WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

Invitation For Bid

[Federal]

Electrical and Data Cable Installation

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Volume 2 – TECHNICAL SPECIFICATIONS

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ELECTRICAL AND DATA CABLE INSTALLATION

TECHNICAL SPECIFICATIONS

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PART 2. WMATA IT-NCS DESIGN AND WIRING STANDARDS

IT-NCS Infrastructure Design and Wiring Standards rev 1.2 May 2014

SECTION 02220

DEMOLITION

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies demolition work.

1. Related Work Specified Elsewhere:
2. Clearing, grubbing, removal and protection of trees and shrubs: Section 02230.
3. Removal of concrete and masonry walls and foundations 12 inches below existing grade: Section 02320.
4. Removal and restoration of miscellaneous facilities: Section 02205.

B. Definitions:
1. Demolition: Complete removal and disposal of existing facilities from areas to be cleared and grubbed and from other areas shown.
2. Existing facilities include, but are not restricted to, buildings, sheds, streetcar tracks, pavements, sidewalks, curbs and gutters, signs, posts, fences, drainage, sewage and other utility facilities located in the area to be cleared and grubbed.
3. Salvage: Section 02205.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements 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. Permits and releases from each owner of property where demolition debris will be deposited absolving the Authority of responsibility in connection with such disposal.

1.03 QUALITY ASSURANCE:

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

1.04 JOB CONDITIONS:

A. Buildings:
1. Demolish buildings in place.

B. 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.

C. Maintenance of Traffic:
   1. 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.
   2. Bridge cuts in traffic areas with steel plates or by other approved means.
   3. Keep traffic areas free from debris and spillage of materials.
   4. 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.

D. 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.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 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.

3.02 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 four cubic feet in volume or, where approved, punch holes of not less than one-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 no one of which exceeds eight 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 Engineer may waive the requirement to fill cellar voids where cellar structures will be subsequently excavated for construction.

3.03 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. 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.
2. Known locations of streetcar tracks are shown.
3. Remove streetcar tracks as necessitated by the work and as directed, whether tracks are shown or encountered during excavation.
4. Transport from the site removed or excavated track accessories or parts thereof which will become the property of the Contractor.
5. Methods of removal and disposal will 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 six-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.

3.04 DISPOSAL:

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

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 debris at demolition site.

END OF SECTION

SECTION 04050

MORTAR, GROUT AND MASONRY ACCESSORIES

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies furnishing mortar, grout, and accessories for masonry work, including brick masonry, concrete unit masonry, granite and other stone masonry. The installation of such material is specified in the various masonry sections.

B. Related Work Specified Elsewhere:
1. Brick masonry: Section 04215.
2. Concrete unit masonry: Section 04220.
3. Granite: Section 04415.
4. Seals and sealants: Section 07900.
5. Flashing and sheetmetal: Section 07600.
6. Miscellaneous metals: Section 05500.
7. Concrete formwork: Section 03100.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings:
   a. Manufacturer's data: Recommendations for use of materials, preparation of substrate, limitations and special instructions for materials necessary to the work.
   b. Granite: Section 04415.
2. Samples:
   a. Three of each type of the following products used in the work:
      1) Mortars: Cured samples showing color of each type.
      2) Accessories: Representative samples of each type.
      3) Certification.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. ASTM: A36, A82, A153, A276, A666, A775, C114, C144, C150, C207, C270, C476, C665, C780, C881, C1019, D570, D638, D695, D1525, D2000, D2240, F593, F594.
3. FS: HH-I-521.

B. Source Quality Control:
1. Obtain mortar ingredients of a uniform quality, including color for exposed masonry, from one manufacturer for each cementitious component and from one source or producer for each aggregate.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Deliver products to job site in their original unopened containers clearly labeled with manufacturer's name and brand designation, referenced specification number, type and class as applicable.

B. Store products so as to prevent water intrusion, dampness and deterioration. Store loose materials sand and aggregates so as to prevent intrusion of foreign materials.

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

1.05 JOB CONDITIONS:

A. Environmental Requirements:
1. Do not use materials or aggregates that are covered with frost. Do not mix mortar when the temperature is below that specified for masonry work.
2. Provide protective covering and heat as specified for masonry work.
3. Perform work under environmental conditions consistent with manufacturer's recommendations for materials being used in the work.

PART 2 - PRODUCTS

2.01 MORTAR AND GROUT MATERIALS:

A. Cement:
1. ASTM C150, Type I, portland cement, packaged in one-cubic-foot waterproof bags.
   a. For exterior walls, use low alkali cement; maximum 0.60 percent total alkali when tested according to ASTM C114.
   b. For below grade use type II cement and lime.
2. Cement for brick masonry:
   a. Factory-prepared, color-blended with nonstaining, inorganic coloring pigment.
   b. Pigments not to exceed 10 percent of weight of cement.
   c. Pigment blended in such quantity to produce cured mortar color matching face brick when mixed with hydrated lime and fine aggregate.

B. Hydrated Lime:
1. ASTM C207, Type S.
2. Uniform color for similar work.

C. Fine Aggregate: Clean, sharp, masonry sand, ASTM C144. For joints less than 1/4 inch, grade aggregate with 100 percent passing the Number 16 sieve.

D. Water: Potable.

E. Pigment: As necessary to produce colored mortar matching color of brick unless otherwise indicated.

F. Admixtures: Do not add admixtures including air-entraining agents, accelerators, retarders, water repellent agents, antifreeze compounds, or other admixtures unless otherwise indicated.

G. Epoxy for Epoxy Mortar: Two-component, ASTM C881, Type 3, Grade 3, Class C, with the following additional requirements:
1. Component A: Modified-epoxy resin of epichlorohydrin bisphenol A-type, containing suitable viscosity control agents and having epoxide equivalent of 180-200.
2. Component B: Primarily reaction product of aromatic amine and an aliphatic amine with epoxy resin of epichlorohydrin bisphenol A-type.
3. Ratio of Component A to Component B: By volume, 1:2.
4. Properties of mixed components:
   a. Solids content: 100 percent by weight.

b. Pot life: 20 to 30 minutes at 73F.
c. Tack-free time, thin film: Two to four hours at 73F.
d. Final cure, 75-percent ultimate strength, ASTM D695: Two days at 73F.
e. Initial viscosity, A plus B: 250 to 350 cps at 73F.

5. Properties of cured material:
   a. Tensile strength, ASTM D638: 5,000-psi minimum at 14 days, 73F cure.
   b. Tensile elongation, ASTM D638 modified: One to three percent at 14 days, 73F cure.
   c. Compressive strength, ASTM D695: 10,500-psi minimum at 28 days, 73F cure.
   d. Water absorption, ASTM D570: One-percent maximum.
   e. Bond strength: 2,000-psi minimum at 14 days.
   f. Hardened to hardened: 73F cure.
   g. Vicat softening temperature, ASTM D1525: 121F minimum.

H. Aggregate for Epoxy Mortar: Silica sand, Size 20 to Size 40, dust-free and moisture-free.

2.02 MORTAR AND GROUT MIXES:

A. Mortar Mixes for Brick Masonry: ASTM C270, types as follows:
1. Type S: For exterior loadbearing masonry and for masonry in contact with earth, proportioned by volume as follows:
   a. Portland cement: One part.
   b. Hydrated lime: 1/4 to 1/2 part.
   c. Fine aggregate: Not less than 2-1/2 nor more than three times sum of volumes of cement and lime.
   d. Pigment: As necessary to produce colored mortar matching color of brick unless otherwise indicated.
2. Type N: For interior non loadbearing masonry, proportioned by volume as specified for Type S, except 1/2 to 1-1/4 parts hydrated lime.
3. Color: As shown or as selected by the Engineer.

B. Mortar Mixes for Concrete Unit Masonry: As specified for brick masonry, except pigment not required.

C. Mortar Mixes for Granite Setting Bed:
1. Granite, except paving, apron at pylons, platform edging, stair treads and landings: Nonstaining mortar composed of one-part portland cement and one-part plastic lime hydrate to four or five parts fine aggregate, ASTM C270, Type N. Pointing mortar of same composition, colored to matched granite.
2. Granite paving and granite apron at pylons: Nonstaining mortar composed of one-part portland cement to no more than four parts natural sand. For pointing use specified preshrunk mortar.
3. Stair treads and landings: Epoxy mortar consisting of one-part epoxy to 3-1/4 parts of aggregate by loose volume.
4. Platform edging: Epoxy mortar consisting of one-part epoxy to 1-1/2 parts of aggregate by loose volume.

D. Grout: For setting steel lintels and similar items, grouting mortar composed of one-part portland cement and two parts fine aggregate with sufficient lime putty added to obtain quick set.

E. Preshrunk Mortar: Dry, premixed, ready-to-use formulation.

2.03 ACCESSORIES:

A. Continuous joint reinforcement:
   1. Accessories for Brick and Concrete Unit Masonry:
      a. Prefabricated continuous-reinforcing tie system fabricated of wire conforming to ASTM A82. Flush-welded cross ties, nine-gauge wire, hot-dip galvanized after fabrication in accordance with ASTM A153, Class B2, 1.50 ounces for side and cross rods.
      b. Fabricate joint reinforcement in straight lengths of not less than 10 feet of truss design with continuous diagonal cross ties spaced maximum 16 inches o.c.
         1) Make width of unit 1-1/2 inches to two inches less than thickness of wall.
         2) For multi-wythe wall, provide one side rod for each face shell of masonry more than four inches in width; plus one side rod for each wythe of masonry four inches or less in width.
         3) At cavity walls, provide integral drips on cross rods.Where horizontal joints of outer wythe does not align with back-up joints, provide adjustable two-piece tab design to engage the outer wythe by at least 1-1/2 inches.
      c. Corner reinforcement: Prefabricated, shop-welded corner-L and intersection-T units matching the continuous wall units.
      d. Spacing: See related work sections.
   2. Dovetail anchors:
      a. Flexible, adjustable or corrugated 1-inch wide dovetail anchors of 12 gauge galvanized steel. Place anchors every 16 inches in height of wall at intersections of masonry walls and concrete, and for masonry furring of concrete. Dovetail slots are specified in Section 03100, by same manufacturer of anchors.
   3. Wall plugs:
      a. Galvanized 26-gauge corrugated metal, approximately three inches long and of standard manufacture, where necessary for attaching other work.
   4. Z-type rigid-steel anchors: Steel, ASTM A36, 1/4-inch thick by 1-1/2 inches wide by 28 inches long, galvanized; with one two-inch opposing 90-degree bend at each end.
   5. Corrugated-steel anchors: 14 gauge by 1-1/4 inches by 20 inches with one two-inch 90-degree bend, with 18 inches of corrugation.
   6. Steel framing anchors: Fabricated of 3/16-inch galvanized wire tie and galvanized flat-steel strap one-inch wide by 22 gauge or 3/4-inch wide by 12 gauge.
   7. Weep-hole tubes: 3/8-inch OD, medium density, nonstaining, polyethylene tubes of lengths ensuring complete panel penetration and unobstructed flow.Fire-resistant compressible filler: Inorganic, non-asbestos mineral fiber safing insulation, with foil facing to impede smoke passage; moisture resistant, mildew-proof and vermin-proof, noncorrosive and nondeteriorating; UL-listed; meeting ASTM C665 and FS HH-I-521 Type III, except for identification marking.
   8. Control joint gasket: Solid styrene-butadiene-rubber compound per ASTM D2000, 2AA-805, factory extruded into shapes for use with standard sashblock to provide stability to masonry walls at expansion and control joints; minimum shear strength 540 psi, durometer hardness 80 (plus or minus 5) per ASTM D2240. Provide T-shape and X-shape for vertical joints as appropriate, flat shape beneath load-relieving angles.
   9. Cavity Drainage System: 1 inch thick by 10 inches high by 5 feet long section of high density polyethylene or nylon mesh designed to allow moisture to flow downward in cavity joint.
   10. Masonry Cell Insulation: Molded polystyrene Insulation Units - Rigid, cellular thermal insulation formed by the expansion of polystyrene - resin beads or granules in a closed mold to comply with ASTM 578, Type I. Provide specially shaped units designed for installing in cores of masonry units.

B. Accessories for Granite:
   1. Stainless steel, ASTM A276 or A666, Type 304, for anchors, cramps, angles, dowels, plates, bolts or other accessories in contact with stone.
   2. Anchor sizes:
      a. Anchors with dowels: 3/16 inch by one inch in cross section.
      b. Two-way anchors: 1/8 inch by two inches in cross section.
      c. One-way anchors: 1/8 inch by one inch in cross section.
      d. Anchors to stone: Anchors of necessary length and of type that turn into stone minimum of 1/2 inch.
      e. Anchors to concrete: Heavy-duty sleeve style or wedge-type anchors with 3,000-pound hold-fast strength or anchors suitable for use with dovetail slots.
      f. Lewis anchors for lifting stones: 3/4 inch in diameter.
      g. Other anchors: Sizes as shown on approved shop drawings.
      h. Fasteners for Stainless-Steel Anchors: Annealed stainless-steel bolts, nuts, and washers; ASTM F593 for bolts and ASTM F594 for nuts.
      i. Setting Shims: Strips of vulcanized neoprene, 50 to 70 Shore A durometer, nonstaining to stone, sized to suit joint thicknesses and depths of stone supports without intruding into required depths of joint sealants or causing third-side adhesion between sealant and setting shims.
      j. Weep and Vent Tubes: Medium-density polyethylene tubing, 1/4-inch OD and of length required to extend from exterior face of stone to cavity behind.
   3. Sizes for other accessories:
      a. Dowels: Minimum of 1/2 inch in diameter, designed to extend two inches into stone and two inches into concrete.
      b. Cramps: 1/8-inch by one-inch plate with 3/8-inch dowels at each end designed to extend into stone and concrete a minimum of one inch.
      c. Angles, plates, and bolts: Sizes as shown on approved shop drawings.

C. Steel lintels: Section 05500.

D. Masonry lintels: Section 04220.

E. Flashing: Section 07600.

PART 3 - EXECUTION

3.01 MIXING OF MORTAR:

A. Mix mortar materials in an approved clean mechanical mixer for at least three minutes and not more than five minutes with a minimum amount of water to produce workable consistency.

B. Mortar which has stiffened because of evaporation of water may be retempered by adding water as needed to restore necessary consistency. Use mortar within 2-1/2 hours of initial mixing.

C. Use an approved method of measuring materials and mortar that will control and accurately maintain specified proportions throughout the work. Shovel measure is prohibited. Measure sand in damp, loose condition.

D. Apply pre-shrunk mortar in accordance with the manufacturer's instructions.

E. For alteration and restoration work, tint or modify mix to match mortar of existing masonry.

F. The Engineer may direct a test of the mortar in accordance with ASTM C780 and a test of the grout for compressive strength per ASTM C1019 to establish compliance with specified requirements.

END OF SECTION

SECTION 07841
FIRESTOPPING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This Section 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

B. Related Work Specified Elsewhere:
   1. Cast-in-Place Structural Concrete: Section 03300 for construction of openings in concrete slabs and walls.
   2. Division 15 Sections specifying duct and piping penetrations.
   3. Division 16 Sections specifying cable and conduit penetrations.

1.02 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.

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B. F-Rated Systems: Provide through-penetration firestop systems with F-ratings indicated, as determined per 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 per 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 outside fire-resistive shaft enclosures.
   3. Penetrations located in construction containing fire-protection-rated openings.
   4. Penetrating items larger than 4-inch diameter nominal pipe or 16 sq. in. in overall cross-sectional area.

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 for plumbing and wet-pipe sprinkler systems, 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.

3. For penetrations involving insulated piping, provide through-penetration firestop systems not requiring removal of insulation.

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.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the Special Conditions 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.

1.04 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. ASTM E 84, E 814.
3. UL - 1479.

B. 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.

C. Source Limitations: Obtain through-penetration firestop systems, for each kind of penetration and construction condition indicated, from a single manufacturer.

D. 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 per 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 designations listed by the following:

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1.05 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.

1.06 PROJECT 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 per manufacturer's written instructions by natural means or, where this is inadequate, forced-air circulation.

1.07 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.

C. Do not cover up through-penetration firestop system installations that will become concealed behind other construction until the Engineer has examined each installation.

PART 2 - PRODUCTS

2.01 FIRESTOPPING, GENERAL:

A. Compatibility: Provide through-penetration firestop systems that are compatible with one another, with the substrates forming openings, and with the items, if any, penetrating through-penetration firestop systems, under conditions of service and application, as demonstrated by through-penetration firestop system manufacturer based on testing and field experience.

B. Accessories: Provide components for each through-penetration firestop system that are needed to install fill materials and to comply with "Performance Requirements" Article. Use only components specified by through-penetration firestop system manufacturer and approved by the qualified testing and inspecting agency for firestop systems indicated. Accessories include, but are not limited to, the following items:
   1. Permanent forming/damming/backing materials, including the following:
      a. Slag-/rock-wool-fiber insulation.
      b. Sealants used in combination with other forming/damming/backing materials to prevent leakage of fill materials in liquid state.
      c. Fire-rated form board.
      d. Fillers for sealants.
   2. Temporary forming materials.

3. Substrate primers.
4. Collars.
5. Steel sleeves.

2.02 FILL MATERIALS:

A. General: Provide through-penetration firestop systems containing the types of fill materials indicated in the Through-Penetration Firestop System Schedule at the end of Part 3 by reference to the types of materials described in this Article. Fill materials are those referred to in directories of the referenced testing and inspecting agencies as fill, void, or cavity materials.

B. Cast-in-Place Firestop Devices: Factory-assembled devices for use in cast-in-place concrete floors and consisting of an outer metallic sleeve lined with an intumescent strip, a radial extended flange attached to one end of the sleeve for fastening to concrete formwork, and a neoprene gasket.

C. Latex Sealants: Single-component latex formulations that after cure do not re-emulsify during exposure to moisture

D. Firestop Devices: Factory-assembled collars formed from galvanized steel and lined with intumescent material sized to fit specific diameter of penetrant.

E. Intumescent Composite Sheets: Rigid panels consisting of aluminum-foil-faced elastomeric sheet bonded to galvanized steel sheet.

F. Intumescent Putties: Nonhardening dielectric, water-resistant putties containing no solvents, inorganic fibers, or silicone compounds.

G. Intumescent Wrap Strips: Single-component intumescent elastomeric sheets with aluminum foil on one side.

H. Mortars: Prepackaged, dry mixes consisting of a blend of inorganic binders, hydraulic cement, fillers, and lightweight aggregate formulated for mixing with water at Project site to form a nonshrinking, homogeneous mortar.

I. Pillows/Bags: Reusable, heat-expanding pillows/bags consisting of glass-fiber cloth cases filled with a combination of mineral-fiber, water-insoluble expansion agents and fire-retardant additives.

J. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

K. Silicone Sealants: Moisture-curing, single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below:
   1. Grade for Horizontal Surfaces: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces.
   2. Grade for Vertical Surfaces: Nonsag formulation for openings in vertical and other surfaces.

2.03 PERIMETER FIRE-CONTAINMENT SYSTEMS:

A. Where indicated for gaps between the perimeter edge of fire-resistance-rated floor assemblies and non-fire-resistance-rated exterior curtain walls, provide a perimeter fire-containment system with the fire-test response characteristics indicated, as determined by

testing identical systems per UBC Standard 26-9 and UL 2079 by UL or another testing and inspecting agency acceptable to authorities having jurisdiction. Materials shall be identified with appropriate markings of applicable testing and inspecting agency.

PART 3 - EXECUTION

3.01 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.

3.02 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.

3.03 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 to achieve 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.

3.04 FIELD QUALITY CONTROL:

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

3.05 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."

3.06 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.

3.07 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 Insulated Pipes: Comply with the following:
1. UL- 1479: CAJ 5087.
2. Type of Fill Materials: Intumescent putty.

D. Firestop Systems for Miscellaneous Mechanical Penetrations: Comply with the following:
1. UL- 1479: CAS 8033.
2. Type of Fill Materials: Mortar.

E. Firestop Systems for Ductwork: Comply with the following:
1. UL- 1479: WJ7007.
2. Type of Fill Materials: Intumescent sealant.

END OF SECTION

SECTION 09320

TILE

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing ceramic tile, ceramic mosaic tile, quarry tile and marble thresholds, typically in restricted areas as shown.

B. Related Work Specified Elsewhere:
   1. Cast-in-Place Structural Concrete: Section 03300.
   2. Seals and Sealants: Section 07900.
   3. Paver Tile: Section 09340.

1.02 PERFORMANCE REQUIREMENTS:

A. Static Coefficient of Friction: For tile installed on walkway surfaces, provide products with the following values as determined by testing identical products per ASTM C1028:
   1. Level Surfaces: Minimum 0.6.
   2. Ramp Surfaces (slope grater than 1:20): Minimum 0.8.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Product Data: For each type of tile, mortar, grout, and other products specified. Include recommendations for product application and use.
   2. Shop Drawings: For the following:
      a. Tile patterns and locations.
      b. Widths, details, and locations of expansion, contraction, control, and isolation joints in tile substrates and finished tile surfaces.
   3. Tile Samples for Initial Selection: Manufacturer's color charts consisting of actual tiles or sections of tiles showing the full range of colors, textures, and patterns available for each type and composition of tile indicated. Include Samples of accessories involving color selection.
   4. Grout Samples for Initial Selection: Manufacturer's color charts consisting of actual sections of grout showing the full range of colors available for each type of grout indicated.
   5. Samples for Verification: Of each item listed below, prepared on Samples of size and construction indicated. Where products involve normal color and texture variations, include Sample sets showing the full range of variations expected.
      a. Ceramic and Ceramic Mosaic Tile: Three panels of each type and composition of tile and for each color and texture required, 12 inches square, mounted on 16 inches square by 1/4-inch thick hardboard with grouted joints using product complying with specified requirements and approved for completed work in color or colors selected by the Engineer.
      b. Full-size units of each type of trim and accessory for each color required.
      c. Quarry Tile: Four standard size units mounted on 16 inches square by 1/4-inch thick hardboard with grouted joints using product complying with specified requirements and approved for completed work in color or colors selected by the Engineer.
      d. Marble Threshold: Three 12-inch lengths showing range of color, veining and finish.

6. Master Grade Certificates: For each shipment, type, and composition of tile, per ANSI A137.1, bearing TCA-Certification Mark, signed by tile manufacturer and Installer stating type and quality of material. Submit at time of shipment..
7. Product Certificates: Signed by manufacturers certifying that the products furnished comply with requirements.
8. Tile Test Reports: Certified test reports in accordance with ANSI A118.1 through A118.4.

1.04 QUALITY ASSURANCE:

A. Codes Regulations, Reference Standards and Specifications:
1. Comply with the codes and regulations of the jurisdictional authorities.
2. ADA: Americans with Disabilities Act.
3. ANSI: A108.1C, A108.5, A108.6, A108.10, A118.1, A118.2, A118.3, A118.4, A118.6, A137.1.
4. ASTM: A82, A185, C144, C150, C206, C207, C241, C503, C920, C1028, D4397.
5. FS: UU-B-790.
6. TCA: Handbook for Ceramic Tile Installation.

B. Installer Qualifications: Engage an experienced installer who has completed tile installations similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.

C. Source Limitations for Tile: Obtain each color, grade, finish, type, composition, and variety of tile from one source with resources to provide products from the same production run for each contiguous area of consistent quality in appearance and physical properties without delaying the Work.

D. Source Limitations for Setting and Grouting Materials: Obtain ingredients of a uniform quality for each mortar, adhesive, and grout component from a single manufacturer and each aggregate from one source or producer.

E. Mockups: Before installing floor and wall tile, construct mockups for each form of construction and finish required to verify selections made under Sample submittals and to demonstrate aesthetic effects and qualities of materials and execution. Build mockups to comply with the following requirements, using materials indicated for completed Work.
1. Mockups shall be minimum four feet square and in the location as directed by the Engineer.
2. Notify the Engineer seven days in advance of the dates and times when mockups will be constructed.
3. Demonstrate the proposed range of aesthetic effects and workmanship.
4. Obtain the Engineer's approval of mockups before proceeding with final unit of Work.
5. Approved mockups may become part of the completed Work.

1.05 DELIVERY, STORAGE, AND HANDLING:

A. Deliver materials to the site in original unopened containers, clearly labeled with the manufacturer’s name, brand designation, type, grade and color. Comply with requirement of ANSI A137.1 for labeling sealed tile packages.

B. Store materials so as to prevent damage or contamination to materials by water, freezing, foreign matter, and other causes.

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

1.06 PROJECT CONDITIONS:

A. Environmental Limitations: Do not start tile work unless ambient temperature of area in which work occurs is at least 50 deg. F and rising and is maintained at not less than 50 deg. F without interruption while work is being done and for at least 72 hours after completion.

B. Substrate Conditions: Do not start tile work unless surfaces to receive tile are in satisfactory condition. Commencement of tile work constitutes Contractor's acceptance of the subfloor condition in accordance with ANSI A108-AN-2, General Requirements for Subsurfaces.

1.07 EXTRA MATERIALS:

A. Deliver extra materials to Owner. Furnish and store extra materials in locations as directed on pallets and in original containers with protective covering for storage, and are clearly identified with labels describing contents and area of placement.
   1. Tile and Trim Units: Furnish quantity of full-size units equal to 5 percent of amount installed, for each type, composition, color, pattern, and size indicated.

PART 2 - PRODUCTS

2.01 PRODUCTS, GENERAL:

A. ANSI Ceramic Tile Standard: Provide tile that complies with ANSI A137.1, "Specifications for Ceramic Tile," for types, compositions, and other characteristics indicated.
   1. Provide tile complying with Standard Grade requirements, unless otherwise indicated.

B. ANSI Standards for Tile Installation Materials: Provide materials complying with ANSI standards referenced in "Setting and Grouting Materials" article.

C. Colors, Textures, and Patterns: Where manufacturer's standard products are indicated for tile, grout, and other products requiring selection of colors, surface textures, patterns, and other appearance characteristics, provide specific products or materials complying with the following requirements:
   1. Provide Engineer's selections from manufacturer's full range of colors, textures, and patterns for products of type indicated.
   2. Provide tile trim and accessories that match color and finish of adjoining flat tile.

D. Factory Blending: For tile exhibiting color variations within the ranges selected during Sample submittals, blend tile in the factory and package so tile units taken from one package show the same range in colors as those taken from other packages and match approved Samples.

2.02 TILE PRODUCTS:

A. Unglazed Ceramic Mosaic Floor Tile: Provide factory-mounted flat tile complying with the following requirements:
   1. Composition: Porcelain or porcelain with abrasive admixture, as indicated.
   2. Module Size: 2 by 2 inches (nominal).
   3. Nominal Thickness: 1/4 inch.
   4. Face: Plain with cushion edges.

B. Unglazed Quarry Tile: Provide square-edged flat tile complying with the following requirements:

1. Wearing Surface: Nonabrasive or abrasive aggregate embedded in surface, as indicated.
2. Facial Dimensions: 6 by 6 inches (nominal).
3. Thickness: 1/2 inch.
4. Face: Plain.

C. Glazed Wall Tile: Provide flat tile complying with the following requirements:
1. Module Size: 4-1/4 by 4-1/4 inches.
2. Thickness: 5/16 inch.
3. Face: Plain with cushion edges.
4. Color: White.

D. Trim Units: Provide tile trim units to match characteristics of adjoining flat tile and to comply with the following requirements:
1. Size: As indicated, coordinated with sizes and coursing of adjoining flat tile where applicable.
2. Shapes: As follows, selected from manufacturer's standard shapes:
a. Base for Thin-Set Mortar Installations: Straight.
b. External Corners for Thin-Set Mortar Installations: Surface bullnose.
c. Internal Corners: Field-butted square corners, except with coved base and cap angle pieces designed to member with stretcher shapes.

2.03 STONE THRESHOLDS:

A. General: Provide stone thresholds that are uniform in color and finish, fabricated to sizes and profiles indicated to provide transition between tile surfaces and adjoining finished floor surfaces.
1. Fabricate thresholds to heights indicated, but not more than ½-inch above adjoining finished floor surfaces, with transition edges beveled on a slope of no greater than 1:2.

B. Marble Thresholds: Provide marble thresholds complying with ASTM C503 requirements for exterior use and with a minimum abrasive-hardness value (Ha) of 10 per ASTM C241.
1. Provide white, honed marble complying with the Marble Institute of America's Group A requirements for soundness.

2.04 SETTING AND GROUTING MATERIALS:

A. Portland Cement: ASTMC150, Type I.

B. Sand: ASTM C144.

C. Hydrated Lime: ASTM C206 or ASTM C207, Type S.

D. Water: Potable.

E. Portland Cement Mortar Installation Materials: Provide materials complying with ANSI A108.1A and as specified below:
1. Cleavage Membrane: Polyethylene sheeting ASTM D4397, 4.0 mils thick.
2. Reinforcing Wire Fabric: Galvanized, welded wire fabric, 2 by 2 inches by 0.062-inch diameter; comply with ASTM A185 and ASTM A82, except for minimum wire size.

F. Dry-Set Portland Cement Mortar: ANSI A118.1.

G. Chemical-Resistant, Water-Cleanable, Ceramic Tile-Setting and -Grouting Epoxy: ANSI A118.3.
   1. Provide product capable of resisting continuous and intermittent exposure to temperatures of up to 140 deg F and 212 deg F, respectively, as certified by mortar manufacturer for intended use.

H. Sand-Portland Cement Grout: ANSI A108.10, composed of white or gray cement and white or colored aggregate as required to produce color indicated.

I. Dry-Set Grout: ANSI A118.6, color as indicated.

J. Chemical-Resistant Epoxy Grout: ANSI A118.3, color as indicated.
   1. Provide product capable of resisting continuous and intermittent exposure to temperatures of up to 140 deg F and 212 deg F, respectively, as certified by mortar manufacturer for intended use.

2.05 ELASTOMERIC SEALANTS AND BACKUP JOINT FILLER:

A. General: Provide manufacturer's standard chemically curing, elastomeric sealants of base polymer and characteristics indicated that comply with applicable requirements of Section 07900.

B. Colors: Provide colors of exposed sealants to match colors of grout in tile adjoining sealed joints, unless otherwise indicated.

C. One-Part, Mildew-Resistant Silicone Sealant: ASTM C920; Type S; Grade NS; Class 25; Uses NT, G, A, and, as applicable to nonporous joint substrates indicated, O; formulated with fungicide, intended for sealing interior ceramic tile joints and other nonporous substrates that are subject to in-service exposures of high humidity and temperature extremes.

