranded, insulated wire, Type XHHW.

F. Electrically insulate all power conductors from equipment racks and equipment cabinets with a separate power ground isolated from communications ground. Insulate Conduit containing power conductors running from AC distribution boxes to equipment racks, equipment cabinets, AC receptacle boxes on equipment racks and equipment cabinets from the equipment cabinet or equipment rack by means of short lengths of non-conducting conduit.

END OF SECTION