D. Multipart, Pourable Urethane Sealant for Use T: ASTM C920; Type M; Grade P; Class 25; Uses T, M, A, and, as applicable to joint substrates indicated, O.

E. Backup Material: As recommended by sealant manufacturer and as required in Section 07900.

F. Prime and Joint Cleaner: Use products as recommended by sealant manufacturer.

2.06 MISCELLANEOUS MATERIALS:

A. Trowelable Underlayments and Patching Compounds: Latex-modified, portland-cement-based formulation provided or approved by manufacturer of tile-setting materials for installations indicated.

B. Concrete Leveling Bed: In accordance with Section 03300, Class 3500 concrete, pea gravel course aggregate 1/4-inch minimum to 3/8-inch maximum. Adjust slump with plasticizers to maintain proper water-cement ratio.

C. Building Paper: FS UU-B-790, red-rosin-sized building, Type I, Style 1B.

D. Tile Cleaner: A neutral cleaner capable of removing soil and residue without harming tile and grout surfaces, specifically approved for materials and installations indicated by tile and grout manufacturers.

2.07 MIXING MORTARS AND GROUT:

A. Mix mortars and grouts to comply with referenced standards and mortar and grout manufacturers' written instructions.

B. Add materials, water, and additives in accurate proportions.

C. Obtain and use type of mixing equipment, mixer speeds, mixing containers, mixing time, and other procedures to produce mortars and grouts of uniform quality with optimum performance characteristics for installations indicated.

PART 3 - EXECUTION

3.01 EXAMINATION:

A. Examine substrates, areas, and conditions where tile will be installed, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of installed tile.
   1. Verify that substrates for setting tile are firm; dry; clean; free from oil, waxy films, and curing compounds; and within flatness tolerances required by referenced ANSI A108 series of tile installation standards for installations indicated.
   2. Verify that installation of grounds, anchors, recessed frames, electrical and mechanical units of work, and similar items located in or behind tile has been completed before installing tile.
   3. Verify that joints and cracks in tile substrates are coordinated with tile joint locations; if not coordinated, adjust latter in consultation with the Engineer.

B. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.02 PREPARATION:

A. Remove coatings, including curing compounds, and other substances that contain soap, wax, oil, or silicone and are incompatible with tile-setting materials by using a terrazzo or concrete grinder, a drum sander, or a polishing machine equipped with a heavy-duty wire brush.

B. Provide concrete substrates for tile floors installed with dry-set or latex-portland cement mortars that comply with flatness tolerances specified in referenced ANSI A108 series of tile installation standards for installations indicated.
   1. Use trowelable leveling and patching compounds per tile-setting material manufacturer's written instructions to fill cracks, holes, and depressions.
   2. Remove protrusions, bumps, and ridges by sanding or grinding.

C. Provide leveling course for masonry or concrete-wall when variation exceeds 1/4-inch in eight feet. Leveling course shall consist of dry-set mortar to which an equal volume of a mixture of one-part portland cement and 1-1/2 parts sand has been added. Apply leveling course to maximum thickness of 1/4-inch.

D. Blending: For tile exhibiting color variations within the ranges selected during Sample submittals, verify that tile has been blended in the factory and packaged so tile units taken from one package show the same range in colors as those taken from other packages and match approved Samples. If not factory blended, either return to manufacturer or blend tiles at Project site before installing.

3.03 INSTALLATION, GENERAL:

A. ANSI Tile Installation Standards: Comply with parts of ANSI A108 series of tile installation standards in "Specifications for Installation of Ceramic Tile" that apply to types of setting and grouting materials and to methods indicated in ceramic tile installation schedules.

B. TCA Installation Guidelines: TCA's "Handbook for Ceramic Tile Installation." Comply with TCA installation methods indicated in ceramic tile installation schedules.

C. Coordinate tile work with work of other trades.

D. Extend tile work into recesses and under or behind equipment and fixtures to form a complete covering without interruptions, unless otherwise indicated. Terminate work neatly at obstructions, edges, and corners without disrupting pattern or joint alignments.

E. Accurately form intersections and returns. Perform cutting and drilling of tile without marring visible surfaces. Carefully grind cut edges of tile abutting trim, finish, or built-in items for straight aligned joints. Fit tile closely to electrical outlets, piping, fixtures, and other penetrations so plates, collars, or covers overlap tile.

F. Jointing Pattern: Lay tile in grid pattern, unless otherwise indicated. Align joints when adjoining tiles on floor, base, walls, and trim are the same size. Lay out tile work and center tile fields in both directions in each space or on each wall area. Adjust to minimize tile cutting. Provide uniform joint widths, unless otherwise indicated.
   1. For tile mounted in sheets, use plastic spacers to make joints between tile sheets the same width as joints within tile sheets so joints between sheets are not apparent in finished work.

3.04 FLOOR TILE INSTALLATION:

A. General: Install floor tile by the portland cement mortar method in accordance with ANSI A108.1C.

B. Tile Type: Unglazed ceramic mosaic tile and quarry tile.

C. Setting Bed and Grout: ANSI A108.1C with the following mortar and grout:
   1. Dry-set portland cement mortar.
   2. Dry-set grout.

D. Joint Widths: Install tile on floors joint widths as recommended by the tile manufacturer.

E. Grout: Dry-set grout in accordance with ANSI A108.10.

F. Where depression is not provided for mortar setting bed, install floor tile by the epoxy method in accordance with ANSI A108.6.

3.05 WALL TILE INSTALLATION:

A. General: Install wall tile by the dry-set mortar method in accordance with ANSI A108.5.

B. Tile Type: Glazed wall tile.

C. Setting Bed and Grout: ANSI A108.5 with the following mortar and grout:
   1. Dry-set portland cement mortar.
   2. Dry-set grout.

D. Joint Widths: Install tile on floors joint widths as recommended by the tile manufacturer.

E. Grout: Dry-set grout in accordance with ANSI A108.10.

F. Where inside corners are shown as flat tiles, make corner joint a sealant joint as specified for expansion joints below.

3.06 STONE THRESHOLD INSTALLATION:

A. Stone Thresholds: Install stone thresholds at locations indicated; set in same type of setting bed as abutting field tile, unless otherwise indicated.
   1. Set thresholds in latex-portland cement mortar for locations where mortar bed would otherwise be exposed above adjacent nontile floor finish.

3.07 EXPANSION AND CONTROL JOINT INSTALLATION:

A. Provide expansion and control joints around floor perimeters, at interior corners of tiled walls, in tile surfaces directly above joints in concrete substrates and where recommended by the TCA Handbook for Ceramic Tile Installation.

B. Do not saw-cut joints after installing tiles.

C. Install removable divider strips of the same depth as the finished tile system, including setting bed, to keep sealant joints free of setting bed, mortar and grout. Remove strips after grouting and curing operations in order to install sealant.

D. Install and cure sealant in accordance with manufacturer's instructions. Use primer unless sealant manufacturer recommends against priming.

3.08 CLEANING AND PROTECTING:

A. Cleaning: On completion of placement and grouting, clean tile surfaces with warm water and washing compound in accordance with recommendations of tile manufacturer. Sponge and wash tile thoroughly and polish with clean dry cloths.
   1. The use of acid or acid cleaners on tile is prohibited.

B. Finished Tile Work: Leave finished installation clean and free of cracked, chipped, broken, unbonded, and otherwise defective tile work.

C. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure tile is without damage or deterioration at the time of Substantial Completion.
   1. When recommended by tile manufacturer, apply a protective coat of neutral protective cleaner to completed tile walls and floors. Protect installed tile work with building paper taped to tile to prevent staining, damage, and wear. Lay board walkways on floors to be used as passageways.
   2. Prohibit foot and wheel traffic from tiled floors for at least seven days after grouting is completed.

D. Before final inspection, remove protective coverings and rinse neutral cleaner from tile surfaces.

END OF SECTION

SECTION 16060

GROUNDING AND BONDING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing complete grounding and bonding system.

B. Related Work Specified Elsewhere:
1. Fencing: Section 02820.
2. Earth tunneling: Section 02415.
3. Fabricated gray iron and ductile iron segmental tunnel lining: Section 02416.
4. Fabricated steel segmental tunnel lining Section 02417.
5. Concrete reinforcement: Section 03200.
6. Piping systems: 15205
7. Wire, cable and busways: Section 16120.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. National Electrical Code (NEC)
3. ANSI/IEEE 80-2000, IEEE Guide for Safety in AC Substation Grounding.
4. UL 467, Grounding and Bonding Equipment..
5. American Standards of Testing and Materials (ASTM) B187-00, Standard Specification for Copper Bar, Bus Bar, Rod and Shapes.
6. ITS: Directory of ITS Listed Products.

B. Source Quality Control:
1. Each item, except for exothermic-welded electrical connections, listed per referenced UL or ITS directory.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements 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.

1.04 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

2.01 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, one-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 for single-conductor cable.
            b) Bare conductor: Section 16120.
         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.
         3) Bare equipment grounding conductor integral with multiple-conductor cable: Section 16120.
      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 for single-conductor cable.
            b) Bare conductor: Section 16120.
         2) Size: As shown or as specified.
   4. Bus bar: ASTM B187-00, 98-percent-conductivity copper bus bar, size two 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 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 ½-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 to 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

3.01 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 one-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-feet six-inches 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 three-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 ductbank 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 A. C. 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 panelboard 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 6AWG 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 a #1/0 AWG insulated ground conductor connected to ground bus bar in A. C. Switchboard room. Leave 20-foot length of conductor coiled up in pits or wellway 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, 6AWG 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 two feet below grade with two-foot separation from footing, using 6AWG 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 two-foot separation from reinforced or buried metallic structures, using 4AWG insulated grounding conductor. At expansion and contraction joints, install 4AWG 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 two feet below grade, at approximate 50-foot intervals

and at each end, with two-foot separation from railing and fence-post footing and other reinforced structure, using 4AWG 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 6AWG bare grounding conductor, O-Z Type CG, Burndy Type GAR or equal connector at fence post, and Burndy Type KS or 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 two feet below grade, with two-foot separation from concrete structure and three-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 4AWG 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 6AWG insulated grounding conductor. For electrical continuity, where necessary, install flexible copper braided or leaf-type jumper or 6AWG 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 six 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 three inches above finished floor of under platform space using 6AWG 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 three 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 6AWG insulated grounding conductor to 5/8-inch diameter by 10-foot long ground rod driven so that top of rod is six 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 three inches above bottom of manhole, handhole and junction box using 6AWG 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 ½-inch or 5/8-inch rubber hose to bond metallic cover to metallic cover frame. Length of cable, chain and hose as required to allow removal of cover adjacent to and clear of handhole and/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, 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.

3.02 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, 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 2AWG insulated conductor as shown and in accordance with Section 15205.
      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.

3.03 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: Two 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: Five 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 Engineer.

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 Engineer, 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 two-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

1.01 DESCRIPTION:

A. This section specifies providing wire, cable and busways.

B. Definitions:
   1. Cable: Cable having low smoke generating characteristics.

C. Requirements for single-conductor cable and for multiple-conductor cable as stated except as otherwise specified.

D. Related Work Specified Elsewhere:
   1. Grading, excavating and backfilling: Section 02320.
   2. Wire connection accessories: Section 16125.
   3. Raceways, boxes and cabinets: Section 16130.

1.02 QUALITY ASSURANCE:

A. Qualifications: Select a manufacturer who is engaged in production of similar wire, cable and busways.

B. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. National Electrical Code (NEC).
   3. 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.
   4. IEEE: 1202-1991 IEEE Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies, 383-1974 IEEE Standard for Type Test of Class 1E Electrical Cables, Field Splices, and Connections for Nuclear Power Generating Stations.
   5. National Electrical Manufacturers Association (NEMA): BU1, WC70, WC71, WC74.
   6. American National Standards Institute (ANSI): *C37.20.1, Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear; C37.20.2, Metal-Clad and Station-Type Cubicle Switchgear; C37.20.3, Metal-Enclosed Interrupter Switchgear; Z55.1, Gray Finishes for Industrial Apparatus and Equipment*.
   7. UL: 44, Rubber-Insulated Wires and Cables Thermoset-Insulated Wires and Cables; 62, Flexible Cord and Fixture Wire; 857, Electric Busways and Associated Fittings; and 1581, Standard for Electrical Wires, Cables, and Flexible Cords.
   8. American Standards of Testing and Materials (ASTM): B3-95, Standard Specification for Soft or Annealed Copper Wire; B8-99, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft; D471-98e1, Standard Test Method for Rubber Property-Effect of Liquids, E662-97, Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials.
   9. ITS: Directory of ITS Listed Products

C. Source Quality Control:
   1. Cable and busways: Listed or labeled per UL or ITS directory.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements 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.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Mark each single-conductor cable, each multiple-conductor cable and each busway to show label per 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

2.01 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, 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 100C, plus-or-minus one 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 121C, plus-or-minus one 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 .005-inch thick, identical to those of finished cables and meeting minimum physical requirements specified.
      1) Prior to testing, submit six-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 four 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 four 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 four 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 four 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 ac voltage dielectric-strength test, i.e., six-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 90C.
2. Conductor: Stranded copper conductor 16AWG 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 40C: 55C.
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, two mils.

PART 3 - EXECUTION

3.01 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. 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 per 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 three-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 three-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 to prevent entry of water into electrical facilities. Where approved, use seal compound specified in Section 16130.

3.02 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.

3.03 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 Engineer.

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 one 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 one minute using 1,000-volt megger. Insulation resistance: One-megohm minimum. When busway shows insulation resistance of less than one-megohm minimum, perform high-potential test.

C. Submit certified test reports.

END OF SECTION

SECTION 16125

WIRE CONNECTION ACCESSORIES

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing wire-connection accessories, such as connectors, terminal lugs and fittings, bundling straps, insulating tape and resin.

1.02 QUALITY ASSURANCE:

A. Qualifications: Select a manufacturer who is engaged in production of similar wire connection accessories.

B. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. National Electrical Code (NEC).
3. UL: 486A,Wire Connectors and Soldering Lugs for Use With Copper Conductors.
4. American Standards of Testing and Materials (ASTM): D149-97a, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies; D257-99, Standard Test Methods for DC Resistance or Conductance of Insulating Materials; D412-98a, Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers-Tension; D570-98, Standard Test Method for Water Absorption of Plastics; D638-00, Standard Test Method for Tensile Properties of Plastic; D696-98, Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30°C and 30°C with a Vitreous Silica Dilatometer; D792-00, Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement; D1000-99, Standard Test Method for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications; D1518-85(1998)e1, Standard Test Method for Thermal Transmittance of Textile Materials; D5034-95, Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test); D5035-95, Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method); D2240-00, Standard Test Method for Rubber Property-Durometer Hardness; and G21-96, Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
5. American National Standards Institute (ANSI): C119.1, Sealed Insulated Underground Connector System 600V
6. ITS: Directory of ITS Listed Products.

C. Source Quality Control:
1. Connectors, terminal lugs and fittings listed, per referenced UL or ITS directory.
2. Factory testing: Submit certified copies of test report for cable splice and tap-insulation/sealing kits as specified.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings.
2. Certification.

1.04 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

2.01 PRODUCTS AND MATERIALS:

A. Connectors, Terminal Lugs and Fittings:
1. In accordance with UL 486A.
2. For 10AWG 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 8AWG 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 40F to plus 185F.
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 D1000-99:
   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 D1000-99:
   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 D5035-95: 50 pounds per inch width.

c. Thermal conductivity, ASTM D1518-85: 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 D1000-99:
   a. Nominal width: 3/4 inch.
   b. Thickness: Seven mils.
   c. Breaking strength: 170 pounds per inch width.
   d. Elongation: Five 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 D149-97a: 400 volts per mil.
2. Volume resistance, ASTM D257-99: 2.8×10^{15} ohm per centimeter cube at 30C.
3. Water absorption, ASTM D570-98:
   a. 0.193 percent in 24 hours at 23C.
   b. 0.62 percent in 24 hours at 53C.
4. Tensile strength, ASTM D638-00: 8,000 psi.
5. Elongation, ASTM D638-00: 2.4 percent.
6. Coefficient of expansion, ASTM D696-98: 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, 90C 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 D412-98a.
      2) Ultimate elongation: 350 percent, ASTM D412-98a.
      3) Hardness, Shore D: 42, ASTM D2240-00.
      4) Water absorption: 0.050 percent, ASTM D570-98, Method 6.1.
      5) Specific gravity: 1.28, ASTM D792-00.
   d. Electrical properties:
      1) Dielectric strength: 450 volts per mil, ASTM D412-98a.
      2) Volume resistivity: $1 \times 10^{14\ \text{ohm}}$ cm, ASTM D257-99.
   e. Thermal properties:
      1) Continuous operating temp.: -55C to +135C.
      2) Air oven aging (14 days at 175C):
         a) Tensile strength: 2,680 psi.
         b) Elongation: 375 percent.
      3) Low temp. flexibility (4 hours at -55C): No cracking when flexed.
      4) Heat shock (4 hours at 250C): No cracking, flowing or dripping.
   f. Chemical properties:
      1) Corrosivity: Non-corrosive.
      2) Fungus resistance: Non-nutrient, ASTM G21-96.
      3) Flammability: Self-extinguishing.

PART 3 - EXECUTION

3.01 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 ½-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.

3.02 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 thermit weld sealed with cast epoxy-resin encapsulation.

3.03 INSPECTION:

A. Have splices in direct-burial cable for stray current and cathodic protection inspected by the Engineer before backfilling.

B. Have splices and taps in manholes, handholes and outdoor junction and pull boxes inspected by the Engineer or the manufacturer's representative, when available.

END OF SECTION

SECTION 16130

RACEWAYS, BOXES AND CABINETS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing conduit, raceways, cable trays, boxes and cabinets to form raceway and support system for power, communication and control cables.

B. Related Work Specified Elsewhere:
1. Underground electrical and communications distribution systems: Section 02585.
2. Concrete formwork: Section 03100.
3. Cast-in-place structural concrete: Section 03300.
4. Structural precast concrete: Section 03400.
5. Grounding and bonding: Section 16060.
6. Firestopping: Section 07841.

1.02 QUALITY ASSURANCE:

A. Qualifications: Select a manufacturer who is engaged in production of similar raceways, boxes and cabinets.

B. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. National Electrical Code (NEC).
3. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum); VE 1, Metallic Cable Tray Systems; TC-2, Electrical Polyvinyl Cloride (PVC) Tubing and Conduit.
4. American National Standards Institute (ANSI): C80.1, Rigid Steel Conduit - Zinc Coated; C80.5, Aluminum Rigid Conduit - (ARC); and Z55.1, Gray Finishes for Industrial Apparatus and Equipment.
5. UL: 5, Surface Metal Raceways and Fittings; 6, Rigid Metal Conduit; 50, Enclosures for Electrical Equipment; 94, Test for Flammability of Plastic Materials for Parts in Devices and Applicances; 360, Liquid Tight Flexible Steel Conduit; 514A, Metallic Outlet Boxes; 514B, Fittings for Conduit and Outlet Boxes; 514C, Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers; 651, Schedule 40 and 80 Rigid PVC Conduit; 884, Underfloor Raceways and Fittings; and 1684, Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
6. Federal Specifications (FS): FF-S-325C, FF-S-760, TT-S-227.
7. American Standards of Testing and Materials (ASTM): A47/A47M-99, Standard Specification for Ferritic Malleable Iron Castings; A123/A123M-00, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; A185-97, Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement; A276-00a, Standard Specification for Stainless Steel Bars and Shapes; A507-00, Standard Specification for Drawing Alloy Steel, Sheet and Strip, Hot-Rolled and Cold-Rolled; A532/A532M-93a(1999)e1, Standard Specification for Abrasion-Resistant Cast Irons; A536-84(1999)e1, Standard Specification for Ductile Iron Castings; A615/A615M-00, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement; A653/A653M-00, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; B138-96, Standard Specification for Manganese Bronze Rod, Bar and Shapes; B455-96, Standard Specification for Copper-Zinc-Lead Alloy (Leaded-Brass) Extruded Shapes; B584-00, Standard Specification for Copper Alloy

Sand Castings for General Applications; B633-98, Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel; C109/C109M-99, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens); C173-94ae1, Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method; C231-97e1, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method; D149-97a, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies; D495-99, Standard Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation; D570-98, Standard Test Method for Water Absorption of Plastics; D638-00, Standard Test Method for Tensile Properties of Plastics; D648-00a, Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position; and D790-00, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

8. American Association of State Highway and Transportation Officials (AASHTO): Standard Specifications for Highway Bridges (SSHB).
9. ITS: Directory of ITS listed products.

C. The following items to be listed or labeled per referenced UL or ITS directory:
   1. Conduit and fittings.
   2. Surface raceways and fittings.
   3. Underfloor raceways and fittings.
   4. Boxes.
   5. Cabinets.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Shop Drawings.
   2. Certification.

1.04 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

2.01 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 A507-00.
      b. Zinc-coated steel sheet: ASTM A653/A653M-00.
      c. Cast iron: ASTM A532/532M-93a(1999)e1.
      d. Ductile iron: ASTM A536-84(1999)e1.
      e. Malleable iron: ASTM A47/A47M-99.
      f. Bronze extrusion: ASTM B455-96, Alloy C38500.

g. Bronze casting: ASTM B584-00, Alloy C83600.
h. Rigid fiberglass reinforced epoxy: UL 1684.
i. Stainless steel: ASTM A276-00a, Type 304.

3. Zinc coating:
a. Hot-dip galvanizing: ASTM A123/A123M-00.
b. Electro galvanizing: ASTM B633-98.

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 90C 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 inch provided with continuous copper bonding conductor, spiral wound between convolutions.
4. Sizes 1-1/2 inch 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 40F to plus 150F without loss of watertight seal.
d. Pot life: 15 minutes.
e. Minimum ambient temperature for application: 35F.
f. Initial cure: 15 minutes.
g. Final cure: Seven days.
h. Hardness, Durometer A: 20-35.
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 inch square by 1-1/2 inch deep.
f. For floor receptacles: Watertight cast-iron outlet boxes, four inches 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, five inches in diameter, extending beyond box 1/2-inch above finished floor, M32 finish.
5) One special screw-plug removal tool with every 10 receptacles.
g. For recessed wall-mounted receptacles: Watertight cast-iron outlet box, three-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, five inches in diameter, extending beyond box, M32 finish.
4) One special screw-plug removal tool with every 10 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 C173-94ae1 or C231-97e1; Section 03300 and Section 03400 and in accordance with the following:

1) 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.

2) 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.

3) Reinforcement:

(a) Sidewalk and landscape locations: Welded wire fabric, ASTM A185-97.

(b) Areas subject to vehicular traffic: Deformed steel bars, ASTM A615/A615M-00.

4) 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

1) Box: Gray-color material formed with closed bottom and sides and flange with recess at top of box to accommodate flush-mounted cover.

2) 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.
3) Loading:
   (a) Sidewalk and landscape locations: AASHTO's SSHB H15-44.
   (b) Areas subject to vehicular traffic: AASHTO's SSHB H20-44.
4) Hardware: Stainless steel.
5) 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

1) Ultraviolet protection: Fiberglass material containing ultraviolet-inhibitor, or coated with polyurethane paint, 1.5 mils minimum dry-film thickness on both inside and outside surfaces.
2) 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, two 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, two 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 B138-96, 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: 22AWG to 12AWG.
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 five-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 -40°F to 230°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

3.01 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.
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 underplatform 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.

3.02 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 07481.

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.

C. Close unused openings or spaces in floors, walls and ceilings. Plug or cap unused conduit and sleeves.

3.03 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.

3.04 FIELD QUALITY CONTROL:

A. Arrange with the Engineer for inspection and approval of embedded conduit and boxes prior to concrete placement.

B. Arrange with the Engineer 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 Engineer.

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 Engineer.

E. Arrange with the Engineer for inspection and approval of direct-buried conduits for future train control circuits prior to backfilling.

END OF SECTION

SECTION 16440

CIRCUIT BREAKERS, PANELBOARDS AND LOAD CENTERS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies furnishing, installing, connecting and testing of circuit breakers, panelboards and load centers.

B. Related Work Specified Elsewhere:
1. Raceways, boxes and cabinets: Section 16130.
2. Wire, cable and busways: Section 16120.
3. Wire connection accessories: Section 16125.
4. Grounding and bonding: Section 16060.
5. Field painting: Section 09920.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. NEC.
3. NEMA: AB1, PB1, ST20, 250.
4. ANSI: Z55.1.
5. UL: 50, 67, 198C, 489, 891, Electrical Construction Materials Directory.
6. ASTM: A276, B187.
7. ITS: Directory of ITS Listed Products.

B. Source Quality Control:
1. Each item listed per referenced UL or ITS directory.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings.
2. Certification.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Mark each circuit breaker, panelboard and transformer in accordance with applicable reference standard.

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

C. Store products in secure and dry storage facility.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. General Requirements:

1. Interchangeability: Components of the same type, size, rating, functional characteristics and make are to be interchangeable.
2. Finish for enclosures for enclosed circuit breakers, panelboards, emergency-service panelboards and load centers:
   a. Clean and degrease metallic surfaces.
   b. Prime with zinc primer.
   c. Finish with one coat of light-gray enamel, ANSI Z55.1, Color 61. Minimum dry-film thickness: Two mils.

B. Circuit Breaker: NEMA AB1, UL 489, 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. Shunt-trip device for tripping by ground-fault relay as shown. 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 40C with the following parameters as shown:
1. Number of poles.
2. Rated voltage.
3. Rated interrupting current.
4. Trip setting.
5. Frame size.

C. Integrally Fused Circuit Breaker:
1. NEMA AB1, molded-case, quick-make/quick-break, mechanically trip-free switching mechanism.
2. Thermal trip for inverse time-delay overload and magnetic trip for instantaneous short-circuit protection. Shunt-trip device for tripping by ground-fault relay as shown. Frame size 400 amperes and above equipped with interchangeable thermal and adjustable magnetic trips.
3. Individually removable current limiter, internally mounted on load side of circuit breaker, with rating and time current limiting characteristics that coordinate with time current-tripping characteristics of circuit breakers to provide the following:
   a. Interruption of circuit breaker under fault-current level up to interrupting capacity of circuit breaker.
   b. Interruption by current limiter in conjunction with circuit breaker under fault-current level above interrupting capacity of circuit breaker.
   c. Where necessary to protect downstream panelboard, limit fault current at branch circuit breakers below their interrupting capacity.
   d. Where necessary to protect associated feeder/branch circuits, limit fault current below short-circuit current withstand capability of cable.
4. Removable cover provided over current-limiter section of circuit breaker with interlock for tripping of breaker upon removal of cover and to prevent turning circuit breaker to ON position with cover removed.
5. Equipped with common trip mechanism for tripping all breaker poles simultaneously on blowing of current limiter to prevent single phasing.
6. Capable of interrupting minimum fault current of 100,000-rms symmetrical amperes at 480 volts ac.
7. Circuit breaker rating:
   a. Number of poles: As shown.
   b. Frame size: As shown.
   c. Voltage rating: 480 volts.
   d. Interrupting capacity: As necessary to coordinate with current limiter.
   e. Trip setting: As shown.

D. Enclosed Circuit Breaker:
1. NEMA AB1.

2. Circuit breaker: As shown and as specified. Overcurrent trip device coordinated to provide selective tripping under overload conditions.
3. Enclosure:
   a. Galvanized steel, surface-mounted, unless otherwise shown.
   b. Type:
      1) Above-ground indoor locations and electrical rooms: NEMA 250, Type 1.
      2) Tunnel areas and underground locations, except electrical rooms: NEMA 250, Type 12.
      3) Outdoor locations: NEMA 250, Type 3R.

E. Panelboard:
1. NEMA PB1, UL 67.
2. Enclosure:
   a. UL 50.
   b. Galvanized steel, surface-mounted unless otherwise shown.
   c. Type:
      1) Aboveground indoor locations and electrical rooms: NEMA 250, Type 1.
      2) Tunnel areas and underground locations, except electrical rooms: NEMA 250, Type 12.
      3) Outdoor locations: NEMA 250, Type 3R.
   d. Gutter size:

Main Bus Rating Amperes	Minimum Top and Bottom Gutter Size in Inches	Minimum Side Gutter Size in Inches
100 and below	4	4
225	6	4
400 and over	8	4

   e. Interior components mounted on backplate of reinforced steel for rigid support and accurate alignment.
   f. Provide latch and handle in accordance with UL 50; screw fastenings will not be accepted in lieu of latch.
   g. Provision for enclosure grounding.
3. Busbars:
   a. ASTM B187.
   b. 98-percent-conductivity copper.
   c. Contact surface silver-plated or tin-plated.
   d. Rating of neutral and ground bus: Equal to that of phase bus.
   e. Neutral bus mounted on insulating block.
   f. Neutral and ground busbars equipped with integral mechanical connectors.
4. AC panelboards:
   a. Type of service: Three-phase, four-wire, 277/480 volt or 120/208 volt or as shown.
   b. Type of main: Main lugs or circuit breakers or integrally fused circuit breakers as shown, conforming to requirements specified, located at top or bottom as necessary
   c. Branch circuit: Circuit breakers or integrally fused circuit breakers as shown, conforming to requirements specified, number of circuits as shown.
   d. Circuit breaker: Trip device coordinated with that of upstream circuit breakers to provide selective tripping.
   e. Suitable for service entrance where necessary.

5. DC Panelboard:
   a. Type of service: 125-volt dc, two-wire.
   b. Type of main: Two-pole circuit breaker, 100-ampere frame, 100-ampere trip and 10,000-ampere interrupting capacity, unless otherwise shown.
   c. Branch circuit: Two-pole circuit breakers, 100-ampere frame and 10,000-ampere interrupting capacity, in accordance with specified requirements, quantities as follows unless otherwise shown:
      1) With 20-ampere trip: Two minimum.
      2) With 30-ampere trip: Two minimum.
      3) With 50-ampere trip: Two minimum.
   d. Enclosure finish: As specified under General Requirements for this section, except color to be OSHA red as specified in Section 09920.
6. Emergency-power panelboard:
   a. NEMA PB1, UL 67, fused-switch.
   b. Enclosure:
      1) Galvanized steel, surface-mounted unless otherwise shown.
      2) Type:
         a) Above-ground indoor locations and electrical rooms: NEMA 250, Type 1.
         b) Tunnel areas and underground locations, except electrical rooms and tunnel areas: NEMA 250, Type 12.
         c) Outdoor locations: NEMA 250, Type 3R.
      3) Minimum of four inches side gutter and six inches top and bottom gutter.
      4) Mounting channel drilled and tapped to accommodate any combination of fused switch.
   c. Busbar:
      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) Drilled and tapped to accommodate any combination of fused switch unit.
      7) Neutral and ground bus equipped with integral mechanical connectors.
   d. Type of service: As shown.
   e. Type of mains: Main lugs or fused switch unit as shown, located at top or bottom as necessary.
   f. Branch circuit: Equipped with fused switch unit, number of circuits as shown.
   g. Fused switch unit:
      1) Individually enclosed, quick-make/quick-break switching mechanism.
      2) Equipped with the following:
         a) Silver-alloy contacts.
         b) External operating handle capable of being padlocked in ON or OFF position.
      3) Defeatable door interlock to prevent opening the door when operating handle is in ON position.
      4) Pressure-type fuse with Class J cartridge fuse conforming to UL 198C.
      5) Current rating and number of poles: As shown; maximum rating, 30 amperes.
      6) Use two-pole or three-pole switch unit if single-pole switch unit is not available.

7. Fuse time-current characteristic coordinated with upstream fuse time-current characteristic to provide selective overcurrent tripping.

F. Nameplates:
1. Three-ply, laminated phenolic plates, engraved through black face to white core and attached by stainless-steel rivets or screws.
2. Lettering: Vertical gothic using round or square cutter. V-shape groove is prohibited.
3. Each panelboard labeled with nameplate one-inch high bearing ½-inch high inscriptions as appropriate.
4. Nameplate for emergency-power panelboard to bear inscription EMERGENCY POWER.

G. Load Centers:
1. Enclosure:
   a. UL 891, stainless steel, ASTM A276, Type 304, or approved equal.
   b. Type:
      1) Above-ground indoor locations and electrical rooms: Non-ventilated indoor.
      2) Underground locations, except electrical rooms and tunnel areas: Non-ventilated outdoor.
      3) Outdoor locations and tunnel areas: Non-ventilated outdoor.
2. Transformer:
   a. NEMA ST20, dry, self-cooled, epoxy-encapsulated, double-wound with insulated copper conductor with 185C-insulation system capable of withstanding full-wave impulse voltage of 10KV.
   b. Five kVa load center: Single-phase, 60 Hertz, 480 volts primary to 120/240 volts secondary.
   c. Nine kVA load center: Three-phase, 60 Hertz, 480 volts primary to 120/208Y volts secondary.
   d. Fifteen kVa load center: Three-phase, 60 Hertz, 480 volts primary to 120/208Y volts secondary.
   e. Maximum allowable temperature rise under continuous full load above ambient temperature of 30C and 40C maximum:
      1) By winding resistance: 115C.
      2) By hottest spot in winding: 145C.
3. Circuit breaker:
   a. Bolt-on or plug-in, as specified.
   b. Primary circuit breaker: 480 volts, bolt-on, 14,000-rms symmetrical amperes interrupting capacity, 100-ampere frame, with the following additional requirements:
      1) For five kVa load center: Two-pole breaker with 20-ampere trip setting.
      2) For nine kVa load center: Three-pole breaker with 25-ampere trip setting.
      3) For 15 kVa load center: Three-pole breaker with 40-ampere trip setting.
   c. Secondary main circuit breaker:
      1) Bolt-on, two or three poles as shown, 240 volts, 10,000-rms symmetrical amperes interrupting capacity with trip setting as follows:
         a) For five kVa load center: 25 amperes.
         b) For nine kVa load center: 30 amperes.
         c) For 15 kVa load center: 50 amperes.
   d. Branch circuit breaker:

1) Single-pole, plug-in, 120 volts, 10,000-rms symmetrical amperes interrupting capacity.
   a) For five kVa load center: Four breakers, each with 20-ampere trip setting.
   b) For nine kVa load center: Six breakers, each with 20-ampere trip setting.
   c) For 15 kVa load center: Twelve breakers, each with 20-ampere trip setting.

e. Nameplate: Laminated plastic, one-inch high, attached by means of stainless-steel rivets or screws, showing load-center number in 1/2-inch high white characters engraved on black background.

4. Neutral and ground bus bar equipped with mechanical connectors.

H. Current-Limiting Circuit Breaker:
1. NEMA AB1, UL 489, molded-case, quick-make/quick-break, mechanically trip-free switching mechanism.
2. Thermal trip for inverse time-delay overcurrent protection and magnetic trip for instantaneous short-circuit protection. Shunt trip device for tripping by ground-fault relay as shown.
3. Limit the fault current, without the use of fusible element, to provide the following:
   a. Protect associated cable by limiting the fault let-through energy to a value below the short-circuit withstand capability of the cable.
   b. Protect downstream panelboard by limiting fault current at branch circuit breakers within their interrupting capabilities.
4. Circuit-breaker rating:
   a. Number of poles: As shown.
   b. Frame size: As shown.
   c. Voltage rating: 480 volts.
   d. Interrupting capacity: Minimum 100,000-symmetrical RMS amperes.
   e. Trip setting: As shown.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Install panelboards at locations shown, with bottom not less than 12 inches above floor. Use multiple-section panelboards to meet such spacings if necessary.

B. Mount panelboards and load centers with front straight and plumb.

C. When feeder serves more than one panelboard or panelboard section, install separate junction box or provide adequate gutter area for termination of feeders and bus taps.

D. Install single and/or multiple-conductor cable in accordance with Section 16120. Connect branch circuit wires as shown. Connect neutral wire of branch circuit to neutral bar in panelboard.

E. Install load centers where shown.

F. Make conduit connections in accordance with Section 16130.

G. Make power cable connections to circuit breakers, integrally fused circuit breakers, fused switch units, neutral and ground bus bars in panelboard and load centers and enclosed circuit breakers 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.

H. Ground panelboards, load centers and enclosed circuit-breaker enclosures in accordance with Section 16060 and the NEC.

I. Apply matching touch-up paint where necessary.

3.02 DIRECTORY OF CIRCUITS:

A. Furnish each panelboard and load center with legibly printed circuit directory located on inside of enclosure.

3.03 FIELD QUALITY CONTROL:

A. Furnish necessary equipment and perform the following tests:
1. Molded-case circuit breakers: Perform pole-to-pole and pole-to-ground insulation resistance tests with 1,000V dc megger. Insulation resistance to be 50 megohms minimum.
2. Panel boards and load centers: Perform insulation-resistance tests of each bus section phase-to-phase and phase-to-ground for one minute using 1,000V megger. Insulation resistance to be not less than manufacturer's recommended minimum or two megohms minimum.
3. Test circuit connections in accordance with wiring diagram.
4. Test panelboard and load-center enclosures for continuity to grounding system.
5. Check cable connections to circuit breakers and fused switch unit for tightness.
6. Check setting of adjustable magnetic trips for compliance with approved coordination study.

B. Submit certified test reports.

END OF SECTION

SECTION 16701

DEFINITIONS OF COMMUNICATION SYSTEM TERMS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Standard Definitions
   1. Definitions pertaining to the communication design and equipment description shall conform to the standard definitions promulgated by the following organizations unless otherwise specified in this Section (16701)
      a. Current versions of the Association of American Railroads (AAR)
      b. Electronic Industries Alliance (EIA)
      c. The Institute of Electrical and Electronics Engineers, Inc. (IEEE)
      d. The National Fire Prevention Association (NFPA)
      e. Local and state building and fire procedure codes not superseded by provision of the "Fire Protection Equipment and Life Safety Agreements" executed between WMATA and local jurisdictions.

B. Order of Priority
   1. Where definitions conflict, the order of priority shall be:
      a. Definitions of Communications Systems Terms (Section 16701)
      b. Current versions of the Association of American Railroads (AAR);
      c. EIA;
      d. IEEE.
      e. NFPA

C. Glossary of Communication Terms Used in These Communication Specifications

1.02 RELATED SECTIONS

1. All Sections in the 16700 and 16800 Series.

1.03 REFERENCES

A. Current versions of the Association of American Railroads (AAR)

B. Electronic Industries Alliance (EIA)

C. The Institute of Electrical and Electronics Engineers, Inc. (IEEE)

A. "Fire Protection Equipment and Life Safety Agreements" executed between WMATA and local jurisdictions

1.04 GLOSSARY OF COMMUNICATION TERMS

A. Words, terms, and phrases used in these Communication System Specifications are defined as follows:
   1. AAR:
      a. Association of American Railroads
         50 F Street, N.W.
         Washington, D.C. 20001-1564
   2. Absorption Losses:

a. (Fiber Optics) Reduction in light amplitude or strength caused by impurities in the optical fiber and by the scattering of light from the optical fiber.

3. AC Service Room:
   a. Room housing equipment and facilities for the distribution of ac power throughout an installation such as a passenger station or shop building.
4. Alarm
   a. An alerting signal indicating an abnormal condition.
5. Alphanumeric:
   a. Alphabetic and numeric representation, letters, numbers, and symbols.
6. Amplitude Modulation (AM):
   a. The process of varying the amplitude of a carrier wave in accordance with the instantaneous value of a modulating signal.
7. Ambient:
   a. Typical of the environment. Specifically used to designate properties of the surroundings which are measurable and distinguishable from absolute zero energy levels.
8. Angstrom:
   a. (Fiber Optics) A unit of optical wavelength historically used in the field of optics, but not an International System unit.
9. 1 Angstrom = 0.1 nanometer
10. American Standard Code for Information Interchange (ASCII):
    a. Consists of 10 or 11 bits per character - one start bit, seven information bits, one parity bit, one or two stop bits.
11. Ancillary Building:
    a. A room, area or structure which is not considered typical to all Metrorail passenger stations.
12. Annunciator:
    a. An audible signaling device which usually includes signal lights, each one indicating the conditions that exist or have existed in an associated circuit.
13. ANSI:
    1819 L Street, NW
    Suite 600
    Washington, DC 20036
14. Armored Cable:
    a. A cable provided with a wrapping of metal primarily for the purpose of mechanical protection. The armor is sometimes used as an electrical shield.
15. ASTM:
    a. American Society for Testing and Materials
       100 Barr Harbor Drive
       West Conshohocken, Pennsylvania 19428-2959
16. At-Grade:
    a. That portion of the system which is constructed at the approximate elevation of the adjacent ground surface.
17. Attenuation:
    a. A decrease in the amplitude of a signal as it travels along or through a transmission medium, usually expressed as a ratio or in dB.
    b. (Fiber Optics) A measure of the decrease in energy transmission (loss of light) expressed in dB/km. In optical waveguides it is primarily due to absorption losses and scattering losses.
18. Attenuation Distortion:
    a. Distortion caused by the non-uniform attenuation or gain of a system, with respect to frequency, under specified terminal conditions.
19. Audio Frequency:

a. Frequency range approximately equal to 15 Hz to 20,000 Hz (i.e. frequencies typically audible by human ears).

20. Authority, The:
    a. Washington Metropolitan Area Transit Authority (WMATA).
21. Auto Scan:
    a. The automatic scan of the TV cameras in the horizontal (pan) plane.
22. Automatic Fare Collection (AFC):
    a. Computer controlled system for the collection of fares, control of access, and associated functions.
23. Automatic Frequency Control (AFC):
    a. Means whereby the frequency of a circuit is automatically maintained, within specified limits, with respect to a reference frequency.
24. Avalanche Photodiode (APD):
    a. (Fiber Optics) One type of receiver or detector used in the receiving portion of Fiber-Optics terminals or repeaters. It is called a detector or receiver, since it detects and converts the light signal to a copy of the original electrical signal.
25. Bandwidth:
    a. Limiting frequencies between which the performance of a device or system falls within specified limits.
    b. (Fiber Optics) The capacity of an optical fiber to transmit information, expressed in bits of information transmitted per specific time period for a specific length of optical waveguide. Bandwidth is limited by pulse spreading or broadening due to dispersion, so that adjacent pulses overlap and cannot be distinguished.
26. Ballast:
    a. Crushed rock or stones placed between, under, and at the ends of railroad ties.
    b. (Electronics) A device utilized to limit current flow.
27. Battery:
    a. An assembly of cells electrically connected for producing electric energy. In telephone systems, it usually refers to centralized dc source, located in the central office, nominally -48 volts.
28. Baud:
    a. Unit of signaling speed equal to the number of discrete signal events per second.
    b. Binary Coded Decimal (BCD)
    c. A notation in which each individual decimal digit is represented by a pattern of "ones" and "zeros."
29. Bit:
    a. A binary digit, 0 or 1 in number representation, with the radix 2.
30. Bus:
    a. A conductor, or group of conductors, that serve as a common connection for two or more circuits.
31. Cable Binder:
    a. A wrapping of tapes or cords around several conductors of a multiconductor cable used to hold them together which may be color coded to designate the group of conductors enclosed.
32. Cable Tray:
    a. A tray or rack used for the installation and support of cable.
    b. Cable Trough
    c. A trough used for the installation, support, and protection of cable.
33. Call:

a. The act of establishing and completing a telephone connection from one telephone instrument to another.

34. Called Party
    a. The telephone instrument at the "distant end" being called.
35. Calling Party:
    a. The telephone instrument that originates the call.
36. Cardioid (Pattern):
    a. A heart-shaped pattern obtained as a response or radiation characteristic of certain directional antennas, or as the response characteristic of certain types of microphones.
37. Cassette:
    a. A small reel-to-reel tape magazine on which is recorded analog or digital information.
38. Cassette Recorder:
    a. A tape recorder used to record or playback cassettes.
39. CCS:
    a. Hundred-Call-Seconds - A measure of communications traffic equal to one hundred seconds of communicating. In practice, "CCS" is used for hundred call seconds per hour.
40. Central Office:
    a. Equipment in a telephone system that provides centralized switching, battery, and supervision for a group of subscribers or terminals (i.e. a Main PABX or Satellite PABX Equipment Room).
41. Channel:
    a. A path for transmitting electrical signals.
42. Character:
    a. A combination of bits denoting a specific alphanumeric symbol.
43. Chromatic or Material Dispersion:
    a. (Fiber Optics) This refers to "colors" or wavelengths in a lightwave source. Light rays with different wavelengths travel along a fiber at different speeds. The broader the range of wavelengths emitted, the more light pulse will spread as it traverses the length of the fiber.
44. Circuit:
    a. A conductor or system of conductors through which an electric current is intended to flow. A network providing one or more closed paths.
45. Cladding:
    a. (Fiber Optics) The low refractive index material which surrounds the core of the fiber and protects against surface contaminant scattering. The cladding may be glass or clear plastic. In interoffice telecommunication systems, glass cladding is used.
46. C-Message Weighting:
    a. Noise weighting used in a noise measuring set to simulate use of the Type 500 telephone (which has characteristics that are typical of most modern telephone instruments in commercial use in this Metropolitan area).
47. Combined Distribution Frame (CDF):
    a. A distribution frame which, in addition to the functions of an MDF, provides for the cross-connection of the PABX subscriber line multiple and the subscriber line circuits.
48. Command Message:
    a. Digital message transmitted from the Mobile Radio System control console to base stations to query status or to direct action.
49. Command Message Enable:
    a. Message used to cause selected base station(s) to be ready for two-way voice operation.
50. Command Message Station Connect:

a. Message used to restore a base station(s) to service in the system in a quiescent mode with its receiver in a monitoring condition with squelch operating.

51. Command Message Station Disconnect:
    a. Message used to intentionally remove a base station(s) from service in the system.
52. Commercial Telephone Network:
    a. The public telephone system. In the WMATA area, usually Bell Atlantic for local public network and special services cable connections.
53. Communications Equipment Room:
    a. Room housing centralized communications equipment for an installation such as a Metrorail passenger station or yard.
54. Communications Ground:
55. Compandor:
    a. An earth ground connection of 5 ohms or less resistance that is provided in the Communications Equipment Room in each passenger station and yard for the sole purpose of grounding communications equipment. The Communications Ground in the Communications Equipment Room at Jackson Graham Building has a resistance of 1 ohm or less to earth.
    b. A combination of a compressor at one point in a communications path for reducing the amplitude range of signals followed by an expander at another point for a complementary increase in the amplitude range. The purpose is to improve the ratio of the signal to the interference entering the path between the compressor and the expander.
56. Compartmental Cable:
    a. A multiconductor cable with its core divided into two compartments, a transmit section and a receive section, which are separated by an insulated metallic divider.
57. Conduit:
    a. A tube-like structure for electrical wires or cables. Conduit may be either rigid or flexible, metallic or non-metallic, as specified.
58. Conduit Stub Out:
    a. A short length of conduit that is joined as a branch to a conduit run and, as used in these Specifications, is the termination of a conduit run.
59. Console:
    a. A panel or cabinet on which are mounted switches or lamps for use by a human operator in monitoring and controlling equipment and functions.
60. Contact Rail:
    a. A bus bar alongside a track that carries electric energy for the propulsion of trains.
61. (The) Contractor:
    a. The person, partnership, corporation, or joint venture that is awarded the prime contract to provide the facilities, equipment, and installations described in these Specifications. The usage of this term in these Specifications also includes subcontractors, suppliers, vendors, and employees thereof, except as otherwise stated (subject at all times to the Contractor's responsibility therefore).
    b. The person or company who is awarded a contract to provide all the facilities, equipment, and installations described in these Specifications.
62. Core:
    a. (Fiber Optics) The light conducting portion of the optical fiber, defined by the high refractive index region. The core is normally in the center of the optical fiber, bounded by the cladding material.
63. Coverage:

a. Inclusion within the range of a communications device, equipment unit, system or medium.

64. Crosstalk:
    a. Undesired signal coupling between two different communications channels or signal components.
65. Data Acquisition and Display System (DADS):
    a. A system for the collection, recording, consolidation, and display of fare collection data at the passenger stations.
66. Enhanced Data Acquisition and Display System (EDADS):
    a. An upgraded version of the DADS System.
67. Data Transmission System (DTS):
    a. The bi-directional, non-vital digital communications system between Central Control and the Train Control Room. The DTS utilizes a channel of the CTS as a transmission medium.
68. Decibel (dB):
    a. Unit used to express the ratio between two amounts of electrical power, Pl and P2, defined as:

$$dB = 10 \log_{10} \frac{P_1}{P_2}$$

    b. Also used to express voltage and current ratios, defined as:(Voltages and currents must be measured with identical impedances.)

$$dB = 20 \operatorname{Log}_{10} \frac{V_1}{V_2} = 20 \operatorname{Log}_{10} \frac{I_1}{I_2}$$

    c. Also used to express intensity of sound; defined as equal to 20 times the common logarithm of the ratio of the sound pressure of a wave to a reference pressure of 0.0002 dyne per square centimeter.
69. dBm:
    a. Measure of absolute electrical power in decibels referred to one milliwatt.
70. dBm0:
    a. A measure of power, with reference to zero dBm, at the reference transmission level point (RTLP).
71. dBrnc0:
    a. A measure of noise power in dB above one picowatt measured with a C-message weighting network referred to or measured at an RTLP.
72. Delay Distortion:
    a. Distortion caused by differences in transit time for different frequencies within a specified system bandwidth.
73. Desk Telephone:
    a. A telephone instrument designed for desk top use.
74. Detector:
    a. A device used to sense a particular condition - smoke, temperature, open circuit, received signal, etc.
75. Dial:
    a. Normally, a face plate which has been graduated into arbitrary units. As a special case, in telephony, the hand operated device used to generate pulses or tones for establishing connections over a telephone switching system.

76. Dialing:
    a. The act of operating a dial - specifically, a telephone dial. As used in this document, includes the act of operating a telephone instrument "touchtone" pad.
77. Diode Auctioneering:
    a. A method of obtaining redundancy in use of power supplies by utilizing diode coupling from each power supply to a common load.
78. Direct Burial:
    a. A method of installing cable underground, not in conduit or duct, in such a manner that it cannot be removed without disturbing the soil.
79. Dry Contact:
    a. An electrical contact through which no direct current flows.
80. Duct Bank:
    a. An arrangement of conduit providing more than one duct to accommodate and protect cables between two points.
81. DTMF:
    a. Dual Tone Multifrequency audio signaling scheme utilized as the standard subscriber line tone signaling method in the USA. Also known as Touch-tone dialing, which is a copyrighted Bell Telephone Company term for such signaling. (Utilized for some other remote control devices also.)
82. Duplex:
    a. Type of operation that permits simultaneous communications in both directions.
83. EIA:
    a. Electronic Industries Alliance
       2500 Wilson Boulevard
       Arlington, Virginia 22201
84. E&M Signaling:
    a. A signaling system characterized by the use of separate paths for the signaling and voice signals. The M lead transmits battery or ground to the distant end of the circuit while incoming signals are received as ground or open on the E lead.
85. E&M Trunk:
    a. An audio trunk circuit utilizing E&M signaling.
86. Electro-Mechanical:
    a. An electrical device with moving parts.
87. Elevated:
    a. That portion of the Metrorail System which is constructed above the adjacent ground surface.
88. Emergency Power:
    a. Electrical power provided to operate essential equipment during periods of failure of primary power source.
89. Emergency Trip Station: (ETS):
    a. An enclosure containing an emergency telephone and an electric switch to de-energize a section of the contact rail.
90. ETS Telephone:
    a. An emergency telephone generally located along Metrorail R.O.W. and collocated with or enclosed in Emergency Trip Station boxes in most instances.
91. Engineer (The):
    a. Wherever, on the Contract Drawings or in the Specifications, the term "Engineer" is used, it shall mean the Resident Engineer or other duly authorized representative of the Contracting Officer.
92. Engineering Services:

a. Engineering Service to be provided, as detailed in Article 3.1, Article 3.20, and as required elsewhere in these Specifications and Contract Drawings.

93. Entrance Escalator:
    a. Escalator from street level to a passenger station.
94. Environment:
    a. The universe within which the system must operate, the elements over which the designer has no control.
95. Error Rate:
    a. The ratio of the number of characters of a message(s) received incorrectly to the total number of characters of the message(s) received.
96. Factory Test:
    a. Test of equipment at the manufacturer's plant.
97. Failure:
    a. An inability to perform an intended function.
98. Fare Gates:
    a. Gate in stations through which passengers pass separating FREE (UNPAID) and PAID areas.
99. FCC:
    a. Federal Communications Commission
    445 12th Street, SW
    Washington, D.C. 20554
100. Fiber Buffer:
    a. Fiber Optics) A material that may be used to protect an optical fiber from physical damage, thus providing mechanical isolation and/or protection.
101. Fiber Bundle:
    a. (Fiber Optics) In a fiber optics cable, a group of parallel optical fibers over which a loose-fitting jacket (fiber buffer) has been extruded. (As used in "loose tube" type fiber optic cables, for example).
102. Fiber Optics:
    a. (Fiber Optics) The branch of optical technology concerned with the transmission of radiant power through fibers made of transparent materials such as glass, fused silica, or plastic.
103. Fiber Optics Cable:
    a. A cable made up of several optical fibers incorporated into an assembly of organic materials arranged for providing the necessary tensile strength, external protection, and handling properties. (Communications cables usually utilize "loose tube" or "open channel" type internal construction.)
104. Fire Zone:
    a. A portion of a building, installation or area designated for fire detection by a specific circuit.
105. Flutter:
    a. Cyclic deviation of signaling power (with a period in the neighborhood of 10 Hz for audio, for example).
106. Foot Lambert (fl):
    a. The amount of light energy reflected from an object or scene equal to the product of illumination in footcandles and the luminous reflectance of the object or scene.
107. 4-Wire Terminating Set:
    a. A hybrid set for interconnecting a four-wire and a two-wire circuit (usually refers to audio frequency devices).
108. Free (Unpaid) Area:
    a. Area of passenger station to which public has access prior to passing through fare gates.
109. Frequency Modulation (FM):

a. The process of varying the instantaneous frequency of a sine wave carrier by an amount proportional to the instantaneous value of a modulating signal.

110. Frequency Response:
   a. The measure of effectiveness with which a circuit or device receives or transmits a range of frequencies.
111. Frequency Shift Keying (FSK):
   a. The form of frequency modulation in which the modulating wave shifts the output frequency between predetermined values, and the output wave has no phase discontinuity (usually accomplished at audio frequencies).
112. Fuse:
   a. An overcurrent protective device with a circuit-opening part that is heated and severed by the passage of overcurrent through it.
113. Fuse Alarm:
   a. A circuit which produces a visual or audible signal to indicate a blown fuse.
114. Fusion Splice:
   a. (Fiber Optics) A splice accomplished by the application of localized heat sufficient to fuse or melt the ends of two lengths of optical fiber, forming a continuous, single fiber.
115. Gallery Place:
   a. A Metrorail passenger station located at the junction of Routes B, E, and F, which is a secondary hub of the WMATA Rail Rapid Transit System.
116. Gatehouse:
   a. A building at the entrance to a Metrorail train yard, from which control of pedestrian and vehicular (other than trains) access to the yard is exercised.
117. Graded-Index:
   a. (Fiber Optics) An optical fiber type wherein the core refractive index decreases almost parabolically radially outward toward the cladding. This type of fiber combines high-bandwidth capacity with moderately high coupling efficiency.
118. Ground:
   a. A conducting connection, whether intentional or accidental, by which an electric circuit or equipment is connected to the earth, or to some conducting body of relatively large extent that serves in place of the earth. A common return to a point of zero potential. (Intentional grounding for WMATA projects providing low resistance current return paths to the earth.)
119. Half Duplex:
   a. A method of operation in which two-way communication is possible, but only one way at a time.
120. Handset/Speaker Station:
   a. A self-contained terminal station of the paging-intercom subsystem of the Yard Public Address System.
121. Hardware:
   a. Physical entities such as computers, equipment, and instruments. Also parts made of metal such as fasteners, straps, clamps, and anchors.
122. Harmonic Distortion:
   a. Non-linear distortion of a system or transducer characterized by the appearance in the output of harmonics, other than the fundamental component, when the input wave is sinusodial.
123. Hertz (Hz):
   a. Unit of frequency equal to one cycle per second.
124. ICEA:

a. Insulated Cable Engineers Association
PO Box 440
South Yarmouth, Massachusetts 02664

125. Identifying Digits:
a. Alphanumeric digits that identify each passenger station and yard.

126. Idle:
a. In communications systems, indicates a circuit, device or system is not in active use (i.e. in the quiescent state).

127. Idle Noise:
a. That noise which is inherent in a circuit or device and is not contingent upon modulation.

128. IEEE:
a. Institute of Electrical and Electronics Engineers, Inc.
345 East 74th Street
New York, N.Y. 10017

129. Impedance:
a. The opposition in an electrical circuit to the flow of alternating current.

130. Impulse Noise:
a. Noise characterized by transient disturbances separated in time by quiescent intervals.

131. Inbound Track:
a. Track that is normally used by trains traveling toward Metro Center passenger station in the A, B, C, D, G, and K routes; and towards the Gallery Place passenger station in the E, F, and L routes.

132. Incident Scene Illumination:
a. The amount of light expressed in foot-candles which is actually falling on an object.

133. Index of Refraction:
a. (Fiber Optics) The relative index of refraction is a fraction or ratio of the velocity of light in one medium, compared to the velocity of light in another medium.

134. Infrared:
a. (Fiber Optics) The region of the electromagnetic spectrum between the long-wavelength of the visible spectrum (about 750nm) and the shortest microwaves (about 1300nm). Infrared is used extensively in the transmission of light through optical waveguides.

135. Injection Laser Diode:
a. (Fiber Optics) A laser employing a forward-biased semiconductor junction as the active medium. Light is emitted from the diode edge.

136. Insertion Loss:
a. The loss resulting from the insertion of a transducer or other device in a transmission system.

137. Install:
a. When used in these Specifications, the verb install shall signify that the Contractor shall furnish, install, and test the equipment and materials specified, unless specifically indicated differently in the text.

138. Interface:
a. A shared boundary. The interconnection between two pieces of equipment or systems/facilities.

139. Interlocking:
a. An arrangement of signals and signal appliances interconnected so that their operations must succeed each other in proper sequence, thereby permitting train movements over controlled routes, only if safe conditions exist.

140. Intermodulation Noise:

a. That noise which is contingent upon modulation and results from any non-linear characteristic in the path or device.

141. Interphone:
   a. Equipment used to provide telephone communications between personnel at various locations within a defined space. As used in these Specifications, provides communications between the Station Manager in the Kiosk and the public.
142. Intrusion Zone:
   a. A portion of a building, installation or an area designated for detection of intrusion by a specific circuit.
143. Jacket:
   a. A thermoplastic or thermosetting covering, sometimes fabric reinforced, applied over the insulation, core, metallic sheath or armor of a cable.
144. Jackfield:
   a. An arrangement of telephone jacks, usually grouped on a mounting strip, to provide convenient access to lines and equipment for testing.
145. Joint Electron Device Engineering Council (JEDEC):
   a. Cooperative effort of Electronic Industries Alliance (EIA) and National Electrical Manufacturers Association (NEMA).
146. Key Telephone System (KTS):
   a. Assemblage of telephone relay or electronic equipment which provides switching and control of telephone service within a localized area. KTS equipment is differentiated from PABX equipment primarily by more limited switching functions. Insofar as external telephone trunks are concerned, KTS equipment is generally limited to applications requiring less than 100 subscriber lines and the provision of service that is generally limited to a single building or area of a building.
147. Kiosk:
   a. A booth-like structure within Metrorail passenger stations which contains station monitoring and control facilities and from which an attendant may provide information and assistance to passengers.
148. Laser:
   a. (Fiber Optics) A device that produces optical radiation using population inversion to provide Light Amplification by Stimulated Emission of Radiation and (generally) an optical resonant cavity to provide positive feedback.
149. Light Emitting Diode (LED):
   a. A pn junction semiconductor device that emits incoherent optical radiation when biased in the forward direction.
150. Main Distribution Frame (MDF):
   a. Provides for the termination and cross connection of outside lines entering a building, including electrical protection devices, internal subscriber lines, and terminal equipment.
151. Manhole:
   a. A subsurface chamber or opening in the route of a conduit or duct run that provides facilities for splicing, testing, and maintaining cables and conductors.
152. Manual Pull Box:
   a. Specifically refers to FIRE alarm switch which, when operated manually, initiates a FIRE alarm.
153. MDF/Protector Cabinet:
   a. Specifically refers to a cabinet located in passenger stations and yard buildings containing MDF and cable protection facilities.
154. Major Items:

a. Major Items are defined as items listed in Estimated Quantities Tables 3.1-X.X.

155. Mechanical Splice:
   a. (Fiber Optics) An optical fiber splice accomplished by fixtures or materials, rather than by thermal fusion. Index matching material may be applied between the two fiber ends.
156. Metro Center:
   a. A Metrorail passenger station located at the junction of routes A, B, C, and D which is the major hub of the WMATA Rail Rapid Transit System.
157. Microbar:
   a. Unit of pressure equal to one dyne per square centimeter.
158. Millisecond (ms):
   a. A unit of time equal to one one-thousandth of a second.
159. Mobile Radio Unit:
   a. A radio transmitter/receiver designed for installation in a vehicle or train.
160. Modal Dispersion:
   a. (Fiber Optics) The component of pulse spreading caused by differential optical path lengths in a multimode fiber.
161. Modem:
   a. A modulator and demodulator housed in a common assembly.
162. Multi-Mode Fiber:
   a. (Fiber Optics) An optical fiber that will allow more than one mode to propagate. May be either a graded index or step index configuration.
163. Multiline Telephone:
   a. A telephone instrument with the capability of being connected to more than one line.
164. Multiplexer (MUX):
   a. A device which combines several inputs into a single output.
165. Muting:
   a. The action of reducing a sound level.
166. NEMA:
   a. National Electrical Manufacturers Association
      1300 North 17th Street
      Suite 1847
      Rosslyn, Virginia 22209
167. Noise:
   a. Any undesired, interfering signal contained in a communications channel or circuit.
168. Noise Weighting:
   a. An amplitude-frequency characteristic of a noise measuring set. C-Message weighting is so designed as to give numerical readings which approximate the amount of transmission impairment, due to noise, that an average listener experiences using a specific commonly utilized modern class of telephone subset. "Flat" weighting and other wideband weighting may be utilized to measure noise on data channels. Meters designed to measure ambient noise (environmental) utilize other weighting networks (to obtain readings in dBa, for example).
169. Numerical Aperture:
   a. (Fiber Optics) Measure of light acceptance of an optical fiber.
170. OCC:
   a. Operations Control Center (now in the Jackson Graham Building which was previously designated as the OCC Building - OCCB on some WMATA documentation). The operational center for the WMATA Metrorail and Metrobus systems (includes centralized operations and communications functions). Also known as Central Control and Command Center.

171. OCCS:
    a. Operations Control Center - Security. Usually refers to the consoles in the Security Center for the WMATA system.
172. Off-Hook:
    a. A telephone line condition or the signal indicating that the circuit is in use (i.e., the handset is off its switch-hook).
173. Omni-Directional:
    a. (Antenna) An antenna having essentially non-directional pattern in azimuth but that may have a directional pattern in elevation in many instances.
    b. (Microphone) A microphone, the response of which is essentially independent of the direction of sound input.
174. On-Hook:
    a. A telephone line condition or the signal indicating that the circuit is idle - not in use.
175. On-Site Test:
    a. Test of equipment or system after installation in its operational location.
176. Open:
    a. A break or discontinuity in a circuit which normally passes a current.
177. Optical Fiber:
    a. (Fiber Optics) Any filament or fiber, made of dielectric material, that guides light.
178. Outbound Track:
    a. Track normally used by trains traveling away from Metro Center passenger station in the A, B, C, D, G, and K routes, and away from Gallery Place passenger station in the E, F, and L routes.
179. Override:
    a. A communications trunk feature whereby one call has a greater priority of using a common facility over another call.
180. PABX:
    a. A designation used in the national telephone system to denote a privately owned telephone switching center which operates by the use of dialing (i.e. Private Automatic Branch Exchange). PABXs can be differentiated from KTS systems by their generally more extensive trunk and remote line switching capability, and by the fact that they generally handle 60 or more subscriber lines.
181. PABX Extension:
    a. A telephone instrument connected to a PABX.
182. PAID Area:
    a. Area of passenger station to which the passengers have access after passing through fare gates.
183. Paging-Intercom:
    a. A system which provides for public address type paging and telephone type intercom service.
184. Parity:
    a. Used in digital code formats for self-checking in which the total number of ls or 0s in an acceptable code is always odd or always even, depending on whether an odd or even parity check is used.
185. Passenger Station:
    a. A location which provides the public access to the WMATA Rail Rapid Transit System (Metrorail System). Provides facilities for payment of fares, train information, entrance and exit of passengers.
186. Phase Modulation (PM):
    a. The process of varying the angle of a carrier from its reference value by an amount proportional to the instantaneous value of a modulating signal.
187. Pin Photodiode:

a. (Fiber Optics) A diode with a large intrinsic region sandwiched between p-doped and n-doped semiconducting regions. A commonly used detector or receiver in fiber systems.

188. Plug-In Unit:
   a. A communications device so designed that connections to the device may be completed through pins, plugs, jacks, sockets, receptacles or other forms of ready connectors.
189. Portable Radio:
   a. A radio transmitter/receiver designed to be carried by or on a person.
190. Power Distribution Panel:
   a. A facility which provides for the distribution of power circuits and overload protection for those circuits.
191. Power Supply:
   a. A unit for converting power from an ac or dc source into ac or dc power at voltages suitable for supplying power to equipment.
192. Pre-empt:
   a. A communications trunk feature whereby one call takes a common trunk facility away from another call.
193. Primary Cable:
   a. Specifically refers to the normally on-line cable of the dual redundant communications cable facility of the Fiber Optics/Carrier Transmission Systems.
194. Protection Tube:
   a. An expulsion arrestor or glow-discharge cold cathode tube that employs a low-voltage breakdown between two or more electrodes to protect circuits against over-voltage.
195. Pulse Dispersion:
   a. (Fiber Optics) The separation or spreading of the input characteristics of the optical signal that appears along the length of the optical fiber and limits the useful transmission bandwidth of the fiber. Expressed in time and distance as nanoseconds per kilometer. Three basic mechanisms for dispersion are the material effect, the waveguide effect, and the multimode effect.
196. PT&Z Camera(Pan, Tilt, Zoom):
   a. A television camera with facility for remote control of azimuth, elevation, and zoom.
197. Public Address System:
   a. A system which provides transmission, amplification, and reproduction of speech with high communications band fidelity and sufficient power to make sound simultaneously available, and fully intelligible, to large numbers of people.
198. Pulse Code Modulation (PCM):
   a. A modulation process involving the conversion of a wave form from analog to digital by means of coding. Usually a form of pulse modulation in which a code is used to represent quantized values of instantaneous samples of the signal waves.
199. Push-To-Talk (Operation):
   a. Voice communications on a circuit in one direction at a time requiring activation of a switch prior to and during transmission.
200. Quench:
   a. An action whereby an active circuit is stifled or inhibited.
201. Radio Base Station:
   a. A complete assemblage of equipment for radio transmission and reception including antenna(s) and control devices or interfacing equipment accommodating remote control devices.

202. Rail Rapid Transit System:
    a. The portion of the WMATA transportation system that is a third rail electrified system as distinguished from the motor bus operations.
203. Rapid Battery Charger:
    a. Electrical device used for rapidly charging storage batteries.
204. Redundancy :
    a. The existence in a system of more than one means of accomplishing a given function, for the purpose of increasing security or reliability.
205. Reliability :
    a. The probability of performing a specified function, without failure and within design parameters, for the period of time intended under actual operating conditions.
206. Redundant Cable:
    a. Specifically refers to the secondary cable of the dual cable facility of the Fiber Optic/Carrier Transmission Systems.
207. Reference Transmission Level Point (RTLP):
    a. In a communications system it is an arbitrarily chosen point to which the levels at all other points in the system are referenced. It is frequently the input to the 2-wire side of the 2-wire/4-wire terminating set at the transmitting end of a telephone channel.
208. Remote Building:
    a. An area or structure (frequently containing support equipment, such as: Fan shafts, chiller plants, substations, and tie breaker stations) generally within or along the WMATA right-of-way, but not part of a passenger station or yard. Remote buildings may also include MRS Two-Way Line Drivers, Fire and/or Intrusions alarm detectors, wayside telephones, etc.
209. Relay Contact Types:
    a. FORM-A: SPNO (Single-Pole, Normally Open) Contact
    b. FORM-B: SPNC (Single-Pole, Normally Closed) Contact
    c. FORM-C: SPDT (Single-Pole, Double-Throw) Contact
210. Remote Terminal Unit (RTU):
    a. A modem installed at each ATC field control location (usually at passenger station TCRs) to act as the interface unit between the Data Transmission System (DTS) and the local ATC and support system functions.
211. Response Message:
    a. Digital message transmitted from base station(s) of the Mobile Radio System to the control console with information in reply to a command message initiated at the control console.
212. Revenue Service:
    a. The transportation of passengers who have paid a fare.
213. Revenue System:
    a. The portion of the METRO System on which revenue service is conducted.
214. Right-of-Way (R.O.W.):
    a. The land or structure surface occupied by the Metrorail Transit System, especially for its mainline. Also, the land or structure surface used by another transportation facility such as a railroad or highway.
    b. The right of traffic on a given route to take precedence.
215. Ringdown:
    a. A method of signaling in which ringing current is transmitted over a circuit to operate a device or circuit to produce a steady signal.
216. Ringing:
    a. The audible or visual signal produced by an alternating or pulsating current to signal a telephone station, central office or other terminating equipment.
217. Root Mean Square (rms):

a. The square root of the mean of the squares of the sum of instantaneous voltages or currents during a complete cycle.

218. Rotary Hunting Group (RHG):
   a. A group of telephone lines which are accessible under a common calling number and are used sequentially as calls are received.
219. Scene Highlight Brightness:
   a. The amount of illumination which is reflected off an object of interest expressed in foot lamberts.
220. Seize:
   a. In communications signaling terminology, to take control of a connecting circuit.
221. Sensitivity:
   a. The degree to which a component, circuit or system is affected by some condition.
222. Sensor:
   a. A device for detection of a condition or change in condition - such as smoke, temperature, humidity, light level, open circuit, closed circuit.
223. Service and Inspection (S&I) Yard:
   a. Yard which provides for the make-up, cleaning, maintenance, inspection, and repair of trains.
224. Shield:
   a. A housing, screen or other object, usually conductive, that substantially reduces the effect of electric or magnetic fields on one side and upon devices or circuits on the other side.
225. Shop Building:
   a. Building within a Metrorail yard or elsewhere which houses repair facilities.
226. Short Circuit:
   a. An abnormal connection of relatively low resistance between two points of different potential in a circuit.
227. Simplex:
   a. A method of operation in which communications takes place in one direction only.
228. Singing Point:
   a. The point at which the gain is just sufficient to make the circuit break into oscillation.
229. Single Mode Fiber:
   a. (Fiber Optics) An optical fiber in which only the lowest order mode can propagate at the wavelength of interest.
230. Slotted Coaxial Cable:
   a. A coaxial cable with slots cut into the outer conductor, thereby permitting radio frequency radiation into and from the cable.
231. Software:
   a. Computer programs and routines; a collection of related utility, assembly, and other programs that are desirable for proper utilization of a device or equipment; detailed procedures, documents, manuals, drawings, and diagrams relating to a device, equipment or system.
232. Solid State:
   a. A device or system whose operation is dependent upon a combination of optical, electrical or magnetic phenomena occurring within a solid. Functions are performed by semiconductors and wholly static components, i.e., resistors, capacitors, etc.
233. Span Section:
   a. A span section is defined in these Specifications as a transmission segment of the Fiber Optic System or Carrier Transmission System that

extends from the Control Center to and including the passenger station, yard or other intermediate repeater or terminal of the span.

234. Spare:
    a. Equipment, assemblies or components, complete or in parts, on hand for repair or replacement.
235. Speech-Plus:
    a. Method of operation that permits the simultaneous transmission of speech and telegraph signals over a single voice channel.
236. Sound Pressure Level (SPL):
    a. A measure, in dB, of acoustic loudness, usually designated to be the effective rms sound pressure referenced to 0.0002 dyne per square centimeter.
237. Squelch:
    a. An action whereby a signal is completely cut off, unless a predetermined threshold level is attained.
238. Stationing:
    a. A system for establishing reference points along the Rail System. Civil stationing is used in initial design and development of the Rail Right-Of-Way. Train Control Stationing is later established as a permanent reference for operation of the Rail System.
239. Storage and Inspection Yard:
    a. A Metrorail yard which provides for the make up of trains and for the cleaning and minor maintenance of cars. No major repair facilities are provided.
240. Sub-Ballast:
    a. Crushed rock or stone that is placed between the ballast and the sub-grade.
241. Subscriber Loop:
    a. A circuit that is formed by the subscriber's telephone, the cable pairs and other conductors, and the telephone central office, PABX or other terminating equipment.
242. Substation, Traction Power:
    a. Building housing equipment and facilities for providing electrical energy to the trains via the contact rail.
243. Subway:
    a. That portion of the system which is constructed beneath the ground surface (i.e. underground Metrorail facilities).
244. Supervision:
    a. The process of monitoring the condition of a circuit to determine its status.
245. Supervisory Alarm Subsystem (SAS):
    a. A subsystem of the Technical Control Facility which provides for the transmission of alarm information from a remote terminal in passenger stations and yards to the Control Center.
246. Talkback System:
    a. A system of the yard which provides two-way voice communications between the Yard Communications Console and the track areas.
247. Talk Path:
    a. In a telephone or radio system, the circuit or channel which provides for the transmission of voice signals.
248. Terminal Strip (Board):
    a. An insulating base equipped with terminals for connecting wires.
249. Third Rail:
    a. See contact rail.
250. Tie Breaker Station:

a. Building housing power switching equipment for the purpose of sectionalizing contact rail power.

251. Tone Call:
   a. A system of exchanging calling or alerting signals and acknowledgment signals between mobile radio units and base stations that utilize modulated tones in the voice band.
252. Tone Dialing:
   a. The transfer of digital information from a telephone instrument to a central office or other terminal device utilizing multi-frequency tones. (Typically by standard DTMF tone signaling)
253. Tone Generator:
   a. A device for providing audio frequency currents suitable for signaling purposes.
254. Total Harmonic Distortion (THD):
   a. A measure of the total effect of the various higher order harmonics of a sinusoidal signal.
255. Trackbed:
   a. The area and material directly under the track which provides support to the track. It includes ties, ballast or other supporting material.
256. Train Control Contractor:
   a. The contractor who has been awarded a contract to provide Automatic Train Control System.
257. Train Control Room:
   a. A room located in a passenger station or at some other strategic point to house wayside ATC equipment including a Remote Terminal Unit. A major wayside control point for the ATC system.
258. Trunk:
   a. A one or two-way channel connecting two telephone central offices, or a central office and an individual terminal.
259. Vehicular Radio:
   a. Radio transmitter/receiver and associated equipment designed to be installed in and operated from vehicles.
260. Voltage Standing Wave Ratio (VSWR):
   a. The ratio of the highest to the lowest voltage of a standing wave at a feed through point.
261. Wayside Telephone System:
   a. A subsystem of the WMATA Telephone System.
262. Wet Contact:
   a. An electrical contact through which direct current flows.
263. WMATA:
   a. Washington Metropolitan Area Transit Authority
264. Headquarters Building:
   a. Jackson Graham Building
      600 Fifth Street, N.W.
      Washington, D.C. 20001

265. WMATA Configuration:
   a. The arrangement of hardware or software, wiring, etc. within the equipment, equipment racks, rooms, or systems utilized by WMATA.
266. WOW:
   a. The slow cyclic deviation of audio signaling power with an approximate period of 0.5 Hz.
267. Yard:

a. A system of Metrorail tracks and buildings within defined limits provided for the make-up of trains, storage of cars, and for cleaning, maintenance, inspection, and repair of trains.

268. Yard Control Room:

a. The room in the yard which contains the yard train control console.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

END OF SECTION

SECTION 16702

COMMUNICATIONS ABBREVIATIONS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Article 1.03 COMMUNICATION ABBREVIATION LIST, of this Section lists various abbreviations for terms and organizations and prescribes the meanings for the abbreviations as used in the Communication Specifications. For further definition of the terms abbreviated, see Section 16701, Definition of Communication Terms.

1.02 SECTION INCLUDES

A. Communication Abbreviation List

1.03 RELATED SECTIONS

A. All Sections in the 16700 and 16800 series.

1.04 COMMUNICATION ABBREVIATION LIST

Abbreviation	Meaning
	A
AAR	Association of American Railroads 50 F St., N.W. Washington D.C. 20001-1564
AASHTO	American Association of State Highway and Transportation Officials
ACD	Automatic Call Distributor
ac	Alternating Current
AFC	Automatic Fare Collection Automatic Frequency Control
AG	Above Ground
AGC	Automatic Gain Control
AHA	American Hardboard Association
AM	Amplitude Modulation
ANSI	American National Standards Institute, Inc. 1819 L Street, NW Suite 600 Washington, DC 20036

amp	Ampere
APAAS	Automatic Public Address Announcement System
APA	American Plywood Association
APL	Average Peak Level
APD	Avalanche Photodiode
AR	As Required
ASCII	American Standard Code for Information Interchange
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASTM	American Society for Testing and Materials 100 Barr Harbor Drive West Conshohocken, Pennsylvania 19428-2959
ATC	Automatic Train Control
AWG	American Wire Gauge

B

BCD	Binary Coded Decimal
BER	Bit Error Rate
BG	Below Ground
bps	Bits Per Second
BUS OCC	Metrobus Operation Control Center
BW	Bandwidth

C

C	Celsius (Centigrade)
CCITT	International Telegraph and Telephone Consultative Committee
CCS	Hundred Call - Seconds
CTV	Closed Circuit Television (System)
CDF	Combined Distribution Frame
CHP	Chilled Water Plant
cm	Centimeter

CMF	Central Maintenance Facility (building) now FMC
COMM	Communications
CPU	Central Processing Unit
CRT	Cathode Ray Tube
CTS	Carrier Transmission System

D

DADS	Data Acquisition and Display System
dB	Decibel
dc	Direct Current
DCDPW	District of Columbia, Department of Public Works
DPS	Drainage Pumping Station
DS	Digital Signal
DTMF	Dual Tone Multiple Frequency
DTS	Data Transmission System

E

ECS	Emergency Communications System
EDADS	Enhanced Data Acquisition and Display System
EE	Emergency Exit
EIA	Electronics Industries Alliance 2500 Wilson Boulevard Arlington, VA 2201
EMS	Emergency Medical Service
EMT	Electrical Metallic Tubing
EPR	Ethylene-Propylene-Rubber
ETS	Emergency Trip Station

F

F	Fahrenheit
FCC	Federal Communications Commission

FD	Fire Department
FDM	Frequency Division Multiplex
FEP	Fluorinated Ethylene Propylene
FIA	Fire and Intrusion Alarm (System)
Fig	Figure
FM	Frequency Modulation
FMC	Facility Maintenance Center
FMFB	Facilities Maintenance Field Base
FMNT	Facilities Maintenance
FOS	Fiber-Optics System
FRE	Fiberglass Reinforced Epoxy
FREC	Fiberglass Reinforced Epoxy Conduit
FRTS	Fire and Rescue Telephone System
FS	Fan Shaft Federal Specification
FSK	Frequency Shift Keying
ft	Foot, Feet
FVD	Flammable Vapor Detection (System)

G

GAC	General Architectural Consultant
GCC	General Construction Consultant
GEC	General Engineering Consultant
GMFB	General Maintenance Field Base (building) now FMFB

H

H	Horizontal
HIB	Halon Interface Box
HVAC	Heating, Ventilation, and Air Conditioning
Hz	Hertz

I

IC	Integrated Circuit
ICEA	Insulated Cable Engineers Association PO Box 440 South Yarmouth, Massachusetts 02664
ID	Identification or Identifier
IDF	Intermediate Distribution Frame
IDW	Intrusion Detection and Warning (System)
IEEE	Institute of Electrical and Electronics Engineers, Inc.
ILD	Injection Laser Diode
IMC	Intermediate Metal Conduit
ips	Inches Per Second
IR	Infrared

J

JEDEC	Joint Electronic Device Engineering Council
JGB	Jackson Graham Building 600 5th St., N.W. Washington, D.C. 20001

K

K	Kelvin
kHz	Kilohertz
km	Kilometer
KTS	Key Telephone System

L

LA	Line Applique
LED	Light Emitting Diode
LF	Linear Feet
LOI	Low Oxygen Index

M

M&TE	Measuring and Test Equipment
mA	Milliampere
Main PABX	Main PABX (at the JGB)
max	Maximum
MDF	Main Distribution Frame
mF	Microfarad
mFd	Microfarad
MHz	Megahertz
min	Minimum or Minute
mm	Millimeter
MPH	Miles Per Hour
MRS	Mobile Radio System
ms	Millisecond
MTBF	Mean Time Between Failures
MTPD	METRO Transit Police Department
MTTR	Mean Time to Repair
MUX	Multiplexer
mV	Millivolt
mW	Milliwatt
µm	Micrometer

N

N	Newton, North
NA	Numerical Aperture
N/A	Not Applicable
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association 1300 North 17th Street Suite 1847 Rosslyn, Virginia 22209

NFPA	National Fire Prevention Association
NIC	Not Included in (this) Contract
NIST	National Institute of Standards and Technology
nm	Nanometer
NRZ	None Return to Zero
NTSC	National Television System Committee

O

O&M	Operations and Maintenance
OCC	Operations Control Center
OCCB	Operations Control Center Bus
OCCB	Jackson Graham Building (formerly the Operations Control Center Building or Operations Command Center Building)
OCCS	Operations Control Center Security (Console)
OD	Outside Diameter
OEM	Original Equipment Manufacturer
OTDR	Optical Time Domain Reflectometer

P

PA	Public Address (System)
PABX	Private Automatic Branch Exchange
PAM	Pulse Amplitude Modulation
PAS	Public Address System
PC	Printed Circuit
PCM	Pulse Code Modulation
PD	Police Department
PEP	Peak Envelop Power
PERS	Passenger Emergency Reporting System
PERT	Program Evaluation and Review Technique
PIN	Positive-Intrinsic-Negative (refers to solid state structure of device)

PLJ	Primary Local Jurisdiction (Radio System)
PM	Phase Modulation
P/O	Part of
Pr	Pair
psi	Pounds Per Square Inch
p to p	Peak to Peak
PT&Z	Pan, Tilt, and Zoom
PVC	Polyvinylchloride

Q

QC	Quality Control

R

RCA	Radio Corporation of America
RCF	Revenue Collection Facility (building)
RCV	Receive
RCVR	Receiver
REA	Rural Electrification Administration
RF	Radio Frequency
RHG	Rotary Hunt Group
RMFB	RAIL Maintenance Field Base
rms	Root Mean Square
ROW	Right-of-Way
RPTR, RPT	Repeater
RTCR	Remote Train Control Room
RTLP	Reference Transmission Level Point
RTRC	Reinforced Thermosetting Resin Conduit
RTU	Remote Terminal Unit
RZ	Return to Zero

S

S&I	Service and Inspection (Yard)
SAS	Supervisory Alarm Subsystem
SCI	Substantial Completion Inspection
SPABX	Satellite PABX
SEJ	Sewage Ejector
SMADS	Station Monitor and Display System
SP	Sump Pump
SPDT	Single-Pole, Double-Throw Contact
SPL	Sound Pressure Level
SPNO	Single-Pole, Normally Open Contact
SPNC	Single-Pole, Normally Closed Contact
SSHB	Standard Specifications for Highway Bridges

T

TBS	Tie Breaker Station
TC	Train Control
TC/COMM	Train Control/Communications
TCR	Train Control Room
TDM	Time Division Multiplex
TDR	Time Domain Refectometry
THD	Total Harmonic Distortion
TPSS	Traction Power Substation
TS,TEL	Telephone System
TV	Television
TX	Transmit

U

UHF	Ultra High Frequency

UL	Underwriters Laboratories
UPS	Uninterruptible Power Supply

V

V	Vertical
Vac	Volts, Alternating Current
Vdc	Volts, Direct Current
Vpp	Volts, Peak to Peak
VS	Vent Shaft
VSWR	Voltage Standing Wave Ratio

W

WDM	Wavelength Division Multiplex
WMATA	Washington Metropolitan Area Transit Authority (METRO). Also referred to as: “the Authority” 600 Fifth St., N.W. Washington, D.C. 20001

X

X	Transmit
XLPE	Cross-Linked Polyethylene
XMT	Transmit
XMIT	Transmit
XMTR	Transmitter

PART 2 PRODUCTS
NOT USED

PART 3 EXECUTION
NOT USED

END OF SECTION

SECTION 16703

COMMUNICATIONS STANDARD SPECIFICATIONS - ENGINEERING SERVICES

PART 1 - GENERAL

1.01 DESCRIPTION OF ENGINEERING SERVICES

A. The Contractor is required, under WMATA Communications Systems Specifications, to design, furnish, install, test, and document communications systems that conform to WMATA operational, performance and other requirements outlined therein. Standard Specifications apply where more specific requirements are not included in other (specific systems) specifications.

1.02 SECTION INCLUDES

A. Standard Specifications for Contractor-furnished engineering services. These Specifications apply to all engineering services and to all equipment 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).

1.03 UNIT PRICES

A. Unit Prices include all Required Contractor furnished engineering services for the communications systems and facilities and incidental items, not specifically mentioned, but required for complete and proper system operation.

1.04 RELATED SECTIONS

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

1.05 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 , Inc. (IEEE).

J. Association of American Railroads.(AAR).

K. WMATA General Provisions and Standards Specifications for Construction Projects.

1.06 SUBMITTALS

A. Submit under provisions of Section 16706.

1.07 ENVIRONMENTAL

A. The communications system/facility shall be such that, when operating within the specified environmental limits, the maximum temperature attained by any component shall be lower than that which will adversely affect the life or performance of equipment.

B. Unless otherwise specified, equipment shall be fully operable without damage or functional degradation under any combination of the following:
   1. Ambient Temperature -18EC to 55EC.
   2. Relative Humidity 0 percent to 95 percent.(This requirement does not apply to equipment installed at the Jackson Graham Building).

C. Permanently mounted equipment, exclusive of the equipment installed and operated in the Jackson Graham Building, shall be so constructed or installed that it will remain fully operative while being vibrated with simple harmonic motion having an amplitude of 0.005 inch (total excursion of 0.01 inch), with the frequency varied uniformly from 10 cycles to 55 cycles per second for a period of 30 minutes in each of three mutually perpendicular planes.

D. All moving contacts (including relay contacts, jack contacts, switch contacts) shall be protected from dust.

E. Equipment panels shall be furnished with dust covers. Proper internal air flow shall be provided when dust covers are in position during operation of the equipment.

F. Unused mounting spaces in equipment racks, equipment cabinets, Kiosk cabinetry and consoles shall be provided with blank panels which are consistent with the arrangement of the assembly.

G. The circuitry of Kiosk equipment panels, yard console equipment panels, and other custom-developed equipment shall be completely enclosed to protect against moisture and dust.

H. Each system, facility, and subsystem element will generally be operated in the unfavorable electrical environment of a Rail Rapid Transit System characterized by heavy direct-current and chopper-controlled pulsating direct-current propulsion equipment, which will cause electrostatic, electromagnetic, and radiated interference. Suitable effective engineering techniques and installation practices shall be incorporated to eliminate the effects of such interference on the performance of the systems, equipment, and devices furnished or installed by the Contractor, and those provided by others for use within or outside of the Metrorail System.

A. Some sources of interference are: 60 Hz ac system, dc traction power system, propulsion power contact shoe and third rail arcing, rotating machinery, lightning discharges and high energy level, chopper-controlled propulsion systems. The arcing between the transit car contact shoe and the third rail which is supplying up to 780 volts dc is a major source of electrical noise. The noise spectrum includes harmonics which vary in amplitude with the change in loading of the section. Relatively high amplitude noise impulses occur throughout the spectrum.

1.08 INTERCHANGEABILITY

A. Standard commercial products shall be furnished whenever such equipment and materials will satisfy the stated Specifications. Suitable modified standard commercial devices shall be furnished when required to satisfy Specification requirements. Custom developed and fabricated equipment units and devices shall be confined to those items for which suitable off-the-shelf commercial products are not available to guarantee compliance with the Specifications. When custom design, fabrication, or assembly is required, every effort shall be made to minimize the number of different modules, solid-state devices, etc. used.

B. With each system, subsystem and facility, two or more like functions shall be performed by identical units. In no case shall the equipment or hardware used in one portion of a system, subsystem or facility be different from that used in another portion to perform the same function under similar operating and environmental conditions.

C. Insofar as possible equipment shall be physically and plug compatible with recent versions of existing Authority equipment performing similar functions and used for comparable applications elsewhere in similar WMATA facilities. The use of adapter plugs, interface boxes, and replacement mounting brackets or enclosures that fit available space and mounting holes may be allowed by the Engineer to maintain interchangeability, when competitive products that do not require such devices are determined to be unavailable (applicable to off-the-shelf major equipment items only). Custom designed and custom fabricated equipment must be fully interchangeable without requiring the use of such devices. If a determination is made to allow use of such devices, the Contractor shall provide all necessary adapters and interface devices with each item of equipment furnished, at no additional cost to the Authority.

D. Major items of equipment furnished by the Contractor shall be within the physical size and configuration limitations specified in provisions of this Contract. If such specifications are not included in the provisions of this Contract, major items of equipment shall be of a physical size and configuration closely comparable to equipment currently in use for comparable applications elsewhere in similar WMATA facilities.

E. Exception: Lighter weight and smaller sized, more modern versions of equipment are sought by the Authority where their use presents significant advantages. The use of new generations of equipment that differ in size and are not fully interchangeable will be considered for approval by the Engineer, in order to take advantage of significant technological improvements developed by industry.

1.09 MAINTAINABILITY AND RELIABILITY

A. The physical and mechanical configurations of equipment and rack assemblies shall give a high priority to the ease with which units may be inspected and removed.

B. Except as otherwise specified, rack mounted equipment shall be mounted on standard equipment racks or in standard equipment cabinets. Each rack and cabinet configuration shall present a neat and orderly appearance and shall be uniform for like systems/facilities at all Communications Equipment Rooms.

C. Equipment units or subassemblies shall be easily removable from rack, cabinet, or equipment cases without the need to disturb unit rack/cabinet/case wiring.

D. Equipment units shall utilize plug-in printed circuit cards or plug-in assemblies whenever the quantity, equipment, size and weight of the components lend themselves to this technique

E. Printed circuit cards in rack mounting equipment units shall plug into either card files or card drawers, whenever feasible and practical.

F. Printed circuit cards shall be keyed to prevent incorrect interchange of cards. However, cards performing a given function in a subsystem or subsystem element shall be interchangeable with cards of another subsystem element performing the same function whenever practical.

G. The replacement of a printed circuit card plug-in subassembly, or component by a new unit shall not require compensating adjustments of devices other than the circuit card or component replaced.

H. Equipment and installation engineering services and designs shall incorporate accepted industry standards and good engineering practices selected to enhance maintainability and reliability.

I. Test points shall be provided for printed circuit cards to permit detection of a failure without removal of wiring. Go/No-Go techniques shall be used to localize failures where possible. Card extenders may be used for this purpose.

J. Test points shall be readily accessible and clearly designated, and shall be capable of accepting probes and connectors furnished with standard test equipment. All testing shall be performed at the front of racks whenever practical.

K. Appropriate equipment, electrical test points, fuses, and adjustment controls shall be available at the front panel.

L. Equipment units shall be of ample capacity and of proper arrangement to perform the functions specified, under the conditions specified, and shall operate in accordance with the specified reliability criteria.

1.10 CUSTOM DEVELOPED AND CONTRACTOR MODIFIED OFF-THE-SHELF EQUIPMENT

A. The construction, panel and chassis layouts, circuit arrangements, components, graphics, and component layouts of custom-developed equipment shall be approved by the Engineer. Drawings detailing all aspects of the developed equipment shall be submitted for preliminary review and comment. The submitted drawings shall include details of the required external connections. After incorporating the comments and obtaining acceptance by the Engineer, the Contractor shall fabricate prototypes of the custom-developed equipment (one for each custom-developed item) in accordance with the approved configurations. The prototypes shall be submitted for evaluation, inspection, testing, and acceptance or rejection by the Authority. Production models shall not be manufactured until the acceptance of the corresponding prototype by the Engineer (including incorporating any additional comments). Only production models shall be furnished to fulfill the requirements of these Specifications.

B. Contractor modified "off-the-shelf" commercial product major items shall be subject to the same review, and all prototype requirements specified above for custom developed equipment, except as otherwise directed by the Engineer. Relief from these requirements will be considered in instances where only minor modifications are proposed.

C. At the discretion of the Engineer, equipment developed and manufactured specifically to fulfill a WMATA requirement, although considered by the manufacturer as "off-the-shelf," shall be considered as developed equipment and shall comply with the requirements specified herein.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

END OF SECTION

SECTION 16704

COMMUNICATIONS STANDARD SPECIFICATIONS - INSTALLATION

PART 1 -GENERAL

1.01 SECTION INCLUDES

A. Standard Specifications for Contractor-furnished installation services. These Specifications apply to all Contractor installation services, 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). Unless otherwise specified, communications, electronics and electrical installations shall be governed by the provisions of the "National Electrical Code, Standard of the National Board of Fire Underwriters for Electrical Wiring and Apparatus." All provisions of this code must be considered applicable, whether specifically mentioned in the body of these Specifications or not. In no case shall the installation in one portion of the system be different from the installation in other portions for similar configurations under similar operating and environmental conditions, unless specified.

1.02 UNIT PRICES

A. Unit Prices include all Required Contractor furnished installation services for the communications systems and facilities and incidental items, not specifically mentioned, but required for complete and proper system operation.

1.03 RELATED SECTIONS

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

1.04 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.

1.05 SUBMITTALS

A. Submit under provisions of Section 16706.

1.06 CONDUIT PLANT

A. Unless otherwise specified, all wiring in structures and tunnels that is external to equipment enclosures and racks, shall be installed in suitable Intermediate Metal Conduit (IMC), or shall be installed in existing cable tray, underfloor duct, or racked to existing channel inserts on tunnel walls, if space is available and assigned by the Engineer. All conduit and cable installations shall be subject to the approval of the Engineer.

B. Available embedded conduit will be assigned for use by the Contractor when not reserved for other requirements. Conduit cleaning, the construction of conduit extensions or rearrangements, cable rerouting, and the construction of conduit plant to enclose all remaining wiring shall be furnished by the Contractor. Surface conduit construction shall not be permitted in most public areas of stations or in a few other places. Core boring of structures may be required to obtain means of passage during conduit plant construction.

C. Inside diameters of conduit shall be determined by the Contractor, based on the NEC, using the appropriate fill factors for the class of service and number and size of conductors. The proposed conduit sizes shall be submitted to the Engineer for approval. Conduits smaller than 0.75 inch shall not be used.

D. All exposed conduit runs shall be installed parallel to walls, floors and ceilings, whenever possible, except where pitch is required for proper drainage. Conduits shall be rigidly

supported at intervals not to exceed eight feet. Standard one-hole, malleable iron galvanized pipe straps of the proper size shall be used for single conduit runs on concrete surfaces. Where conduits are supported on concrete surfaces, machine-bolt type expansion shields and bolts of the proper size shall be used. All screws, bolts and fittings for conduit supports shall be galvanized or cadmium plated. Stainless steel 304 conduit spacers shall be used for conduits running on flat surfaces. Standard conduit elbows or field bends are permitted; they shall not be less than the minimum radius, as required by the NEC, .

E. Conduits shall be connected to equipment metal enclosures using two locknuts and a bushing, except where conduit hubs are provided. Where enclosures, fittings with openings, or boxes of any type are installed in locations determined by the Authority to be subject to moisture, watertight conduit fittings shall be used. Watertight covers with seals shall be provided, and approved sealant applied to openings to effectively prevent the entry of moisture.

F. All conduit entering Communications Equipment Rooms of passenger stations and yards shall be covered and sealed. Watertight conduit and cable seals shall be used where the building or structure penetration is at a lower elevation than the manhole or below the water table. Details are furnished in the Information Drawings.

G. All terminal ends of conduits shall be provided with insulated metallic bushings.

H. Whenever a conduit or exposed cable enters or leaves a box, it shall be permanently tagged, external to the box, with a plastic tag approved by the Engineer. The tags shall be permanently stenciled with a number which shall identify the conduit or cable with an assigned circuit.

I. All conduits installed shall be free of burrs and other sharp edges throughout the entire length. Conduit fittings or boxes shall be installed in conduit runs, where required, to limit the number of bends to a maximum of three 90-degree bends or equal. All conduits used shall be thoroughly cleared by pulling through a mandrel tool, and shall be blown clean by forcing compressed air through the run before wires or cables are pulled.

1.07 CUTTING AND PATCHING

A. All necessary cutting and patching of existing construction shall be provided by the Contractor for the installation of the equipment and cables.

B. All cuttings shall be of the appropriate required sizes and shapes for the materials, cables and equipment to be installed. All cuttings shall be performed using the appropriate type of tools and equipment for the corresponding surfaces and material. The locations, sizes, shapes, and methods of performance for all cuttings shall be subject to approval by the Authority.

C. All patching shall match existing adjacent construction to the satisfaction of the Authority, using the best possible workmanship of the various trades involved. All required material, compounds, sealants and hardware for all patching shall be provided. Fire wall integrity shall be maintained in appropriate construction.

D. Services shall be provided by the Contractor for the removal and reinstallation of all necessary existing items (i.e., platform tiles, manhole covers) to accomplish the installations. Replacement shall be provided for any removed items that are damaged or missing during the performance of work, at no additional cost to the Authority. Replacements shall be identical in manufacture and type to the damaged or missing items.

E. All existing items and construction (i.e., platform tiles, plenums, ceilings, floors, lighting fixtures, junction boxes, structures, and finishes) that are damaged, changed, or modified in the performance of work shall be restored to their original condition and/or surfaces. Appropriate required material, hardware, paints, finishes, and compounds shall be provided. Any items that are damaged, which are determined to be unrepairable, are to be replaced at no additional cost to the Authority. Replacements shall be identical in manufacture and type to the damaged items.

1.08 JUNCTION BOXES

A. Junction boxes shall be furnished and installed for terminating cable runs and for pulling of cables. Boxes provided in conduit runs, to minimize the number of 90-degree bends in a run, shall be considered junction boxes, although used only for the pulling of cable.

B. All boxes shall be mounted plumb and level and shall be rigidly anchored to the supporting surface. Machine bolt type expansion anchors shall be used to fasten boxes to concrete surfaces where inserts are not otherwise provided. In no case shall bolts of less than 0.25-inch diameter be used. Stainless steel spacers shall be used on bolts to provide a 0.25-inch air space between boxes and mounting surfaces.

C. All boxes shall have a number stenciled on the cover. Numbers shall identify the service of the circuits in the box, as approved by the Engineer.

1.09 CABLE TRAYS

A. Unless otherwise specified, cable tray construction shall be allowed only in Communications Equipment Rooms and other equipment rooms assigned for the installation of significant quantities of communications-related equipment. Tray supports shall be located on eight-foot centers, maximum, and shall be subject to the approval of the Engineer. Sufficient supports shall be provided to keep the loaded cable tray deflection to 0.25 inch maximum at mid-span. Tray supports and trays shall be mounted plumb and level.

B. Tray supports, angle iron, or prefabricated channels shall be anchored to ceilings or walls by machine-bolt type expansion anchors and 0.5-inch minimum diameter bolts. Where cable tray fittings occur in a run, trays shall be supported immediately adjacent to, and on both sides of, the fittings.

C. Trays shall be bolted to support members. Precautions shall be taken to prevent anchoring bolts from damaging cables placed in the trays.

D. Cable tray fill shall not exceed 75 percent of the cross-sectional area of the tray, assuming an area of each cable to be equal to the square of the cable diameter.

1.10 EQUIPMENT MOUNTING

A. Unless otherwise specified, equipment shall be anchored to the concrete walls, floors, or ceilings by machine-bolt type expansion shields and 0.5-inch minimum diameter bolts. The number of bolts shall be adequate to provide a rigid and safe support. Where required, concrete bases or pedestals shall be provided by the Contractor with anchor bolts cast in place for the mounting of equipment. All equipment shall be mounted plumb and level.

1.11 PAINTING

A. All painted areas damaged in route to, or at the installation site, shall be repainted with matching colors by the Contractor. The surfaces of equipment and material not accessible after mounting shall be painted prior to installation.

1.12 WIRE AND CABLE

A. Powdered soapstone or other suitable lubricating medium non-injurious to insulation shall be used, if required, when pulling wires or cables in conduits or ducts.

B. Each conduit, duct and pipe shall be cleaned before installing cables therein. The conduits, ducts and pipes shall be maintained in a clean and dry condition during the installation process up to and including the time which each conduit, duct, and pipe is sealed

C. Wires shall not cross one another when they are pulled into a conduit nor shall the conductors be pulled tight or kinked in conduit fittings or boxes.

D. Cables shall be laid, not pulled, into trays or in troughs provided by others. Cables shall be installed with a minimum amount of crossover in the trays and troughs and shall not be placed tightly around bends. Where cables enter or leave trays via conduits, such conduits shall be rigidly affixed and supported at their ends by suitable brackets and conduit straps from the sides of the trays.

E. Wires and cables shall be permanently tagged with plastic tags at each entry to and exit from all equipment terminal blocks. Tags shall be permanently marked to identify the system in which the wire or cable is used. Tags and markings shall be subject to the approval of the Engineer.

F. All cable pairs, including spares, shall be terminated on connectors, protectors, or line terminating blocks on the MDF.

G. Solder with a minimum of 60 percent tin and 40 percent lead with non-corrosive flux shall be used in soldering wires and cables.

H. The Contractor shall seal all openings through which cable, conduit and cable trays pass. The material used to seal the openings shall be furnished and installed by the Contractor. It shall be a fire retardant, non-toxic material and shall comply with the local fire prevention code.

I. All exposed wires and cables entering or leaving equipment housing or junction boxes shall be protected from abrasion by sharp metallic edges. Chase nipples shall be provided in openings having conduit hubs. Chase nipples and locknuts shall be provided in drilled or punched openings.

J. The Contractor shall seal all openings in equipment enclosures and junction boxes where exposed cables enter the enclosure or box. A pliable sealing compound made expressly for the purpose shall be furnished and installed after the cables are in place.

K. Nylon straps shall be furnished and installed for bundling and cabling of conductors where two or more single conductors of the same circuit are run exposed in cable trays or in cable troughs. Straps shall be installed approximately every five (5) feet along the cable run. Wires of multi-conductor cables exposed by the stripping of the cable jacket for termination shall be trimmed in a neat, workmanlike manner and tied approximately every three inches with nylon straps. Care shall be taken in terminating or splicing cable. Removal of insulation shall be done in a manner which does not nick the conductor material. In no case shall the conductor be kinked or bent at sharp angles. Smooth bends shall be utilized.

L. Appropriate exposed cables entering or leaving equipment enclosures and junction boxes shall be protected from abrasion by sharp metallic edges. Chase nipples shall be provided in openings having conduit hubs. Chase nipples and locknuts shall be provided in drilled or punched openings.

M. All cables and wires installed in environmental air plenums, cable vaults, and under passenger station platforms shall be placed in appropriately sized electrical metallic tubing (EMT) unless otherwise specified.

N. Appropriate channel inserts, arms and insulators shall be provided to support cables in the manholes of the duct bank.

O. Dewatering and removal of all dirt and trash from trenches, manholes, pull chambers, cable troughs, surface trenches, conduit and duct banks shall be provided prior to, and maintained during, the installation of cables.

P. Cables shall be permanently tagged with plastic tags at each entry to and exit from all junction boxes, cable trays, cable ladders, equipment enclosures, conduits, ducts and pipe. Appropriate identification shall be permanently marked on each tag. These plastic tags shall be provided in two forms: Sleeve and flat. The sleeve form shall be of the heat shrinkable type and shall be properly sized to fit the cable for which it is intended. The sleeve form type may be used on cables with an outer diameter of 1/2 inch or less. The flat form type shall be made of flat sheet stock with slots for installation with nylon tie-wrap fasteners. The markings on the tags shall be provided in a color that will contrast sharply with the color of the associated tags. The plastic tags shall be properly installed.

Q. Low-smoke, low-toxicity (not PVC) plenum rated wire and cable shall be utilized throughout installations of equipment in the Jackson Graham Building Communications Equipment Room (i.e., for cables extending outside of equipment enclosures, for inside plant cables extending to other rooms and floors, but not for outside plant cables extending to areas outside of the building), unless otherwise specified. Exceptions may be allowed by the Engineer when such plenum rated 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.

1.13 DIRECT FIXATION IN TUNNEL AREAS

A. Unless otherwise directed, cables shall be installed along the tunnel walls in an organized fashion within the area allotted for communications cables. Cable crosses shall be kept to a minimum.

B. Channel inserts have been provided by others, mounted on approximately four-foot centers, in the tunnel walls. Stainless steel type fasteners or mounting devices shall be provided to secure the cables to the channel inserts. Cables shall be individually mounted to the channel inserts. Cable shall be secured to each channel insert. The fasteners or mounting devices shall be properly sized to the cable, or shall be adjustable to the proper size to support the cable without undue compression. Prior to cable installation, the channel inserts shall be cleaned and foreign material shall be removed, where necessary.

C. Unless otherwise specified, cables shall be installed on the channel inserts in the space allocated for communications cables.

D. In those areas where the specified locations for cables within the tunnels do not coincide with the channel inserts provided by others, or when channel inserts are not available for communications cables, and as necessary to secure MRS antennas, and other cables,

appropriate type cable ladder with hardware, cement anchors, fasteners, and mounting devices, shall be provided to secure cables to the tunnel structure. Appropriate type cement anchors, fasteners, and mounting devices, shall also be provided to secure cables to the tunnel structure when routed to equipment, equipment housings, junction boxes, terminals, and conduits.

E. Sufficient slack shall be provided in the cables between fasteners and mounting devices to allow for expansion and contraction of the cables without damage to the cables or the fasteners and mounting devices.

F. The Authority is installing Tunnel Ventilation Barriers in the tunnels between passenger stations in the vicinity of some fan shafts. The Contractor shall install communications cables running along the tunnel walls through the cable openings that are provided in the Tunnel Ventilation Barrier structures. Openings are either provided on the side near the cable runs or at the top near the ceiling area of the tunnel.

1.14 CABLE TROUGHS ALONG THE TRACK RIGHTS-OF-WAY

A. Cable troughs along the track rights-of-way are utilized for the installation of Communications cables, Automatic Train Control cables and Traction Power Substation (TPSS) control cables.

B. A vertical metal divider has been installed throughout most of the length of the track right-of-way cable troughs to separate the TPSS control cables from the Automatic Train Control and Communications cables. In some locations, the metal divider has been omitted in favor of a small TPSS-control-cable trough mounted within the regular cable troughs.

C. The following conditions and potential problems with the track rights-of-way cable troughs are noted:
   1. The covers for the cable troughs may not be of uniform length of drilling, i.e., each cover section should be regarded as unique to that particular section of trough.
   2. The pressure of ballast on the outside of all metallic constructed cable troughs may cause the outer side to deflect somewhat when the top covers are removed, a condition which may interfere with reinstallation of the trough covers.
   3. The covers are not watertight.

D. The following required installation services shall be provided by the Contractor when installing cables in the track rights-of-way cable troughs:
   1. Removal of snow, ice, dirt and debris from the metal trough covers to obtain access.
   2. Removal of all the metal trough covers.
   3. Removal of fluids, snow, ice, dirt and debris from the troughs.
   4. Protection of all cables already installed in the cable troughs.
   5. Provision for access to conduits entering the cable troughs (possibility of shifting already installed cables).
   6. Proper reinstallation of the trough covers when cable installation is completed.

1.15 FIBER-OPTIC COMMUNICATION CABLE

A. Splicing of single mode fiber-optic communications cable is authorized only at designated cable terminal locations and in Communications Equipment Rooms (splicing trays or enclosures) at passenger stations and transit yards, and in other approved locations, only when essential to join the ends of one or more standard or larger sized full reels of cable together with one partial reel of cable. Only low loss (0.20 dB or less) fusion type splicing and splicing to factory installed pigtails on connectors will be authorized. Approval of the

exact location and methods utilized to make and protect each splice shall be obtained from the Engineer prior to commencing field work.

1.16 COPPER INSIDE PLANT CABLE

A. Splicing is not authorized in cables within the passenger station limits, or within ancillary structures, garages, parking lots, and transit yard S&I Shop and Operations Buildings.

1.17 COAXIAL, TRIAXIAL AND SPECIAL PURPOSE CABLE

A. Splicing is not authorized in coaxial and triaxial cables, or in cable or cable harnesses designated by equipment manufacturers or the Engineer as "special purpose cable." Properly installed and protected connectors shall be used in lieu of splicing.

1.18 COPPER OUTSIDE PLANT CABLE

A. Outside plant cables extending beyond passenger station limits shall be free of splices, unless approval for splicing is obtained from the Engineer. Approval may be granted for splice(s) in cable runs or CTS cable spans, only if the following conditions exist:

B. No more than one splice in each individual cable run (or individual CTS cable span) shall be authorized except where deemed necessary to join two or more standard sized full reels plus one partial reel of cable together to make up the required length for an individual cable run (or individual CTS cable span) which extends between two cable end terminations.

C. Exception:
   1. Splicing of multi-pair copper CTS cables shall not be allowed within 400 feet of either end of the span.

1.19 SPLICE CASE TYPES

A. Highly durable, watertight splice cases shall be furnished and installed in accordance with the manufacturer's instructions, when splicing is authorized. Filled splice cases shall be utilized when splicing filled cable (REA PE-39 telephone and CTS cable, for example).

1.20 SPLICE CASE (AND FIBER-OPTIC CONNECTOR) TECHNICAL SPECIFICATIONS

A. Splice case (and fiber-optic connector) technical specifications and samples must be submitted to the Engineer for review and approval prior to installation.

1.21 SPLICE CASE PHYSICAL PROTECTION

A. Splice cases must be protected from physical damage and must be accessible (i.e. in manholes, hand-holes, cable troughs, terminal or junction boxes, or other protected locations readily accessible for maintenance purposes.) Splices shall not be placed in conduit.

1.22 MAINTENANCE OF FIBER-OPTIC AND COPPER CONDUCTOR IDENTIFICATION

A. When multi-conductor copper or fiber-optic cables are spliced, the same color code, number and group identification shall be maintained throughout the entire cable run. Conductors and individual fibers shall be clearly identified at both end terminals (or cable ends - if not terminated).

1.23 SIGNAL ATTENUATION, CONTINUITY, CROSSTALK AND GROUNDING

A. Splicing shall be accomplished in such a manner that optical or electrical signal attenuation, discontinuities, or cross-talk, do not appreciably increase as a result of such splicing. Cable shields, armor, and all other metallic elements shall be bonded across splices with copper straps and clamps or other approved hardware, to maintain electrical continuity with less than 0.2 ohm increase in resistance. Grounding for electrical protection shall be accomplished as specified or as approved by the Engineer (or, if not specified or detailed in the Engineer's approval, in accordance with applicable NEC provisions).

1.24 AS-BUILT RECORD DRAWING REQUIREMENTS

A. The Contractor shall clearly indicate the location, size, and type of all splices and terminals on As-Built Record Drawings.

1.25 EQUIPMENT ENCLOSURES AND JUNCTION BOXES

A. All equipment enclosures and junction boxes shall be mounted plumb and level, and shall be rigidly anchored to the supporting surface. Appropriate type expansion anchors and bolts shall be used to fasten the enclosures and boxes to support surfaces. An adequate number of bolts of the proper diameter with lock washers shall be used, but in no case shall bolts of less than 0.25 inch diameter be used. Stainless steel 304 spacers shall be used on bolts to provide a 0.25-inch air space between all enclosures/boxes and mounting surfaces.

B. Where equipment enclosures and junction boxes are to be mounted on walls of material other than concrete, the method of mounting and the hardware to be used shall be approved by the Authority.

C. All junction boxes and equipment enclosures shall have a unique identification stenciled on one exposed accessible surface and on the exterior of the cover. The painted stencil markings shall be applied with a procedure that produces clear, legible letters/numbers without voids and without paint running between the stencil and the surface being marked. The marking paint shall provide a definite contrast with the surface on which it is applied.

1.26 BURIED CABLES

A. When direct burial of cable is specified, the following shall apply:
   1. Only cable and wire specified by the manufacturer to be for direct burial shall be buried.
   2. Cable shall be buried not less than 42 inches below grade and shall be below the frost line. The cable trench shall have a minimum width of 12 inches or three times the cable diameter, whichever is greater. The trench floor shall be free of rock, roots and debris, and shall provide a smooth bed for the cable. A minimum of four inches of sand shall be placed on the trench floor. The cable shall be placed in the trench, on the top of the sand, with slack and without kinks or bends. The cable shall be covered with four inches of sand before backfilling. If the trench spoil is used for backfill, it shall be free of rock, stone and debris. The backfill shall be compacted and leveled at specified grade. At no time shall a communications cable or wire be buried within 12 inches of a power conductor.
   3. The Contractor shall provide all shoring required. The Contractor shall mark the cable trench for future location and identification.

4. No digging below the ties within the trackbed shall be permitted. The trackbed is defined as the area along the track extending one foot beyond the end of each track tie.
5. When it is necessary to drive conduit under the trackbed, Authority approval shall be obtained for each case prior to commencement of work. The request for approval shall include details on the type of conduit, depth below surface and method.
6. All wires and cables shall be tested after installation as detailed in Table 3.22-1 and other applicable specification provisions. Installation Completion Tests shall verify that cable shields and armor are bonded across each splice or junction box authorized (if any), and that twisted pairs maintain their identity and continuity end-to-end without crosses, shorts, opens, transpositions or splits. Insulation resistance tests shall be made either with an insulation resistance test set or a dc megohm meter utilizing a test voltage of 250 Vdc or greater, and shall be made in the presence of the Engineer's representative.

1.27 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 rights-of-way, and in all ancillary structures that are open to tunnels (vent shafts, fan shafts, pumping stations, etc. - 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. Exception: Galvanized conduit may be used with stainless steel 304 mounting hardware. Electronic equipment connectors, and other relatively small sized specialty items that are not available in Stainless Steel 304 material may be allowed by the Engineer as exceptions (Ref. Article 3.1 Request for Approval Of Minor Technical Specification Deviation).

C. Unless otherwise specified, stainless steel equipment enclosures, cabinets, and boxes with dull gray colored epoxy paint applied shall be utilized in areas where surface glare may be visible to rail car operators, to avoid glare.

D. Definitions: "Hardware" includes bolts, screws, clamping devices, anchoring devices, threaded rods, nuts, washers, hangers, covers/wall plates etc. "Boxes" includes junctions boxes, outlet boxes, disconnect switch boxes, circuit breaker boxes, and terminal boxes, etc. "Cabinets" includes terminal cabinets, equipment cabinets, MDF cabinets, and power distribution panelboards. (Note: Definitions include, but are not limited to, the items listed herein.)

TABLE 3.22-1

INSTALLED CABLE AND WIRE CONTINUITY
INSTALLATION RESISTANCE AND MISCELLANEOUS TEST REQUIREMENTS

Application	Type(s)/ Characteristics	Continuity Conductor loop	
(Tunnel, wall shaft, duct bank and direct burial outside plant applications - terminal-to-terminal, including extensions through en-trance conduits and to inside terminal(s)).	Jacketed, armored, shielded, filled, twisted multipair cable with or without compartmentalized core	resistance, each pair:	Required Minimum Reading Calculated Value
		Shield resistance, each:	±7%
		Armor resistance, each:	±15%
		Insulation Resistance	±20%
		Conductor to Conductor (all):	Megohms
		Conductor (all) to core separator and shield:	
	With Compartmentalized Core	Shield to armor:	500
		Armor to ground:	500
	Without Compartmentalized Core	Armor to ground:	500
		Continuity	50
	Jacketed, shielded, filled or nonfilled, twisted multipair cable	Conductor loop resistance, each pair:	100
		Shield resistance, each:	Calculated Value ±10%
	Jacketed coaxial cable, single center conductor plus shield(s)	Continuity	±20%
		Conductor resistance, each:	
		Shield resistance, each:	
		Insulation Resistance	
		Conductor to shield:	Calculated Value ±10%
		Shield to shield(s) - if applicable:	±20%
		Outer shield to ground:	Megohms
	Insulated wire, 600 volt or less rating		100
		Continuity	
		Conductor resistance:	
		Insulation Resistance	100
		Conductor to Conductors (all) - if applicable:	30
		Conductor (each) to ground:	Calculated Value ±10% Megohms
			10
			10

Measurement
Description

NOTES:

1. Additional tests may be required in accordance with other applicable Specification provisions.

2. The Authority may require the testing, or may elect to re-test, the insulation resistance of tunnel wall, duct bank, or direct burial outside plant cable during periods of high dampness or high ground water. Any single failure to obtain the minimum required readings shall be considered conclusive in determining that defects requiring Contractor repair or replacement are present.

3. Disconnect grounded and terminated cable elements as necessary to facilitate testing.

4. Full information concerning the type, application, to/from terminal destinations, junction boxes/splices (if any), size, conductor size, and actual installed length, must be included on test data sheets for each cable tested.

5. Notwithstanding manufacturers specifications or REA standards, cable(s) that does not meet minimum readings specified shall be replaced by the Contractor, at no additional cost to the Authority.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

NOT USED

END OF SECTION

SECTION 16705

COMMUNICATIONS STANDARD SPECIFICATIONS - EQUIPMENT AND MATERIAL

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Standard Specifications for Contractor-furnished equipment and materials. 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).

1.02 UNIT PRICES

A. Unit Prices include all Required conduits and fittings, wiring, and cabling to provide rack, cabinets and enclosures for the communications systems and facilities and incidental items, not specifically mentioned, but required for complete and proper system operation.

1.03 RELATED SECTIONS

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.

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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

1.04 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.

1.05 SUBMITTALS

A. Submit under provisions of Section 16706.

PART 2 - PRODUCTS

2.01 EQUIPMENT RACKS

A. Construction: Open Frame, Aluminum 3-Inch X 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. 12-24.

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.

2.02 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.

2.03 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.

2.04 JUNCTION BOXES

A. Junction boxes shall be constructed of 12-gauge sheet steel, except for sizes 24-inch x 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.

2.05 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 Engineer 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 Engineer 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 Engineer 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 shall be required to furnish and install suitable conduit to Authority standards to accommodate the communications cables required.

2.06 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 a 100 pound per linear-foot load, with a maximum mid-span deflection of 0.25 inch when considered as a simple beam with supports on eight-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.

2.07 CABLE LADDERS

A. Cable ladders shall be prefabricated aluminum, open ladder type, approximately three (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.

2.08 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.

2.09 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 Engineer.

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, pumping stations, etc. - 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 Engineer 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 the Contractor shall 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, covers/wall plates etc. “Boxes” includes junction boxes, outlet boxes, disconnect switch boxes, circuit breaker boxes, and terminal boxes, etc. “Cabinets” includes terminal cabinets, equipment cabinets, MDF cabinets, and power distribution panelboards. (Note: definitions include but are not limited to the items listed herein.)

2.11 ELECTRICAL

A. All electrical and electronic components furnished in accordance with this Contract 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; and
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. Any deviation from these requirements and the requirements detailed herein, including those inherent in standard production equipment, shall be subject to the approval of the Engineer.

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 Engineer.

2.15 INTEGRATED CIRCUITS

A. All integrated circuits (ICs) shall be available from at least two manufacturers. The Contractor shall 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/or outputs.

2.16 TRANSFORMERS

A. All transformers provided under this Contract shall be of air-cooled, dry type, unless otherwise approved by the Engineer.

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 .0002 dynes per sq. cm., at a distance of three 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 under this Contract 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 Engineer. 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 Engineer. 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 shall 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 Engineer.

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, toggle, etc.), the operation of the pushbuttons and switches (momentary action, maintained action, etc.), and the configuration of the pushbuttons and switches on developed equipment shall be determined by the Contractor and approved by the Engineer. 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 Engineer, 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 ±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-thru 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, mounting hardware, etc.) 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 Engineer 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 ten inches. Where more than one twisted pair is included, length of lay of adjacent pairs shall differ by at least one-half 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-I 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

3.01 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 16706

COMMUNICATIONS SYSTEM SUBMITTALS & SERVICES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Submittal procedures.

B. Construction progress schedules.

C. Proposed Products list.

D. Product Data.

E. Shop Drawings.

F. Contract Record Drawings

G. Spare Parts

H. Equipment Manuals

I. Training

J. Samples.

K. Design data.

L. Test reports.

M. Certificates.

N. Manufacturer's instructions.

O. Manufacturer's field reports.

1.02 RELATED SECTIONS

A. Division 1

B. Section 16707 - Communications Systems Quality Assurance & Testing.

1.03 REFERENCES

A. AGC (Associated General Contractors of America) publication "The Use of CPM in Construction - A Manual for General Contractors and the Construction Industry."

1.04 SUBMITTAL PROCEDURES

A. Transmit each submittal with Engineer accepted form.

B. Sequentially number the transmittal form. Revise submittals with original number and a

sequential alphabetic suffix.

C. Identify Project, Contractor, Subcontractor or supplier, pertinent drawing and detail number, and specification section number, as appropriate.

D. Apply Contractor's stamp, signed certifying that review, approval, verification of Products required, field dimensions, adjacent construction Work, and coordination of information is in accordance with the requirements of the Work and Contract Documents.

E. Schedule submittals to expedite the Project, and deliver to Engineer. Coordinate submission of related items.

F. For each submittal for review, allow 30 days excluding delivery time to and from the contractor.

G. Identify variations from Contract Documents and Product or system limitations that may be detrimental to successful performance of the completed Work.

H. Provide space for Contractor and Engineer review stamps.

I. When revised for resubmission, identify all changes made since previous submission.

J. Distribute copies of reviewed submittals as appropriate. Instruct parties to promptly report any inability to comply with requirements.

1.05 CONSTRUCTION PROGRESS SCHEDULES

A. Submit initial schedule in duplicate within 20 days after date established in Notice to Proceed.

B. Revise and resubmit as required.

C. Submit revised schedules with each Application for Payment, identifying changes since previous version.

D. Submit a computer generated network analysis diagram using the Program Evaluation and Review Technique (PERT) Technique method, as outlined in AGC - The Use of CPM in Construction.

E. Show complete sequence of construction by activity, identifying Work of separate stages and other logically grouped activities. Indicate the early and late start, early and late finish, float dates, and duration.

F. Indicate estimated percentage of completion for each item of Work at each submission.

G. Indicate submittal dates required for shop drawings, product data, samples, and product delivery dates.

1.06 PROPOSED PRODUCTS LIST

A. Within 30 days after date of Notice to Proceed, submit list of major products proposed for use, with name of manufacturer, trade name, and model number of each product.

B. For products specified only by reference standards, give manufacturer, trade name, model or catalog designation, and reference standards.

C. The Contractor shall use the major products described in the Communications Sections when practical, to avoid increasing WMATA's maintenance requirements.

D. If "equal" products are proposed by the Contractor, he shall insure that the proposed products will interface and operate properly with other Contractor-supplied products, subsystems and systems, and with existing communications products, subsystems, and systems.

E. Whenever the Contractor proposes a new major product (one where salient characteristics have been described in any Communications Section) that has not been previously used on the Transit System, the Contractor shall include that new product in his training program to be conducted for WMATA operations and maintenance personnel.

1.07 PRODUCT DATA

A. Product Data For Review:
   1. Submitted to Engineer for review for the limited purpose of checking for conformance with information given and the design concept expressed in the contract documents.
   2. After review, provide copies and distribute in accordance with SUBMITTAL PROCEDURES article above and for record documents purposes.

B. Product Data For Information:
   1. Submitted for the Engineer's review.

C. Product Data For Project Close-out:
   1. Submitted for the Authority's benefit during and after project completion.

D. Submit the number of copies that the Contractor requires, plus two copies that will be retained by the Engineer.

E. Mark each copy to identify applicable products, models, options, and other data. Supplement the manufacturers' standard data to provide information specific to this Project.

F. Indicate Product utility and electrical characteristics, utility connection requirements, and location of utility outlets for service for functional equipment and appliances.

G. After review distribute in accordance with the Submittal Procedures article above and provide copies for record documents.

1.08 SHOP DRAWINGS

The Contractor is not required to prepare new Shop Drawings for the Kiosk Fabrication. The Contract Drawings specify the details for fabrication of the Kiosk. These Kiosk Fabrication Drawings may be submitted by the Contractor as Shop Drawings, with a notation on each drawing stating that the Contractor has elected not to change the drawing, or with the Contractor's changes clearly marked. Alternatively, the Contractor may elect to submit individual sheets of Contractor developed Shop Drawings, which replace specific Kiosk Fabrication Contract Drawing Sheets.

A. The Contractor shall, unless otherwise directed, submit one reproducible original and four black ink on white paper copies of all communications system shop drawings to the

Engineer for approval using standard transmittal forms in accordance with detailed instructions furnished by the Engineer. Shop drawings shall be 11" x 17" except for drawings designated by the Authority to be full size.

B. The Contractor shall develop an Engineering Drawing Index which shall be submitted to the Engineer for review and approval. The drawing index shall include descriptive titles, drawing numbers, revision numbers, and the dates of completion of drawings for communications systems and facilities covered in these Specifications and for all Contractor-furnished equipment. The Engineering Drawing Index shall be definitive as to the availability and content of subsequent drawings. It shall be compatible in format and drawing number sequence with Authority Drawing Index for previous Communications Contracts and subject to approval .The Engineer shall assign the drawing number sequence. The drawing number sequence shall be 15XXX. The Contractor shall be responsible for maintaining, revising and updating the Engineering Drawing Index for the duration of the Contract. The Engineering Drawing Index shall be revised and updated quarterly, or as required by the Engineer. A completed Final Drawing Index shall be provided to the Engineer at the conclusion of the Contract.

C. Shop drawings shall be complete, detailed and dimensioned. All necessary shop drawings shall be provided for use in fabricating, assembling, handling, erecting, installing, connecting, trouble-shooting, testing, and maintaining each complete system/facility, all changes to existing systems, facilities and equipment, and all equipment furnished, as follows:

1. Equipment installation drawings, including sections, elevations, and floor plans showing dimensions necessary for installation, equipment base or mounting details, and location of entrance/exit for cable(s).
2. Outline drawings indicating overall dimensions, aisle space requirements, locations of all devices mounted on equipment racks/cabinets and panels, locations of all terminal blocks or connectors for connections to external cable, and removable plates for cable entry; sufficient detail shall be provided to show accessibility for maintenance.
3. Complete detail system/facility block and level diagrams for each system/facility and for all equipment that is provided by the Contractor; each block shall represent one specific function, and each apparatus shall be divided into as many blocks as required. Such system/facility diagrams shall also include existing equipment details.
4. Complete cable/wire plan and riser diagrams for each system/facility and all equipment that is provided by the Contractor; including designations, destinations, color codes, and termination details for the conductors of each cable and wire.
5. Separate and complete schematic and logic functional diagrams for circuits of equipment furnished by the Contractor; circuits which are repetitive may be shown as a single schematic and/or logic functional diagram with identical parts indicated. All variations in circuitry must be clearly shown on individual diagrams for each subsystem. Notes which indicate exceptions to typical layout schematics or logics will not be acceptable. Schematic and logic diagrams shall indicate signal flow for all inputs and outputs, bus connections, and all terminal points for external connection. These shall be clearly identified and in agreement with corresponding terminal points on the wiring diagrams. Functional blocks plus their module schematic diagrams on separate drawings will be acceptable for solid-state portions of the logic servicing a specific function. Logic diagrams and schematic diagrams shall conform to the applicable IEEE standards or to alternate approved standards.
6. Interconnecting wiring drawing(s) for each piece of equipment, indicating all terminal points for external cable connections, including cable designations, wire

colors or designations; the number of conductors in each cable; and the destination of each cable, by reference to the appropriate unit and Contractor's drawing number or point device and drawing number as provided in the Contract Drawings.

7. Wiring drawings with all terminals, relays, modules, and other devices shown in their relative physical locations shall be provided. Each drawing shall indicate exact point-to-point connections between interconnected devices and between devices and terminals for external connections. Wire lists and cable running lists will be accepted if they include a description and a diagram of the system/facility. The Contractor shall be responsible for the accuracy of the wiring, terminal point identifications, device identifications, and device designations which shall be in exact agreement with schematic functional diagrams accepted by the Engineer.
8. Schematics and wiring diagrams for all printed circuit boards with all electronic components and test points shown in their relative locations.
9. Both the schematic functional diagrams and the wiring drawings shall indicate all the points essential for troubleshooting, with their respective operating voltage levels, logic state, current, or other applicable measurable parameters.
10. Fabrication and assembly drawings for developed equipment, including panel and chassis layouts, circuit designs, components, graphics, component layouts and list of material.
11. Additional requirements specified in the various Communications Sections.

D. Groups of associated drawings shall be submitted together, so that Authority reviewers can evaluate the composite design and interface considerations involved for specification compliance. Submissions not in compliance with the foregoing requirement may be returned by the Authority without action.

E. Separate drawings shall be furnished for each passenger station, building structure, yard, and site along the right-of-way. Notes which indicate exceptions to a typical drawing for a passenger station, building structure, yard, or site along the right-of-way shall not be acceptable.

F. During construction, (after Shop Drawing approval) the Contractor shall maintain for inspection by the Engineer a record set of Shop Drawings annotated to show all authorized changes incorporated as work progresses. Three set of annotated Shop Drawing shall be submitted not later than three working days after changes are authorized by the Engineer. Information shall include, but not be limited to, the following:

1. Field changes of any type.
2. Changes accomplished by Change Orders (Change Orders may also specify requirements for the prior submission and approval of Shop Drawings before work commences).

G. Before Substantial Completion Inspection (SCI), the Contractor shall furnish to the Engineer one set (2 vellum and 1 black on white paper print) of Shop Drawings for the record, all clearly revised and completed and brought up to date, showing the permanent construction as actually accomplished. Not later than 15 calendar days after Substantial Completion, updated shop drawings shall also be submitted on electronic media (optical compact disk or 3.5 inch magnetic disk) using either AutoCad Version 14 (.DWG) or other Authority approved drawing file formats. In addition to these submission requirements for SCI, additional submissions are required subsequently in accordance with the CONTRACT RECORD DRAWINGS article.

H. Work in the Contract requires modifications, reconfigurations and connections of various existing communications systems and facilities in the passenger stations, transit yards, sites along the rights-of-way and the Jackson Graham Building. Upon request by the Contractor,

and approved by the Engineer, existing Authority Record Drawings may be obtained to incorporate the requirements of this Contract and may be submitted as Contract Shop Drawings. Process for utilizing the Authority Record Drawings shall be in accordance with the requirements of the CONTRACT RECORD DRAWINGS article of this Section.

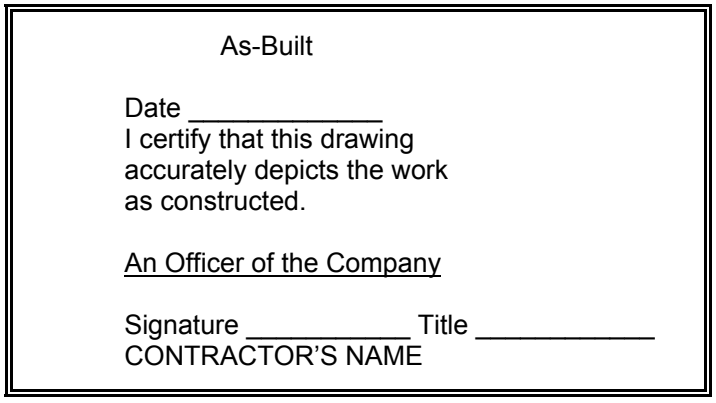
1.09 CONTRACT RECORD DRAWINGS

A. General:

1. Before the scheduled date of the Final Acceptance of all Contract work, the Contractor shall submit approved as-built mylar original drawings, electronic media, and microfilmed aperture cards for the completed work.
2. As-built drawings shall be on 22 inch by 34 inch Mylar.

B. As-built Drawings:

1. As-built CONTRACT RECORD DRAWINGS shall include Installation Drawings, Shop Drawings, Working Drawings, kiosk data file drawings and revisions to all affected existing Authority Record Drawings.
2. Authority Record Drawings are as-built drawings provided to the Authority in previous communications contracts. The Contractor shall coordinate with the Authority to determine which existing Authority Record Drawings require revisions.
3. The Authority will furnish the original mylars of the Authority Record Drawings which require revisions from which the Contractor shall make reproductions for his use in preparing as-built drawings. Such reproductions shall be on three-mil plastic film for black line Diazo printing, both sides matte, similar to mylar and Estar. Images shall be clear, sharp and readily legible. The original Authority Record Drawings shall be returned to the Authority not later than 10 calendar days after their receipt from the Authority.
4. Revisions to Authority Record Drawings shall match the base drawings in line weights, symbols, and lettering style and size. Drafting shall be performed with AutoCad software, and shall match original Contract Drawings in line weights, symbols, and lettering style and size.
5. The Contractor shall submit three sets of prints of as-built drawings in a timely manner for review and approval.
6. Additions and corrections resulting from Authority review comments shall be incorporated by the Contractor. One mylar original and two copies shall be submitted to the Authority not later than the applicable date specified in the Contract Schedule. Final As-Built Drawings shall also be submitted on electronic media (5 sets of CD-ROM's) using either AutoCAD(.DWG) or other Authority approved drawing file formats.
7. Completed as-built Contract Record Drawings shall bear the signature of an officer of the Contractor's organization, certifying compliance with as-built conditions using a rubber stamp, or electronic facsimile, as follows:



1.10 SPARE PARTS

A. This Contract includes the requirement for Communications spare parts. The Contractor shall assure that all spare parts required by this Contract are provided and delivered in accordance with the requirements of Division 1.

1.11 EQUIPMENT MANUALS

A. The Contractor shall furnish Operations and Maintenance (O&M) Manuals for communications systems, as specified in Division 1. The Contractor shall also furnish complete sets of O&M Manuals for each type and variation of Contractor furnished equipment - including all communications equipment and other electronic equipment and associated peripheral equipment, of the communications systems (Contractor furnished items only - unless otherwise specified). Sets of manuals shall generally describe the operation, specifications and characteristics, theory of operation, maintenance, and trouble-shooting procedures for each type of equipment. Complete parts lists and detailed information concerning specific equipment options installed at WMATA shall be included in equipment manuals. The communications manuals shall be divided into three (3) categories and will meet the additional requirements, as follows:

1. Volume A Manuals shall consist of system-related manual(s) with contents as specified herein.
2. Volume B Manuals shall consist of equipment-related manual(s) with contents as specified herein.
3. Manufacturers Service Manuals shall consist of the most complete and most extensive manufacturers' service manual sets available for each item of equipment (applicable to test equipment, or as otherwise specified). (No Contractor furnished supplements or oil resistant covers are required for this category of manuals.)
4. Accurate, technically correct, easily understandable, concise text, charts, tables, illustrations, photographs, and drawings; all of which are directly applicable to the subject matter and are highly appropriate for their intended purpose; shall be provided by the Contractor subject to review and approval by the Engineer.
5. Page layouts, formats, spelling and grammar utilized, and reproduction quality, shall be of good commercial quality and shall be subject to review and approval by the Engineer.
6. Dividers with custom printed tab labels shall be provided for each major subsection (1-1, 1-2, 1-3, etc.), and a distinctive type of divider with custom printed labels shall be provided to separate major parts of each multi-part manual.
7. Secure screw-down, or other equivalent manual bindings shall be furnished by the Contractor, subject to approval by the Engineer. Standard 3-ring binders will not be acceptable for these manuals. Binders shall have front or back (preferably both) pockets for convenient document storage, if this feature is available as an option to the binders otherwise approved by the Engineer.
8. Revision Log sheet shall be included in the front of each manual.
9. The Authority will grant access to all available technical documentation pertaining to prior versions of Communication Systems to aid the Contractor in developing Communication System Manuals.
10. The Authority will provide one copy of manufacturer’s specification sheets for existing equipment installed in prior systems at the start of the Contract. Most of these Specifications will not be of reproducible quality and will require retyping before including them in the manuals. Whenever good reproductions of manufacturers’ specification sheets can be made, especially those with photos or illustrations, their use in manuals is preferred.

B. Adequacy and Completeness

1. Each complete manual set shall contain a significant amount of detail and significant degree of depth of technical content, including all available details for subsystems. Completeness and accuracy to best commercial standards shall be required. Printing, reproduction, drafting, photographs, graphics, illustrations, and organization, shall be to best commercial standards. All manuals shall be written in English. Each individual manual furnished shall be subject to examination by the Authority for Specification compliance. The Engineer will exercise wide latitude in determining Specification compliance, and may reject manual(s) for noncompliance in minor degrees thereof.

C. Volume A System Related O&M Manuals

1. The Contractor shall furnish complete sets of Volume A Manuals for each of the individual systems.

D. Volume B Equipment Related O&M Manuals

1. The Volume B Manuals shall be equipment-related manual(s). Complete sets of the most extensive and complete Manufacturers' Manuals available shall be provided, with contractor-developed supplemental parts lists, data covering specific options utilized at WMATA, etc. - when applicable.
2. As an exception to the requirements stated herein, abbreviated requirements shall apply to all "Test Equipment," and "Additional Equipment" (i.e. only standard Manufacturers' Service Manuals shall be required, in the quantity specified for such equipment).

E. Submittals Required for Each Volume A and Volume B Manual

1. Five copies of sample formats and Table of Contents outlines (with or prior to the Engineering Development Review).
2. Three copies of complete manuals in draft form prior to Installation Completion Testing.
3. See Tables for quantities of final manuals.

Table of Contents Outline with Minimum Content Requirements:
Carrier Transmission System O&M Manual
(Volume A - CTS Systems Manual)

SECTION	TITLE/CONTENTS	QTY	MAKEUP
1-1	**INTRODUCTION** (scope of manual coverage, i.e. all types of carrier transmission systems installed in WMATA passenger stations)	1	page (text)

1-2	**SYSTEM DESCRIPTION** (detailed description of the latest system, with brief information about major differences in prior systems installed in WMATA passenger stations)	9+ 2+ 1+	pages (text) photographs illustration (sketch)
1-3	**SYSTEM SPECIFICATIONS** (complete detailed specifications for the latest system, with major differences for prior versions still in use)	1	table
1-4	**SYSTEM THEORY OF OPERATION** (system theory of operation in detail, covering the latest version of the WMATA Carrier Transmission System)	5+	pages (text)
1-5	**INSTALLED SYSTEM CONFIGURATIONS** (include written and photographic details covering all types of carrier transmission systems in use)	3+ 15+	pages (text) photographs
1-6	**EQUIPMENT LIST** (separate lists for each configuration installed in WMATA passenger stations)	1+	page (text)
1-7	**EQUIPMENT CHARACTERISTICS** (including all models of equipment utilized in various types of WMATA carrier transmission systems)	100+ 60+ 92+	pages (text) photographs tables of equipment specs (derived manufacture's spec sheet info/options, etc.)(WMATA will provide.)
1-8	**SYSTEM TROUBLESHOOTING CHARTS** (decision tree type flow charts, and horiz. symptom/test/result charts)	1+ 4+	page (text) charts
1-9	**SYSTEM/INSTALLATION DRAWINGS** (one complete set of system and installation drawings for the current version system, plus block and level diagrams for each prior version)	8+	drawings

OVERRIDING MINIMUM REQUIREMENT TOTALS

Total Page Requirement includes at least 90 full text pages, plus partial text pages; plus pages with photos, charts, tables, illustrations, and title pages	200 (or more)
Total Drawing Requirement, fold-out sizes	10 (or more)
Grand Total of Pages and Drawings Required (minimum acceptable count)	210

Note: The Engineer may allow minor variations to individual section minimum page requirements, when such actions are in the best interest of the Authority, so long as overriding minimum requirements are satisfied.

Table of Contents Outline with Minimum Content Requirements:
Fiber Optic System O&M Manual
(Volume A - FOS Systems Manual)

SECTION	TITLE/CONTENTS	QTY	MAKEUP
1-1	**INTRODUCTION** (scope of manual coverage, i.e. both types of fiber-optic systems installed in WMATA passenger stations)	1	page (text)
1-2	**SYSTEM DESCRIPTION** (detailed description of the latest system, with brief information about major differences in prior system installed in WMATA passenger stations.)	9+ 2+ 1+	pages (text) photographs illustration (sketch)
1-3	**SYSTEM SPECIFICATIONS** (complete detailed specifications for the latest system, with major differences for prior versions still in use)	1	table
1-4	**SYSTEM THEORY OF OPERATION** (system theory of operation in detail, covering the latest version of the WMATA Fiber-Optics System)	5+	pages (text)
1-5	**INSTALLED SYSTEM CONFIGURATIONS** (include written and photographic details covering all types of fiber optic systems in use)	3+ 15+	pages (text) photographs
1-6	**EQUIPMENT LIST** (separate lists for each configuration installed in WMATA passenger stations)	1+	page (text)
1-7	**EQUIPMENT CHARACTERISTICS** (including all models of equipment utilized in various types of WMATA fiber optic systems)	20+ 10+ 10+	pages (text) photographs tables of equipment specs (derived manufacture's spec sheet info/options, etc.)(WMATA will provide.)
1-8	**SYSTEM TROUBLESHOOTING CHARTS** (decision tree type flow charts, and horiz. symptom/test/result charts)	1+ 4+	page (text) charts
1-9	**SYSTEM/INSTALLATION DRAWINGS** (one complete set of system and installation drawings for the current version system, plus block and level diagrams for each prior version)	8+	drawings

OVERRIDING MINIMUM REQUIREMENT TOTALS

Total Page Requirement includes at least 60 full text pages, plus partial text pages; plus pages with photos, charts, tables, illustrations, and title pages)	125
Total Drawing Requirement, fold-out sizes	10
Grand Total of Pages and Drawings Required (minimum acceptable count)	135+

Note: The Engineer may allow minor variations to individual section minimum page requirements, when such actions are in the best interest of the Authority, so long as overriding minimum requirements are satisfied.

Table of Contents Outline with Minimum Content Requirements:
Telephone System O&M Manual
(Volume A - TEL Systems Manual)

SECTION	TITLE/CONTENTS	QTY	MAKEUP
1-1	**INTRODUCTION** (scope of manual coverage, i.e. all types of telephone systems installed in WMATA facilities) (WMATA will provide sections for Telecommunication Network and PABX System for insertion in this section.)	1	page (text)
1-2	**SYSTEM DESCRIPTION** (detailed description of the latest system, with brief information about major differences in prior system installed in WMATA facilities) (WMATA will provide sections for Telecommunication Network and PABX System for insertion in this section.)	9+ 2+ 1+	pages (text) photographs illustration (sketch)
1-3	**SYSTEM SPECIFICATIONS** (complete detailed specifications for the latest system, with major differences for prior versions still in use) (WMATA will provide sections for Telecommunication Network and PABX System for insertion in this section.)	1+	table
1-4	**SYSTEM THEORY OF OPERATION** (system theory of operation in detail, covering the latest version of WMATA telephone systems) (WMATA will provide sections for Telecommunication Network and PABX System for insertion in this section.)	5+	pages (text)
1-5	**INSTALLED SYSTEM CONFIGURATIONS** (include written and photographic details covering all types of telephone systems in use) (WMATA will provide sections for Telecommunication Network and PABX System for insertion in this section.)	3+ 15+	pages (text) photographs
1-6	**EQUIPMENT LIST** (separate lists for each configuration installed in WMATA passenger stations) (WMATA will provide sections for Telecommunication Network and PABX System for insertion in this section.)	1+	page (text)
1-7	**EQUIPMENT CHARACTERISTICS** (including all models of equipment utilized in various types of WMATA telephone systems)	8+ 8+ 8+	pages (text) photographs tables of equipment specs (derived manufacture's spec sheet info/options, etc.)(WMATA will provide.)
1-8	**SYSTEM TROUBLESHOOTING CHARTS** (decision tree type flow charts, and horiz. symptom/test/result charts)	1+ 4+	page (text) charts

1-9	**SYSTEM/INSTALLATION DRAWINGS** (one complete set of system and installation drawings for the current version system, plus block and level diagrams for each prior version) (WMATA will provide sections for Telecommunication Network and PABX System for insertion in this section.)	8+	drawings

OVERRIDING MINIMUM REQUIREMENT TOTALS

Total Page Requirement includes at least 90 full text pages, plus partial text pages; plus pages with photos, charts, tables, illustrations, and title pages)	260+
Total Drawing Requirement, fold-out sizes	15+
Grand Total of Pages and Drawings Required (minimum acceptable count)	275+

Note: The Engineer may allow minor variations to individual section minimum page requirements when such actions are in the best interest of the Authority, so long as overriding minimum requirements are satisfied.

Table of Contents Outline with Minimum Content Requirements:
Mobile Radio System O&M Manual
(Volume A - MRS Systems Manual)

SECTION	TITLE/CONTENTS	QTY	MAKEUP
1-1	**INTRODUCTION** (scope of manual coverage, i.e. all types of mobile radio systems installed in WMATA facilities) (WMATA will provide brief section on Rail Car radios system.)	1	page (text)
1-2	**SYSTEM DESCRIPTION** (detailed description of the latest system, with brief information about major differences in prior system installed in WMATA facilities) (WMATA will provide brief section on Rail Car radios system)	9+ 2+ 1+	pages (text) photographs illustration (sketch)
1-3	**SYSTEM SPECIFICATIONS** (complete detailed specification for the latest system, with major differences for prior versions still in use) (WMATA will provide brief section on Rail Car radios system)	1+	table
1-4	**SYSTEM THEORY OF OPERATION** (system theory of operation in detail, covering the latest version of WMATA mobile radio systems) (WMATA will provide brief section on Rail Car radios system)	5+	pages (text)
1-5	**INSTALLED SYSTEM CONFIGURATIONS** (include written and photographic details covering all types of mobile radio systems in use) (WMATA will provide brief section on Rail Car radios system)	3+ 15+	pages (text) photographs
1-6	**EQUIPMENT LIST** (separate lists for each configuration installed in WMATA passenger stations and yards) (WMATA will provide brief section on Rail Car radios system)	1+	page (text)

1-7	**EQUIPMENT CHARACTERISTICS** (including all models of equipment utilized in various types of WMATA mobile radio systems)	8+ 8+ 8+	pages (text) photographs tables of equipment specs (derived manufacture's spec sheet info/options, etc.)(WMATA will provide.)
1-8	**SYSTEM TROUBLESHOOTING CHARTS** (decision tree type flow charts, and horiz. symptom/test/result charts) (WMATA will provide brief section on Rail Car radios system)	1+ 4+	page (text) charts
1-9	**SYSTEM/INSTALLATION DRAWINGS** (one complete set of system and installation drawings for the current version system, plus block and level diagrams for each prior version) (WMATA will provide brief section on Rail Car radios system)	8+	drawings

OVERRIDING MINIMUM REQUIREMENT TOTALS

Total Page Requirement includes at least 60 full text pages, plus partial text pages; plus pages with photos, charts, tables, illustrations, and title pages)	230+
Total Drawing Requirement, fold-out sizes	15+
Grand Total of Pages and Drawings Required (minimum acceptable count)	245+

Note: The Engineer may allow minor variations to individual section minimum page requirements when such actions are in the best interest of the Authority, so long as overriding minimum requirements are satisfied.

1.12 TRAINING

A. The objective of the training program shall be to qualify WMATA training instructors, field engineers, and key supervisory personnel to train WMATA maintenance and operating personnel to properly operate, diagnose, troubleshoot and maintain the communications equipment and/or systems provided by, or affected by, work in this Contract.

B. The Contractor shall provide training for Authority training instructors, engineers, key supervisory technical personnel, and a cadre of maintenance personnel. Training in operating and maintaining equipment shall be provided in accordance with these Specifications. Training shall consist of a combination of formal classroom instruction and hands-on equipment training. Classrooms and on-site training locations will be provided by WMATA. All test equipment and tools for training equipment installation and training course work shall be provided by the Contractor, (for both Contractor personnel and WMATA Trainee use) until training is complete.

C. Scope of Training Program

1. The training program shall be devoted to overall system functioning and instruction on key items of equipment. The training shall be a combination of formal and hands-on training, including demonstrations. Training shall be conducted at Authority training facilities.
2. The Contractor shall provide the instruction and training sessions specified herein.
3. As part of the Engineering Development Review, the Contractor shall submit a Training Concept Plan to the Authority for approval. It shall include the subject matter to be covered, a tabulation of the hours of instruction to be provided, and the equipment to be included in the training program. It shall include a list of proposed

Contractor training to be conducted at various Authority facilities and locations. The Authority will select training sessions from this list.

D. Training Course Objectives
1. The Contractor shall develop an individual Training Course designed to cover basic maintenance of the Fiber Optic System using new Training Equipment Mockups supplied by the Contractor.
2. The maintenance course shall provide each student with instruction designed to meet the following objectives:
   a. Understanding of the basic overall operation of the Mockup as it relates to an equivalent installed Passenger Station Communications subsystem.
   b. Understanding of the nature of each of the signal and power inputs and outputs of major Communications equipment items.
   c. Knowledge of the location of all equipment test points and the best strategy for using the test points.
   d. Familiarity with the Operation and Maintenance Manuals, and knowledge of how to contact the equipment manufacturers for parts, and information.
   e. Qualification of the student to begin assuming maintenance (or operations) responsibilities for the system and equipment items.

E. The Contractor's training program shall be conducted by fully qualified instructors. The instructors shall have thoroughly mastered the specific specialized subject matter involved and shall have the ability to impart technical information to others in easily understood terms. The Contractor shall provide a professional resume for each instructor for review and approval by the Authority. Contractor installation, repair and technical personnel shall also be provided to do installation tasks, with WMATA trainee participation (to the extent agreed to by the Engineer).

F. Training Aids and Materials
1. The training shall be organized to make optimum use of Volume "B" O&M Manuals, Contract Specifications and Drawings, approved Progress Review material, approved Contractor Shop Drawings, and the test equipment furnished to the Authority, in accordance with other provisions of this Contract. The Contractor shall furnish all other required training aids and materials necessary for the training program.
2. The Contractor shall provide copies of each Course Outline, copies of each Lesson Plan, copies of Instructor's Guide(s) and copies of Student Work Books. Operations and Maintenance Manuals, Volume "A" System Manuals and Volume "B" Equipment Manuals, furnished by the Contractor, shall be furnished to each student attending the Maintenance Courses, along with additional copies as required.
3. Training materials, such as lesson plans, study guides, and student handouts, as well as training aids, such as transparencies, slides, photographs, dynamic mockups, models for hands-on demonstration training and hardware cut-aways, utilized in the courses shall become property of the Authority.

G. WMATA requires the following training course materials to be delivered by the Contractor, according to the following specifications:
1. An instructor's guide, containing all the information and directions necessary for the instructor to make an effective presentation. It shall include adequate guidelines to conduct a comprehensive training program. Individual lessons within the course shall be organized as separate blocks (or modules) which may be taught individually. The Instructor Guide should contain, at a minimum:
   a. Discussion of student prerequisites (if any);

b. Program overview;
c. Statement of overall program goals;
d. Lesson plans (a session by session outline containing the following):
1) Student learning objectives, stated in measurable terms;
2) Overview of each lesson;
3) Suggested instructional methods/ learning activities;
4) Required equipment and/or resources.

2. Student work books, to include all materials for the student to interact in the learning situation. It shall contain, at a minimum:
a. Program overview/introduction;
b. Statement of overall program goals
c. Learning objectives, stated in measurable terms, that specifically describe desired behaviors or knowledge to be gained;
d. A fully-developed prose treatment (not outline format) of content presentation, developed in the same modular format as the Instructor's Guide;
e. Illustrations, charts, or graphics, as needed to enhance text presentation;
f. Problems/questions related to lesson content, as appropriate.

3. Audio-visual aids, (handouts, transparencies, slides, films, and mock-ups used to conduct the Training Courses).

4. Supplemental materials, a functional mockup, or a functional representation, is required of any equipment item which requires theoretical discussion. This may be in the form of an animated schematic, a model of the equipment, an actual device, an interactive video training device, or a WMATA approved substitute. All mockups become the property of WMATA.

5. The Contractor shall deliver final copies to WMATA as follows:
a. Two complete sets of training materials that are completely camera-ready. Camera-ready copy is defined as typewritten or typeset originals or high-quality copies from which further copies can be made with no noticeable decrease in copy quality.
b. Five copies of all student and instructor materials, to be used for archival purposes in the WMATA Technical Library.

H. The Contractor shall meet the following specifications in instructional delivery.

1. A description of instructor qualifications, resume, curriculum vitae, or other similar credentials must be submitted to WMATA at least 60 days prior to the presentation of training. The description should document a thorough knowledge of the equipment being taught, an understanding of the adult learning process, and demonstrated experience in vocational instruction.

2. The course shall include at least 4 hours of instruction for each major system, and at least 1 hour of instruction for each significant minor system/subsystem (course layout and time allotment shall be submitted for approval by the Authority at least 30 days prior to scheduled classes).

3. For the purposes of course development and presentation, contractors should assume all WMATA students are high school graduates (or equivalent), and that maintenance personnel possess the ability to use basic hand tools and electronic test equipment, and that most trainees have some experience with the systems to be taught.

4. Instructors shall include written and/or practical tests in the Training Courses. Whenever possible, a practical hands-on test shall be developed to demonstrate the transference of operational/ maintenance skills. Results and student evaluations will be provided to the Engineer on a confidential basis, for WMATA use.

1.13 SAMPLES

A. Samples For Review:
   1. Submitted to Engineer for review for the limited purpose of checking for conformance with information given and the design concept expressed in the contract documents.
   2. After review, produce duplicates and distribute in accordance with Submittal Procedures article above and for record documents purposes.

B. Samples For Information:
   1. Submitted for the Engineer's knowledge.

C. Samples For Selection:
   1. Submitted to Engineer for aesthetic, color, or finish selection.
   2. Submit samples of finishes from the full range of manufacturers' standard colors, textures, and patterns for Engineer selection.
   3. After review, produce duplicates and distribute in accordance with Submittal Procedures article above and for record documents purposes.

D. Submit samples to illustrate functional and aesthetic characteristics of the Product, with integral parts and attachment devices. Coordinate sample submittals for interfacing work.

E. Include identification on each sample, with full Project information.

F. Submit the number of samples specified in individual specification sections, one of which will be retained by Engineer.

G. Reviewed samples that may be used in the Work are indicated in individual specification sections.

H. Samples will not be used for testing purposes unless specifically stated in the specification section.

1.14 DESIGN DATA

A. Submitted for the Engineer's review.

B. Submit for information for the purpose of assessing conformance with information given and the design concept expressed in the contract documents

1.15 TEST REPORTS

A. Submitted for the Engineer's review.

B. Submit test reports for information for the purpose of assessing conformance with information given and the design concept expressed in the contract documents.

1.16 CERTIFICATES

A. When specified in individual specification sections, submit certification by the manufacturer, installation/application subcontractor, or the Contractor to Engineer, in quantities specified for Product Data.

B. Indicate material or Product conforms to or exceeds specified requirements. Submit

supporting reference data, affidavits, and certifications as appropriate.

C. Certificates may be recent or previous test results on material or Product, but must be acceptable to Engineer.

1.17 MANUFACTURER'S INSTRUCTIONS

A. When specified in individual specification sections, submit printed instructions for delivery, storage, assembly, installation, start-up, adjusting, and finishing, to Engineer for delivery to Authority in quantities specified for Product Data.

B. Indicate special procedures, perimeter conditions requiring special attention, and special environmental criteria required for application or installation.

C. Refer to Section 16707 - Quality Control, Manufacturers' Field Services article.

1.18 MANUFACTURER'S FIELD REPORTS

A. Submitted for the Engineer's review.

B. Submit report within 30 days of observation to Engineer for information.

C. Submit for information for the purpose of assessing conformance with information given and the design concept expressed in the contract documents.

PART 2- PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

END OF SECTION

SECTION 16707

COMMUNICATIONS SYSTEMS QUALITY ASSURANCE & TESTING

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. These quality control (QC) system requirements define characteristics, in addition to those in Division 1 of the Specification, of the quality control system that must be implemented by the Contractor during the course of Communications System design, equipment procurement, factory testing, installation and acceptance testing.

B. The Contractor shall provide and maintain a Quality Assurance Plan, and an Inspection and Testing Plan covering the equipment, materials, and services specified herein.

C. The CQCS Quality Assurance Program, Quality Assurance Plan, and Inspection and Testing Plan, including related directives, procedures, processes, instructions, forms and schedules, shall be submitted to the Engineer for approval. The basis for approval shall be the Engineer's acceptance of a document describing how the Quality Assurance Program requirements, set forth herein, shall be met and the acceptance of the form and substance of each document submitted for approval. The approved program and plans shall be used by the Contractor in the performance of any inspection of the equipment, materials and services being furnished. If program/plans are returned as unacceptable, the Contractor shall revise and resubmit the Quality Assurance Program or plans to the Engineer within 30 calendar days.

D. The basis for this quality control (QC) system requirements are the American National Standards Institute (ANSI) Standard ANSI/ISO/ASQC Q9002-1994 entitled "Quality Systems -Model for Quality Assurance in Production and Installation and Servicing.." Quality control systems based on other standards may also be acceptable provided they contain elements that meet these requirements.

1.02 RELATED SECTIONS

A. Division 1

B. Division 16 - Communications Sections

1.03 REFERENCES

A. American National Standards Institute (ANSI) Standard ANSI/ISO/ASQC Q9002-1994

1.04 DEFINITION OF TERMS

A. Quality Assurance Program: The document containing the Contractor's quality-related policies, practices, procedures and methods, which are utilized to assure compliance with Contract Specifications.

B. Quality Assurance Plan: A document detailing how the Contractor will implement the Quality Assurance Program

C. Inspection and Test Plan: A document detailing how the Contractor will inspect and test Contract equipment, materials, workmanship, and services.

D. Inspection: The physical act of verifying, by measurement and examination of the equipment, materials, workmanship, and services, that they conform to approved documents and established quality requirements.

E. Audit: An examination of the Contractor's implementation of the approved Quality Assurance Program for the purpose of determining compliance with and conformance to the Quality Assurance Plan and other related documents.

1.05 QUALITY POLICY

A. The Supplier shall establish and document policies to implement quality control systematically in a manner that meets these QC system requirements. These policies shall be revised or amended until they are accepted by the Engineer.

1.06 QUALITY SYSTEM

A. The Contractor shall document and implement a quality control system consistent with the policies accepted by the Engineer. The quality system shall include:
1. Written procedures and instructions governing the work covered by this contract.
2. Effective and verifiable implementation of these procedures and instructions.

B. Activities affecting quality shall be prescribed via documented instructions, procedures, or drawings of a type appropriate to the circumstances and shall be accomplished in accordance with these instructions, procedures, or drawings.

C. Instructions, procedures, or drawings shall include appropriate measurable or otherwise verifiable criteria for determining that important activities have been satisfactorily accomplished.

1.07 ORGANIZATION

A. The submitted Quality Assurance Program document shall be organized as follows:
1. Name of Contractor and Contract
2. Revision Dates
3. Index
4. Contents

B. The Contractor shall identify the elements of its organization involved with this Contract, including subcontractors and Original Equipment Manufacturers (OEMs), and the scope of responsibility and authority of these parties.

C. Interfaces with OEMs, subcontractors, and WMATA shall be identified and the scope of each group's responsibilities described

D. The responsibility, authority and the interrelation of personnel who manage, supervise, perform and verify work affecting the quality of items intended for WMATA shall be defined, particularly for personnel who must exercise authority to:
1. Initiate, recommend or provide solutions through designated channels to eliminate identified noncompliance or nonconformance,
2. Control further processing, delivery or installation of items until the noncompliance or nonconformance has been corrected, and

3. Initiate action to prevent the occurrence of noncompliance or nonconformance.

E. Inspection and testing functions shall have sufficient resources and organizational independence to perform their responsibilities. Except in-process monitoring, they shall not report to the same management as those who performed the work nor have had input as to how the work was accomplished or accepted.

1.08 SCOPE

A. The Contractor shall provide a statement that identifies the functional areas of Contractor work and the locations where such work is performed. The Quality Assurance Program shall apply to all equipment, systems, and services included in these Specifications, except as otherwise stated. The Contractor's functional work area breakdown shall include, but shall not be limited to, management, engineering, procurement, manufacturing, installation, and inspection.

1.09 SUBMITTALS

A. The Quality Assurance documents shall be submitted within 30 calendar days after Notice-To-Proceed. Contractor test and inspection procedures shall be added to the approved Quality Assurance Program within 30 days after they are developed. Details concerning fabrication processes for equipment and systems that require development shall be added to the approved Quality Assurance Program as the development work progresses (within 30 days after they are developed).

1.10 DELIVERY, STORAGE AND HANDLING

A. The Contractor shall establish and implement measures for maintaining the integrity, security, and acceptability of items during receiving, handling, storage, movement or placement of items.

B. The Contractor shall maintain packing and preservation of items to the extent necessary to ensure conformance with this contract until these items are installed. The packaging of items inspected at the receiving point shall be resealed upon completion of the inspection.

C. The Contractor shall provide secure storage areas to prevent loss of, damage to, or deterioration of items pending their use:
1. Items of different types shall be segregated while in storage;
2. Measures shall ensure that the shelf life of items which deteriorate over time are reported, and that those with expired shelf life are scrapped;
3. Special environment, maintenance (when items are stored for long periods), and stacking limits required by the manufacturer shall be observed.
4. In order to detect deterioration, the condition of items in storage shall be checked and assessed at appropriate intervals.
5. Appropriate methods shall be established for authorizing receipt or release of items at these storage areas.

D. Handling
1. The Contractor shall employ qualified personnel, methods and equipment to prevent damage during handling.
2. Handling equipment and rigging shall be periodically inspected, maintained and tested. Load capacities or ratings shall be visible on the equipment; capacities and ratings shall not be exceeded.

3. Operators shall be trained, and, where required by local codes or elsewhere in this contract, certified. WMATA requirements and rules for use of handling equipment shall also be observed at all WMATA properties, leased premises, or construction sites.

PART 2 - PRODUCT

NOT USED

PART 3 EXECUTION

3.01 QUALITY MANAGEMENT

A. The Contractor shall identify and describe the organizational units having responsibility and authority for development, implementation, and management of the Quality Assurance Program. Achievement of quality objectives shall be verified by individuals and organizations that are responsible for checking, inspecting, auditing, or otherwise verifying that the work has been performed satisfactorily.

B. The Contractor shall identify the program for assuring that sufficient records are maintained to provide documentary evidence of the performance of activities affecting quality and for use in managing the Contract. Typical records shall include Quality Assurance plans, procedures, instructions, nonconformance or defect reports, corrective action reports, and such other quality-related documents as are specified in the Contract Specifications.

C. The Contractor shall identify the program for verifying and determining the cause of unsatisfactory product or workmanship quality and for initiating necessary improvements and corrections to preclude repetition. The Contractor's program should extend, when necessary, to the performance of subcontractors and suppliers.

3.02 DESIGN (AND DEVELOPMENT)

A. The Contractor shall prepare and maintain a plan for inspecting the quality of engineering, development, testing, and documentation activities. The Contractor shall identify the procedures, practices, tables, charts and diagrams applicable to the effort.

B. The Contractor shall document the engineering criteria applicable to the product being supplied. Include performance objectives, operating ranges and conditions, requirements for safety, reliability, availability, the requirements (codes, standards, and practices) for materials, fabrication, construction, testing, operation, maintenance, and quality assurance.

C. Studies, to be conducted in support of the engineering (or development) activity, shall be identified by the Contractor. They shall include analysis of allowable "tradeoffs" and alternatives, identification of potential weaknesses, and the appropriate preventative engineering features, operating and maintenance practices, and safety precautions.

D. The Contractor shall identify the program for assuring that specifications, drawings, and other engineering documents will delineate, as applicable:
   1. Materials and methods, including fabrication, construction, installation, inspection, maintenance cleaning, packaging, shipping, handling, and storage.
   2. Traceability of materials, parts, components, and processes through appropriate lot, piece part, serial, or other appropriate numbers.
   3. Product or workmanship acceptance criteria and the checkpoints during the work process for verifying compliance with the criteria.

E. The Contractor shall identify the methods and procedures for defining and controlling engineering interfaces with other project participants and design organizations. The procedures shall cover the exchange of required engineering data, analysis and resolution of engineering interface problems.

F. The Contractor shall identify procedures for controlling release of documents for authorized use.

G. The Contractor shall identify procedures for documenting the reporting, verifying, analysis, and correcting of troubles that occur during development.

H. Design criteria and input, including computer applications software, shall be identified, documented, and their selection reviewed by those responsible for the technical adequacy of the design. In all cases, the names of the preparer, checker, and the date the checker accepted the document shall be shown.

I. Incomplete, ambiguous, or conflicting requirements shall be resolved by those who drew up the design criteria and input and those who approved their selection.

J. The design input obtained from surveys of existing systems, structures, or facilities shall be documented and identified.

K. Design output (calculations, specifications, and drawings) shall be documented as requirements in a clear, logical, and uniform manner.

L. In all cases, the names of the preparer, checker and the date the checker accepted the document shall be shown.

M. Where required by the applicable Code, design standard, or this contract, design output shall be certified and/or sealed by the appropriate professional practitioner.

N. The calculation method or computer program shall be identified (including computer software version). The reference source of special, state-of-the-art, or experimental features that are not widely accepted in the railroad industry shall also be identified and those features briefly summarized.

O. Where the design output is a computer or computer software, specifications, user manuals, and testing and validation files shall be provided. Where the contract conveys to WMATA the license to duplicate, upgrade, repair, and modify the computer or computer code, detailed schematic diagrams, specifications, any special tools, and working standards shall be provided to enable the exercise of the license.

P. The design shall be verified to have met the requirements of this Contract. Design verification shall be documented and may take the form of design review, checking, alternative analysis or calculation, comparison with proven design, or performance of qualification tests and demonstrations. Design verification documentation. (including OEM equipment qualification testing) shall be made available to the Engineer upon request.

Q. The Contractor shall establish and implement measures to identify, control, and assess the impact of proposed design changes (including those from the OEMs) on specified functional, safety, and quality requirements, and added cost and schedule changes are identified and justified.

R. Design changes shall be reviewed, verified and approved in the same manner as the original version. The Contractor shall assign qualified personnel to review and coordinate design changes.

S. The Contractor shall obtain the Engineer's approval of proposed changes prior to implementing these.

3.03 DOCUMENT CONTROL

A. The Contractor shall establish and implement measures to control reports, procedures, contract technical deliverable documents, OEM and subcontractor technical submittals, and other records and information it generates or receives that relate to equipment performance characteristics, qualification testing, factory testing, installation, inspection, and acceptance testing. This control shall ensure that:
   1. The latest, approved versions of documents or information described above are available where affected Supplier's activities are performed.
   2. Revised documents are redistributed to those who received the previous issue.
   3. Superseded or obsolete documents are promptly removed from areas of work and stations where controlled documents must be distributed.
   4. Changes are reviewed and approved by the same functions or organizations that performed the original review and approval or their designated successors.
   5. A means (such as a list or computerized database) to identify the current revision of instructions, procedures, drawings, specifications, or calculations is available.
   6. Communications (memorandums of meetings, requests for clarification, etc.) and reports are issued or responded to in a timely manner.

B. The Contractor shall establish and implement measures to revise and maintain procedures and other records that relate to the performance characteristics, installation, inspection, and testing of components, equipment, or systems in an updated condition. Current as-built condition of equipment shall be retained on file.

C. Purchasing documents shall contain data clearly describing the product ordered, including, where applicable:
   1. The type, class, style, grade, or other precise requirements,
   2. The title, number designation and revision of specifications, drawings, process requirements, inspection/test requirements and other relevant technical and quality control requirements, including requirements for approval or qualification of product, procedures, process or inspection equipment and personnel.
   3. The title, number and revision of any applicable technical and quality standards to be applied to the product.
   4. As a minimum, OEMs shall be required to furnish Certificates of Conformance to the design and manufacturing standards specified by the Supplier, together with the equipment supplied.

3.04 PROCUREMENT

A. The Contractor shall identify the procedures for controlling the receipt, inspection, testing, handling, storage, and distribution of received equipment and its protection from damage, deterioration, loss or substitution. Inspection instructions and test procedures shall provide for verification of characteristics required by the Contract Drawings and Specifications, and documentation of results.

B. The Contractor shall identify the procedures for controlling purchased items that do not conform to Specifications. The procedures shall provide for prompt identification, documentation, segregation, technical review, and disposition of non-conforming items.

C. The Contractor shall establish and implement measures for obtaining items and services from suppliers or subcontractors that conform with specified requirements:
   1. The Contractor shall select its OEMs, subcontractors and other sub-suppliers on the basis of their ability to meet specified requirements
   2. Any procurement requirement which differs from those in the selected OEM, subcontractor, or other sub-supplier's proposal or offer is resolved and the resolution incorporated into the purchase order or contract, and
   3. Records are maintained to show acceptability of the selected OEM, subcontractor, or other sub-supplier (where available, records of previously demonstrated capability and performance should be provided to show acceptability of the selected supplier).

3.05 MANUFACTURING, FABRICATION, AND ASSEMBLY

A. The Contractor shall identify the procedure and instructions that will be used to assure that fabrication, processing, and assembly operations are being satisfactorily performed.

B. The Contractor shall identify the inspection and test plans that will be applied to all manufacturing activities for the purpose of verifying conformance to procedures and instructions.

C. The Contractor shall identify the method employed for tracing the identity of materials and items throughout fabrication, processing, or assembly operations.

D. The Contractor shall identify the procedures, instructions, and checklists for the control of the fabrication and assembly processes. This shall include such items as shop orders, process sheets, travelers, and inspection instructions, covering all mechanical, electrical, and metallurgical processes. Inspection instructions shall identify the nondestructive examination processes employed.

E. The Contractor shall identify the methodology of the program including record maintenance.

F. The Contractor shall identify the procedures for prompt identification, documentation, segregation, technical review, and disposition of non-conforming items.

G. The Contractor shall identify the procedures and instructions for handling, preserving, packing, packaging, storing, and shipping items shipped to the construction site.

3.06 INSTALLATION

A. The Contractor shall identify the procedures, check off lists, and instructions governing receipt inspection of equipment on arrival at the construction site. The Contractor shall include in the procedures the control of non-conforming items.

B. The Contractor shall identify the procedures for on-site configuration control. This shall include the control of drawings, specifications, work instructions, quality-control procedures, inspection instructions, and testing procedures, used in connection with installation.

C. The Contractor shall identify the procedures and work instructions that apply to installation methods, tests, repairs and rework, cleaning and protection.

D. The Contractor shall identify the inspections and tests to be performed to verify installation suitability.

E. The Contractor shall identify the procedures for controlling the on-site identification, documentation, segregation, technical review, and disposition of non-conforming supplies or workmanship.

3.07 INSPECTION AND TESTING

A. The Contractor shall establish and implement a Unified Test Program that will ensure all communications and related systems, equipment, material and services, furnished during the performance of this Contract, meet the technical requirements and standards specified, as well as all performance criteria.

B. As part of the Contractor's area of responsibility for the Unified Test Program, the Contractor will be required to:

1. Develop a comprehensive Test Plan detailing methods and test procedures to be utilized to ensure compliance with all applicable specifications.
2. Develop detailed test procedures for each individual test within each category of testing, except Authority tests.
3. Submit the Test Plan (including Authority System Validation Tests, Substantial Completion Acceptance, and Final Acceptance Programs) and all test procedures to the Engineer for evaluation, review, and acceptance or rejection. Revise and resubmit until acceptance by the Engineer is received.
4. Furnish personnel, calibrated test equipment, tools, and miscellaneous supplies as necessary to perform all tests and retests, and to maintain all systems and equipment during the test period and until acceptance by the Authority.
5. Coordinate Unified Test Program activities with the schedules and activities of other contractors and with the Engineer, to avoid conflicts with Authority operational requirements.
6. Perform tests and inspections as detailed in all approved test procedures.
7. Evaluate test procedure and inspection results and documentation. Prepare detailed test evaluation reports, summary reports and progress reports.
8. Submit all raw test data, test results, evaluations, and summary reports for evaluation, review and acceptance or rejection by the Engineer.
9. Prepare and submit revised test procedures and test plans to correct procedural and technical errors or omissions discovered in those documents, after their initial Authority acceptance.
10. Furnish corrective actions to effect Specification compliance, including: Remedy test program deficiencies, and system, equipment, material, workmanship, and documentation deficiencies promptly upon request by the Engineer.
11. Perform retesting and additional inspections until successful results are obtained, evaluated, and accepted by the Engineer.
12. Participate in Authority Pre-final Inspections, Substantial Completion (if any), and Final Acceptance activities. Clean the equipment and work site, secure the equipment, and remain responsible for prompt repair or replacement in the event of loss or damage until acceptance by the Authority is received. Furnish inventory services and demonstrate system or equipment operation in support of requests by the Authority. Provide support and access so that the Authority Engineers, Technicians, Mechanics and Inspectors can inspect and test any portion of the work during normal work hours.

13. Provide Unified Test Program reports on a monthly basis beginning within 30 days after the Engineer's acceptance of the Test Plan, and continuing until the final completion of all contract work.

C. The performance of each task requirement shall be subject to the Engineer's acceptance of methods, procedures, and results, for Specification compliance, and as to scheduling for the benefit of the Authority.

D. A Preliminary Test Plan shall be submitted to the Engineer for review. Subsequently, the Final Test Plan shall be submitted to the Engineer for review and acceptance or rejection. In the event of rejection or subsequent rejections, corrected re-submissions shall be delivered to the Engineer within 15 days after the receipt of each rejection. An accepted Test Plan shall be required prior to implementing any category of tests except for factory tests and inspections, installation and completion tests, inspections for cable, and associated terminal equipment, which may be accepted on an individual basis for equipment, and materials that are scheduled to be installed or delivered prior to NTP + ###.

E. Detailed test procedures shall be submitted to the Engineer for review and acceptance or rejection. In the event of rejection or subsequent rejections, corrected re-submissions shall be delivered to the Engineer within 15 days after receipt of each rejection. Approved test procedures shall be required prior to commencing any associated test.

F. Each individual test procedure shall include, but not be limited to: An outline of test objectives, detailed step-by-step procedures with required results and allowable tolerances for each measurement or observation, diagrams illustrating all required test set-ups, manufacturer and model number of each unit and accessory item of required test equipment, and further details as may be required by the Engineer to ensure that both Contractor and Authority field forces are presented with a totally comprehensive, understandable and accurate working procedure.

G. The Contractor shall include complete and adequate safety procedures, warnings, and emergency instructions in Test Plans and test procedures, as appropriate. Test procedures shall also include complete examples of test Data Record Forms with required resultant values and allowable tolerances, in accordance with Specification requirements.

H. The Authority reserves the right to perform additional non-destructive tests and inspections at any time during the course of the contract work. Results indicating deficiencies involving noncompliance with Specification requirements will be reported to the Contractor for corrective action.

3.08 DEFICIENCIES

A. If the Engineer determines from test data acquired from any category of test(s) that the system, equipment, materials, technical documentation, or services furnished do not conform to any Specification requirement(s), the Contractor shall recommend appropriate remedial action based on an analysis of test results within fifteen days after receipt of the Engineer's notice of deficiency. When such recommendations relate to engineering deficiencies, the Contractor shall, upon receipt of the Engineer's approval, make the necessary changes to all equipment and documentation of the type to be delivered or previously delivered (even if previously accepted) during the course of the Contract, at no additional cost to the Authority.

B. When recommendations relate to other deficiencies such as quality control and installation workmanship, the Contractor shall correct all deficiencies at each location, at no additional

cost to the Authority. Retesting after the changes have been completed (Factory Tests and Inspections, Installation Completion Tests and Inspections, and Technical Documentation Verifications) shall be required in whole or part, as determined by the Engineer, at no additional cost to the Authority. If the timely correction of all deficiencies is not completed to effect Specification compliance, as evidenced by the Engineer's acceptance of retest results, the Engineer will initiate remedial actions to the benefit of the Authority. Such actions may include the exercise of warranty, correction of deficiency, delay of payments, disputes or default, and termination actions, in accordance with the General Provisions, or actions of benefit to the Authority, in accordance with any combination of these and other Specification provisions.

3.09 CATEGORIES OF TESTS

A. Tests and inspections shall be required in each of seven categories, as listed below:
   1. Factory tests and inspections, including factory certifications and factory calibration certifications.
   2. Installation completion tests and inspections.
   3. System and integration tests.
   4. System validation tests and evaluations (Authority Conducted Program).
   5. Substantial Completion acceptance tests and inspections (if any) (Authority Conducted Program).
   6. Technical documentation verification inspections.
   7. Final acceptance tests and inspections (Authority Conducted Program).

B. Each test and inspection in each category shall be comprehensive, so that sufficient test result data and inspection result data is furnished to permit complete detailed examination and evaluation, as determined by the Engineer.

C. Additional specialized testing shall also be furnished, as defined in individual system specification Sections .

D. Retesting, and the acceptance or rejection of test results, documentation, and evaluations, shall be within the discretion of the Engineer.

3.10 FACTORY TESTS AND INSPECTIONS

A. All equipment and materials, including custom developed Additional Equipment and any custom developed Test Equipment, furnished in accordance with these Specifications, shall be subject at all times and during all stages of manufacture and assembly, to inspection, test, and rejection by the Engineer. The Engineer may elect to accept factory or Contractor certifications in lieu of complete test result data for certain items when, 1) a WMATA accepted factory test has been previously conducted on one or more production samples or identical deliverable products, 2) the same brand and model of the product to be furnished has proven reliable in Authority revenue service for one year or more, or 3) to simplify test program administration when not adverse to achieving Test Program objectives.

B. Before offering items for inspection or test, the Contractor shall furnish a complete set of applicable drawings for Authority use including, but not limited to, schematics, wiring diagrams, major assembly drawings, manufacturing drawings for custom developed equipment, and detailed specifications for the equipment and materials to be tested.

C. The Contractor shall submit Factory Test and Inspection Plans and Procedures to the Engineer for review. Tests required shall be performed at the point of manufacture and the

point of assembly before shipment to the field. The Contractor shall furnish additional testing by an independent testing laboratory if the manufacturer's Factory Test Plan or Procedures are determined by the Engineer to be inadequate to verify Specification compliance (a maximum of three major items may be designated by the Engineer for independent laboratory testing at no additional cost to the Authority).

D. After the Engineering Development Review for each system has been submitted and approved by the Engineer, Factory Tests and Inspections shall be scheduled for major items, custom prototypes, and other items of equipment and material designated for such testing by the Engineer, to verify compliance with environmental criteria, quality assurance, specified performance, grade of components, reliability, and workmanship including manufacturing processes. The Contractor shall advise the Engineer, in writing, when manufacturing of equipment begins and again two weeks prior to date of scheduled inspection or tests.

E. A "Report of Factory Visit" for the purpose of confirmation and subsequent agreement of any decisions made on site shall be prepared by the Contractor and submitted to the Engineer ten working days subsequent to each factory visit by the Contractor, Engineer, or designated Authority Representative. Each report shall include the purpose of the visit, summary of tests performed and decisions made or required prior to factory certification and shipment.

F. Two copies of test results certified by the manufacturer or an independent laboratory shall be furnished to the Engineer for review and acceptance or rejection prior to shipment. Equipment shall not be shipped before the factory test results have been accepted by the Engineer. Optionally, the Authority may elect to accept Contractor certified test and inspection results in lieu of manufacturer or independent laboratory certified test results.

G. A 200 hour burn-in period (power on - attended or unattended) shall be required for all units of electrically operated and powered custom-made major items of equipment prior to installation, in accordance with instructions from the Engineer. Each unit of custom made equipment shall be set up and powered on the Contractor's, Subcontractor's, or supplier's premises. Reports of such activity shall be furnished to the Engineer.

H. The Contractor shall assemble all of the rack-mounted equipment for a Passenger Station Communications Equipment Room and test prior to shipment to the installation site.

3.11 INSTALLATION COMPLETION TESTS AND INSPECTIONS

A. Installation Completion Tests and Inspections shall be performed after installation to ensure that equipment and materials were not damaged in shipment and that they are properly installed and functioning in accordance with specified criteria, parameters and good commercial practice. Installation Completion Tests and Inspections shall consist of:

1. Visual inspection with check-off lists to verify the following:
    a. That full compliance with requirements detailed in the General Equipment and Material Standards and General Installation Standards sections of these Specifications has been meet.
    b. That only approved products have been used.
    c. That Factory Tests and Inspections have been satisfactorily completed for major items, as required.
    d. That inventory of major equipment and material items is available and accurate.
    e. That equipment is installed in agreement with approved installation shop drawings.

f. That wire and cable terminations as to location, cable identification, routing, color code, and workmanship have been identified.

g. That Time Domain Reflectometry (TDR) measurements of all coaxial and outside plant cables have been made. Printed TDR records of each coaxial and outside plant cable shall be delivered to the Authority to illustrate the length of cable run (proven by demonstrating an open and a short condition before final termination), and the absence of any detectable faults on each coaxial cable and each outside plant cable pair after installation of the cable.

2. Detailed testing shall be required to demonstrate that material and equipment installed meet the criteria and possess the characteristics and parameters contained in the Contract Specifications; including additional requirements and stated tolerances that are specified in Contractor engineering and product approval data submissions and in manufacturer's published specifications attributed to approved products.

B. The testing of all items of equipment and material shall include electrical, mechanical, operational, and functional parameters. Such parameters include, but are not limited to: Levels of voltages, currents, power, distortion, noise, cross-talk, insulation resistance, continuity, attenuation (optical and electrical), physical strength, suitability of mounting method, paint and marking quality, graphics quality and style, location of operating controls and adjustments, and maintainability.

C. These tests shall be performed after the installation of material and equipment and shall be in addition to any Factory Tests and Inspections previously performed. The Contractor shall perform all necessary alignments, adjustments, and maintenance prior to requesting the scheduling of Installation Completion Tests and Inspections.

D. The Contractor shall advise the Engineer, in writing, two weeks prior to the date(s) of scheduled tests and inspections. The Engineer will witness these tests. Two certified copies of Installation Completion Test and Inspection data shall be submitted to the Engineer within seven (7) days after test completion for review and acceptance or rejection.

3.12 SYSTEM AND INTEGRATION TESTS

A. System and Integration Tests shall be on-site performance tests to verify that all operating parameters and functions perform as specified and that each system performs as specified in conjunction with each system or subsystem with which it interfaces. The Contractor shall demonstrate that all material and equipment elements of each installed system function together to meet the system criteria specified. Each system shall be powered a minimum of 48 hours prior to commencing system and integration tests. The Engineer shall be notified, in writing, seven (7) days prior to equipment being powered. Failures shall be recorded by the Contractor and findings furnished to the Engineer at the end of the 40 hours. The Contractor shall also include a description of corrective actions taken.

B. The Contractor shall be responsible for meeting all System and Integration Test requirements including testing and documenting interface compatibility and integration with existing Authority-owned systems and equipment.

C. Each and every interface shall be verified as to operation, function, level, and voltage. The Contractor shall test across the interface points; however, these tests shall only be made under the supervision of appropriate Authority personnel. When minor adjustment to, or reconfiguration of, existing equipment is required, the Contractor shall notify the Engineer, in writing, of the required adjustment or reconfiguration. Authority personnel will make the

adjustment or reconfiguration in the presence of the Contractor. The Contractor shall be responsible for the necessary adjustments or reconfigurations of Contractor-furnished equipment to ensure proper functioning, as specified.

D. The successful completion of all specified Factory Tests and Inspections, and Installation Completion Tests and Inspections, including the correction of all outstanding discrepancies and subsequent retesting, is required as a prerequisite to System and Integration Tests.

E. The tests will vary with each specific system. However, each test shall include all operating parameters and functions. Tests shall be conducted on a location-by-location basis with all failures and discrepancies noted. The Contractor shall not engage in further testing until the Engineer has verified that the Contractor has taken necessary corrective action with respect to those failures and discrepancies. The Contractor shall retest after each successive failure and corrective action to verify Specification compliance.

F. The Contractor shall advise the Engineer, in writing, two weeks prior to the date(s) of scheduled tests. Prior to commencing the System and Integration Tests, the Contractor shall provide failures recorded and corrective action taken, at the conclusion of powering equipment a minimum of 40 hours. The Engineer will witness these tests. Two certified copies of System and Integration Test data sheets shall be submitted to the Engineer within seven (7) days after test completion for review and acceptance or rejection.

3.13 MEASURING AND TEST EQUIPMENT

A. The Contractor shall establish and implement measures for the selection, calibration, and control of measuring and test equipment (M&TE) used to determine conformance.

B. M&TE of a range, accuracy, and sensitivity conforming with measurement tolerances specified within this contract shall be selected and used.

C. Calibration procedures shall require M&TE identification and establish frequency of calibration, calibration method, acceptance criteria, records to be generated, and the action to be taken when results are unsatisfactory.

D. M&TE shall be periodically calibrated using certified references traceable to the National Institute of Standards and Technology (NIST), to other nationally recognized standards when no such NIST standards exist, or to a documented standard acceptable to the Engineer when none of the preceding standards exist.

E. The calibration of M&TE shall be checked at prescribed intervals if testing or inspection will continue over an extended period.

3.14 INSPECTION AND TEST STATUS

A. The Contractor shall establish and implement measures to identify and maintain the inspection and test status of systems, equipment or components until these are accepted by the Engineer, to ensure that only purchased items that have passed the required inspection and test have been used.

B. The means for status identification shall be such that the surface of the item is not damaged nor its use impaired. Status identification may also be via inspection records, test software, physical location, or other suitable means, which indicate the conformance or nonconformance of these items with regard to inspection and tests performed.

3.15 CONTROL OF NONCONFORMANCE

A. The Contractor shall establish and implement measures to prevent the inadvertent use or installation of nonconforming items.

B. Procedures shall provide for identification, segregation, documentation, evaluation, and disposition of nonconforming items, define the responsibility and authority for the disposition of nonconforming item.

C. Nonconforming items shall be positively identified and the matter brought to the attention of Supplier's management representative, the Engineer, and the appropriate OEM, subcontractor or sub-supplier.

D. The Contractor shall hold the nonconforming item from further work and, where possible, shall be physically segregated in an area clearly marked, until the responsible parties have provided for the disposition of the item.

E. The disposition of a nonconforming item may be:
   1. Reworked (to meet original requirements)
   2. Accepted as-is
   3. Repaired (to meet an alternative criteria)
   4. Re-graded (for alternative use)
   5. Rejected, returned to vendor, or scrapped

F. The Contractor shall obtain written approval from the Engineer prior to using a nonconforming item as-is or repairing it to be acceptable to a standard different from the original standard.

G. Nonconforming items that have been repaired or reworked shall be re-inspected or retested by the party responsible for the original inspection or test in accordance with approved acceptance standards before being declared acceptable.

H. The technical details of nonconformity that have been accepted as-is and of any repairs made shall be included in "as-built" documentation.

I. Items for return to vendor shall be removed from the area of work and controls placed to prevent the reuse of the item or any part of it.

J. Rejected or scrapped items shall be removed from the area of work and rendered unusable in a manner that prevents their inadvertent use.

3.16 CORRECTIVE ACTION

A. The Contractor shall establish and implement measures to:
   1. Investigate the cause(s) of noncompliance and nonconformance, and identify action(s) to prevent recurrence.
   2. Implement corrective action to minimize or eliminate noncompliance or nonconformance.
   3. Apply controls over the implementation of corrective action.
   4. Incorporate the preventive action into procedures.

3.17 QUALITY CONTROL RECORDS

A. The Contractor shall establish and implement measures to identify, collect, index, file, and store quality control records as required in the Special Conditions of this Contract.

B. Quality control records shall be available at designated, controlled, but accessible areas at work locations. Procedures shall identify the responsible custodians for these records.

C. Quality control records shall be stored and maintained in such a way that they are readily retrievable and provided with a suitable environment that minimize deterioration or damage, and prevent unauthorized alteration or loss.

D. Quality control records shall be legible, reproducible, identifiable with the item involved, and contain the date of origination and identity of the originator, verifier, and/or responsible supervisor.

E. Retention period for quality control records shall be defined, and shall be at least as long as the term required in the Special Conditions of this Contract. Quality control records shall be made available to WMATA or its representative throughout the retention period.

3.18 AUDITS

A. By WMATA

B. Quality audits may be conducted by WMATA or its representatives. Direct access to Contractor personnel, original records, items in process, and facilities where work is performed shall be provided by the Contractor. The Contractor shall ensure, via procurement documents, that such access are also provided by their subcontractors and suppliers.

1. The Contractor shall provide a written response within 15 days after receipt of the audit report, fully describing the methods and timetable by which compliance will be achieved. Deficiencies shall be corrected within 30 days after receipt of the audit report.
2. Any survey, audit or inspection performed by WMATA or its representatives shall not relieve the Contractor of any of the responsibilities under this contract.

C. By The Contractor

1. The Contractor shall carry out a comprehensive system of planned and documented audits to verify whether activities within its scope of responsibility are performed in compliance with applicable portions of this Quality Control system requirements, and to determine the effectiveness of quality control.
2. Audits and follow-up actions shall be carried out in accordance with documented procedures and by qualified personnel. Audit schedules shall be established to ensure coverage of the scope of the quality control system at least once in the life of this Contract.
3. Results of the audits shall be documented and brought to the attention of the personnel having responsibility in the area audited. Management responsible for the area shall take timely corrective action on the deficiencies found by the audit.

3.19 TRAINING AND PERSONNEL QUALIFICATION

A. The Contractor shall ensure that the Quality Policy are understood and implemented by all elements of its organization that affect the quality of the items or services provided to WMATA.

B. When qualified personnel are required by this Contract, personnel qualification shall be based on an appropriate combination of education, training and experience. Where

required by the applicable code or standard, personnel qualification shall also be certified. Appropriate records of qualification, training and certification shall be maintained as quality records.

3.20 STATISTICAL TECHNIQUES

A. The Contractor shall identify any statistical technique to be used for sampling inspections or testing. Acceptance by means of representative sampling shall be in accordance with generally accepted statistical methods.

END OF SECTION

SECTION 16708

CORRECTION OF COMMUNICATIONS SYSTEMS DEFICIENCIES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Definitions: As used in this Section

B. General Conditions

C. Deficiencies of Accepted Communications System Materials, Equipment, Systems or Subsystems

D. Pre-Acceptance Recognition of Deficiencies in Communications System Materials, Equipment, Systems or Subsystems

E. Time for Performance, Contract Price

F. Transportation Charges

G. Failure to Correct

H. Correction of Deficient Replacements and Re-performances

I. Disassembly/Reassembly Expense

J. Warranties

1.02 RELATED SECTIONS

A. All 16700 and 16800 - Series Sections

1.03 DEFINITIONS: AS USED IN THIS SECTION

A. Deficiency:
   1. Communications System materials or equipment will be regarded as having a deficiency if a type of material or equipment in like service accumulates a failure rate greater than five percent within a period of 24 months following final acceptance by the Authority.
   2. Communications System systems or subsystems will be regarded as having a deficiency if they exhibit any condition or characteristics which are not in compliance with the requirements and intent of this Contract anytime during a period extending for 24 months following their final acceptance by the Authority.

B. Correction
   1. Correction of Communications System materials or equipment exhibiting a failure rate greater than five percent means taking of any and all actions necessary to correct the deficiencies, including removal and replacement of all pieces of material or equipment in like service in a manner satisfactory to the designated Resident Engineer.
   2. Correction of Communications System systems or subsystems exhibiting one or more deficiencies means taking any and all actions to eliminate any and all deficiencies in a manner satisfactory to the designated Resident Engineer.

1.04 GENERAL CONDITIONS

A. The rights and remedies of the Authority provided in this Section:
   1. Shall not be affected in any way by any other provisions under this Contract concerning the conclusiveness of inspections and acceptance, and;
   2. Are in addition to and do not limit any rights afforded to the Authority by any other Section of this Contract.

B. This Section shall apply only to those deficiencies discovered by either the Authority or the Contractor within 24 months after acceptance.

C. The Contractor shall not be responsible under this Section for the correction of deficiencies in Authority-furnished property, except for deficiencies in installation, unless the Contractor performs or is obligated to perform any modifications or other work on such property. In that event, the Contractor shall be responsible for correction of deficiencies to the extent of such modifications or other work.

D. The Contractor shall not be responsible under this Section for the correction of deficiencies caused by the Authority.

1.05 DEFICIENCIES OF ACCEPTED COMMUNICATIONS SYSTEM MATERIALS, EQUIPMENT ,SYSTEMS OR SUBSYSTEMS

A. Notice of Deficiency to Contractor: If the Contracting Officer determines that a deficiency exists in any of the Communications System materials, equipment, systems or subsystems provided to the Authority under this Contract, he will promptly notify the Contractor of the deficiency, in writing, within 30 days.

B. Recommendation for Correction: Upon timely notification of the existence of such a deficiency, or if the Contractor independently discovers a deficiency in accepted Communications System materials, equipment, systems or subsystems, the Contractor shall promptly submit to the Contracting Officer his recommendation for corrective actions, together with supporting information in sufficient detail for the Contracting Officer to determine what corrective action, if any, shall be taken. The recommendation shall be submitted to the Contracting Officer within 15 working days of notice of the deficiency.

C. Direction to Contractor Concerning Correction of Communications System Deficiencies: Within 30 days after receipt of the Contractor's recommendations for corrective action and adequate supporting information, the Contracting Officer, at his sole discretion, will give the Contractor written notice not to correct the subject deficiency, or to correct or partially correct the subject deficiency within a reasonable time and at a specified location.

D. Correction of Communications System Deficiencies by Contractor: The Contractor shall promptly comply with any timely direction by the Contracting Officer to correct or partially correct a Communications System deficiency, at no increase in the Contract price. The Contractor shall also prepare and furnish to the Authority data and reports applicable to any correction required under this Section (including revision and updating of all other affected data called for under this Contract) at no increase in the Contract price.

E. Schedule of Deficiency Corrections: The Contractor shall prepare a Schedule of Deficiency Corrections and deliver it to the Authority for approval within 15 working days of discovery of a Communications System deficiency by the Authority.

F. Modification of Contract with respect to Uncorrected Communications System Deficiencies: In the event of timely notice of a decision not to correct, or only to partially correct a

Communications System deficiency, the Contractor shall submit within 15 working days, a technical and cost proposal to amend the Contract to permit acceptance of the affected materials, equipment, systems or subsystems in accordance with the revised requirements, and an equitable reduction in Contract price shall promptly be negotiated by the parties and stated in a modification to this Contract.

1.06 PRE-ACCEPTANCE RECOGNITION OF DEFICIENCIES IN COMMUNICATIONS SYSTEM MATERIALS, EQUIPMENT, SYSTEMS OR SUBSYSTEMS

A. If the Contractor becomes aware at any time before acceptance by the Authority (whether before or after tender to the Authority) that a deficiency exists in any Communications System materials, equipment, system or subsystems, he shall promptly correct the deficiency or, if he elects to invoke the procedures specified in Part 1.05**,** he shall promptly communicate information concerning the deficiency to the Contracting Officer in writing, together with his detailed recommendation for corrective action.

1.07 TIME FOR PERFORMANCE; CONTRACT PRICE

A. In no event will the Authority be responsible for extension or delays in the scheduled deliveries or periods of performance under this Contract as a result of the Contractor's obligations to correct Communications System deficiencies, nor shall there be any adjustment of the delivery schedule or period of performance as a result of such correction of deficiencies, except as may be agreed to by the Authority in a supplemental agreement with adequate consideration.

B. It is hereby specifically recognized and agreed by the parties hereto that this Section shall not be construed as obligating the Authority to increase the Contract price of this Contract.

1.08 TRANSPORTATION CHARGES

A. When the Authority returns supplies to the Contractor for correction or replacement pursuant to this Section, the Contractor shall be liable for transportation charges up to an amount equal to the cost of transportation by the usual commercial method of shipment from the designated destination point under this Contract to the Contractor's plant, in addition to any charges specified in Part 1.08.B. The Contractor shall also bear the responsibility for the supplies while in transit.

B. When compliance with the terms of this Section by the Contractor involves shipment of corrected or replacement supplies from the Contractor to the Authority, the Contractor shall be liable for transportation charges up to an amount equal to the cost of transportation by the usual commercial method of shipment from the Contractor's plant to the designated destination point under this Contract, in addition to any charges specified in Part 1.08.A. The Contractor shall also bear the responsibility for the supplies while in transit.

1.09 FAILURE TO CORRECT

A. If the Contractor fails or refuses to:
   1. present a detailed recommendation for corrective action in accordance with Part 1.05,
   2. correct deficiencies in accordance with Part 1.05 C, or
   3. prepare and furnish data reports in accordance with Part 1.05 D.**,** the Contracting Officer will give the Contractor written notice specifying the failure or refusal and setting a period after receipt of the notice within which it must be corrected.

B. If the failure or refusal is not corrected within the specified period, the Contracting Officer may, by contract or otherwise, as required:

1. Obtain detailed recommendations for corrective action;
   a. Correct the materials, equipment, systems or subsystems, or;
   b. Replace the materials, equipment, systems or subsystems, and if the Contractor fails to furnish timely disposition instructions, the Contracting Officer may dispose of non-conforming materials, equipment, systems or subsystems for the Contractor's account in a reasonable manner, in which the Authority is entitled to reimbursement from the Contractor or from the proceeds for the reasonable expense of care and disposition, as well as for excess costs incurred or to be incurred, and;
2. Obtain applicable data and reports; and charge to the Contractor the cost occasioned to the Authority thereby.

1.10 CORRECTION OF DEFICIENT REPLACEMENTS AND RE-PERFORMANCES

A. Any Communications System materials or equipment corrected or furnished in replacement, and any Communications Systems or subsystems revised pursuant to this Section shall also be subject to all the provisions of the Contract to the same extent as Communications System materials, equipment, systems or subsystems initially accepted, i.e., for a new 24-month period.

1.11 DISASSEMBLY/REASSEMBLY EXPENSE

A. The Contractor shall be liable for reasonable cost of assembly/reassembly of larger items necessary to remove the materials or equipment to be inspected and/or returned for correction or replacement.

1.12 WARRANTIES

A. All Communications System materials and equipment provided under this Contract shall be warranted for a period of 24 months beginning with final acceptance by the Authority.

B. All subcontractors', manufactures', and suppliers' warrantees and guarantees, expressed or implied, respecting any part of the Communications System work, and any materials or equipment used therein shall be deemed obtained and shall be enforced by the Contractor as the agent and for the benefit of the Authority without the necessity of separate transfer or assignment thereof. Furthermore, if directed by the Contracting Officer, the Contractor shall require such subcontractors, manufacturers and suppliers to execute such warrantees and guarantees in writing to the Authority.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

NOT USED

END OF SECTION

SECTION 16710

COMMUNICATIONS GROUNDING

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This section describes hardware, and installation methods that the Contractor shall use to insure 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 installed under this Contract. In addition to the methods detailed in this Section, the Contractor shall insure that his 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.

1.02 UNIT PRICES

A. Unit Prices include all Required conduits and fittings, junction boxes, wiring, and cabling to provide grounding to the communications systems and facilities and incidental items, not specifically mentioned, but required for complete and proper system operation.

1.03 RELATED SECTIONS

A. Section 16705 – Communications Standard Specifications - Equipment & 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.

1.04 REFERENCES

A. NFPA 130 - Standard for Fixed Guideway Transit Systems

1.05 SUBMITTALS

A. Submit under provisions of Section 16706.

B. Shop Drawings: Indicate electrical system wiring diagram.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.01 INSTALLATION

A. Ground Communication system and facilities, equipment and cables using a single-point grounding scheme. Each Communication Equipment Room will 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

SECTION 16715

COMMUNICATIONS ELECTRICAL POWER DISTRIBUTION

PART 1 - GENERAL

1.01 SECTION DESCRIPTION AND BASIC REQUIREMENTS

A. The Electrical Power Distribution System provides power distribution from the 3-phase, 4-wire, 120/208 Vac, primary power feed to the communications systems. The Electrical Power Distribution System described herein includes the following facilities:
   1. 120 Vac Emergency Power (from station UPS) for communications equipment in the Communications Equipment Rooms, and Kiosks.
   2. -48 Vdc power for communications equipment in the Communications Equipment Rooms.

B. The 120 Vac Emergency Power Distribution System described herein includes for each Passenger Station, but is not limited to, the following components:
   1. In the Communications Equipment Room:
      a. Power Distribution Panelboard.
      b. AC Power Receptacles.

C. In the Kiosk - AC Power Receptacles.
   1. Required conduits and fittings, junction boxes, feeder wires, branch circuit wiring, and cabling to apportion the 120 Vac power to the communications systems and facilities equipment.

D. The -48 Vdc Power Distribution System described herein includes, but is not limited to, the following components:
   1. -48 Vdc Power Supply(s).
   2. -48 Vdc Status Panel.

E. The -48 Vdc Power Distribution System provides fail-safe service by load-sharing several power supplies. Power supplies may be removed from the active -48 Vdc Power Distribution System for repair, or added for increased capacity, without disrupting communications services.

F. The Status Panel provides voltage and current metering for the -48 Vdc Power Distribution System. The Status Panel also distributes -48 Vdc power to the Telephone (TEL), Carrier Transmission System(CTS) and Fiber Optic System(FOS) Systems equipment racks or, as needed, to any other communications equipment racks requiring a source of -48 Vdc power.

1.02 SECTION INCLUDES

A. Power Distribution Panelboard.

B. AC Power Receptacles.

C. -48 VDC Power Supply(s).

D. -48 VDC Status Panel.

1.03 UNIT PRICES

A. Unit Prices include all Required conduits and fittings, junction boxes, feeder wires, branch circuit wiring, and cabling to apportion the 120 VAC power and –48VDC power to the communications systems and facilities and incidental items, not specifically mentioned, but required for complete and proper system operation.

1.04 RELATED SECTIONS

A. Section 16706 - Communications System Submittals & Services.

B. Section 16707 - Communications Systems Quality Assurance & Testing

C. Section 16710 - Communications Grounding.

D. Section 16721 -Communications Telephone System.

E. Section 16771 -Communications Carrier Transmission System.

F. Section 16776 -Communications Fiber Optics System.

G. Section 16851 -Communications Closed Circuit Television System.

1.05 REFERENCES

A. National Electrical Manufacturers Association (NEMA) Standard Publication 250-1997, Enclosures for Electrical Equipment (1000 Volts Maximum).

B. NEMA Standard AB-1, Molded Case Circuit Breakers and Molded Case Switches

C. National Electric Code (NEC).

D. Insulated Cable Engineers Association (ICEA) S-95-658/NEMA WC70, Nonshielded 0 - 2kV Cables; ICEA S-96-659/NEMA WC71, Nonshielded 2001 - 5kV Cables; ICEA S-93-639/NEMA WC74, Shielded Power Cables 5 - 46 kV; ICEA S-94-649, Concentric Neutral Cables Rated 5 - 46 kV; ICEA S-97-682, Utility Shielded Power Cable Rated 5 - 46 kV; ICEA S-105-692, 600V Single Layer Thermoset Insulated Utility Underground Distribution Cable; and ICEA S-81-570, Direct Burial, 600V, Ruggedized Insulation.

1.06 SYSTEM DESCRIPTION

A. Description: The Communication Electrical Power Distribution provides power distribution from the 3-phase, 4-wire, 120/208 VAC, primary power feed to the communications systems.

B. Capacity:
   1. The Power Distribution Panelboard shall be sized to provide separate power circuits to each freestanding or wall-mounted equipment rack and cabinet, and any other equipment requiring an ac circuit feed. The Panelboard shall also include at least 20% unused (spare) circuit-breaker spaces.

2. The AC Power Disconnect Switch shall be rated to switch the calculated worst-case ac current load, plus 50% spare capacity.
3. The Communications Equipment -48 Vdc Power Supply shall be rated to provide the calculated worst-case dc current load, plus 100% spare capacity.
4. The -48 VDC Power System Status Panel shall be chosen to be fully compatible with the –48 Vdc Power Supply throughout its rated operating range.

C. The -48 VDC Power Distribution System provides fail-safe service by load-sharing two, or more, power supplies. At least one power supply may be removed from the active -48 VDC Power Distribution System for repair, or added for increased capacity, without disrupting communications services.

D. The Status Panel provides voltage and current metering for the -48 VDC Power Distribution System. The Status Panel also distributes -48 VDC power to the Telephone System (TEL), Carrier Transmission System (CTS) and Fiber Optic System (FOS) Systems equipment racks or, as needed, to any other communications equipment racks requiring a source of -48 VDC power.

E. The GETS system includes an existing personal computer (PC) (located in the Jackson Graham Building) equipped with software to interrogate the Emergency Telephones and telephone circuits to assure reliable emergency communications. The PC software also provides for remote programming of the Emergency Telephones in the parking garages.

1.07 SUBMITTALS

A. Submit under provisions of Section 16706.

B. Shop Drawings: Indicate electrical characteristics and connection requirements, including system wiring diagram.

C. Product Data: Provide showing electrical characteristics and connection requirements for each component.

D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

E. Calculate full load ac power requirements per branch circuit and shall configure each panelboard for an optimum phase load balance. Submit the calculations to the Engineer for approval. The calculations shall indicate the full load ac power requirements for each item of equipment connected to each branch circuit.

1.07 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

B. Supplier: Authorized distributor of specified manufacturer with minimum three years documented experience.

C. Installer: Service facilities within 50 miles of Project.

1.08 MAINTENANCE SERVICE

A. Furnish service and maintenance of Electrical Power Distribution System until Final Completion.

PART 2 - PRODUCTS

2.01 POWER DISTRIBUTION PANELBOARD

A. Manufacturers:
   1. Square D Co., Model No. NQOD424L100CU (or approved equal).

B. Type: NQOD, 3-phase, 4 wire, 120/208 Vac, main lugs only with isolated solid neutral bus and a ground bus.

C. Enclosure: NEMA Type 12 surface mounting and surface screw front cover with hinged door and flush lock.

D. Minimum Ratings:
   1. Capacity: 20 single-pole branch circuit breakers.
   2. Panel Amperage: 750,000.
   3. Power Requirements: Main Lugs, 100 Amps.
   4. Minimum Circuit Breakers: 16 single-pole NEMA Standard AB-1.

2.02 TERMINAL SUPERVISOR'S AC POWER DISCONNECT SWITCH

A. Manufacturers:
   1. Square D Co., Model No. H221NAWK, (or approved equal).

B. Minimum Ratings:
   1. Type: NEMA Type 12 surface mounting and surface screw front cover with hinged door and flush lock.
   2. Amperage Rating: 30 Amps.

2.03 10 - OUTLET AC POWER RECEPTACLE

A. Manufacturers:
   1. Wiremold Company, Multi-outlet System/Plugmold 2000, Series GB, Model No. 20GB506, (or approved equal).

B. Minimum Ratings:
   1. Pre-wired receptacles on 6-inch centers.
   2. 3-wire circuit, insulated ground conductor.
   3. Receptacles grounded to raceway.

2.04 6-OUTLET AC POWER RECEPTACLE

A. Manufacturers:
   1. Wiremold Company, Multi-outlet System/Plugmold 2000, Series GB, Model No. 20GB306, (or approved equal).

B. Minimum Ratings:

1. Pre-wired receptacles on 6-inch centers.
2. 3-wire circuit, insulated ground conductor.
3. Receptacles grounded to raceway.

2.05 DUPLEX AC POWER RECEPTACLE

A. Manufacturers:
1. Arrow Hart Division, Cooper Industries, Model No. IG5362 with Model No. IG8248 wall plate, (or approved equal).

B. Minimum Ratings:
1. Rated for 20 Amps, 125 VAC.
2. Isolated ground receptacle.
3. Color: Orange.

2.06 WIRE

A. Manufacturers:
1. Triangle PWC, Inc., Everene, Model No. USE/RHW, (or approved equal).

B. Minimum Ratings:
1. Insulation Type: Cross-linked Polyethylene in accordance with ICEA S-95-658/NEMA WC70, ICEA S-96-659/NEMA WC71, ICEA S-93-639/NEMA WC74, ICEA S-94-649, ICEA S-97-682, ICEA S-105-692, and ICEA S-81-570.
2. Conductor: 12 AWG or larger Class B stranded copper.
3. Voltage Rating: 600 volts.

2.07 GROUND CLAMP

A. Manufacturers:
1. Wiremold Company, Multi-outlet System/Plugmold 2000, Model No. 2009, (or approved equal).

B. Ratings:
1. Compatible with Plugmold 2000.
2. For use on multi-outlet systems.
3. Plated.

2.08 COMMUNICATIONS EQUIPMENT -48 VDC POWER SUPPLY

A. Manufacturers:
1. Power Conversion Products, Model No. PS-19 shelf complete with PCP Model No. MOD-4812 rectifier modules (quantity of 2 per shelf), (or approved equal).

B. Minimum Ratings:
1. Input: 95-130 VAC, 60-Hz (nominal), Power Factor: PF>90%.
2. Output: -48 VDC, 24-amp (load sharing).
3. Alarms: Rectifier Output Failure indicator with Form "C" alarm contacts.
4. High dc voltage shutdown.
5. Mounting: 19-inch rack complete with 23-inch rack mount adapters and hardware.

2.09 -48 VDC POWER SYSTEM STATUS PANEL

A. Manufacturers:
   1. Power Conversion Products, Mini Load Center Model No. MDM-48-75, complete with 6 appropriately-sized alarm breakers, (or approved equal).

B. Minimum Features:
   1. Metering: Voltage and current.
   2. Alarms: High/low dc voltage Form-C contacts.
   3. Alarm breaker power distribution center: 6-position
   4. Mounting: 19-inch rack complete with 23-inch rack mount adapters and hardware.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Calculate full load ac power requirements per branch circuit and configure each panelboard for an optimum phase load balance.

B. Communications Equipment Room
   1. Surface mount the completely assembled Communications Equipment Room Power Distribution Panelboard adjacent to the Communications Equipment Room feeder disconnect switch. Install power feeders (power phases, neutral and equipment ground) from the Communications Equipment Room feeder disconnect switch to the Communications Equipment Room Power Distribution Panelboard using appropriately sized steel conduit and make the necessary connections.
   2. Install an ac power receptacle strip on each equipment rack and in each equipment cabinet. Install the required mounting hardware to secure the ac power receptacle strips to the equipment racks and cabinets. Install a ground clamp in each raceway of the ac power receptacle strips to ensure that the raceway base is grounded to the equipment rack or cabinet. The ac power receptacle strips shall be installed so that they do not create obstructions to mounted equipment within the equipment racks and equipment cabinets and so that all outlets are accessible.
   3. Install the branch circuit conductors (power phases and neutral) from the Communications Equipment Room Power Distribution Panelboard to each ac power receptacle strip on the equipment racks and in the equipment cabinets, using appropriately sized rigid steel conduit.
   4. Install branch circuit conductors (power phases, neutral and equipment ground) from the Communications Equipment Room Power Distribution Panelboard to the Power Isolation Transformer of the passenger station Closed Circuit Television System using appropriately sized rigid steel conduit. Install branch circuit conductors (power phases and neutral) from the Power Isolation Transformer to the Closed Circuit Television Camera Power Distribution Panel(s) using appropriately sized rigid steel conduit.
   5. Install and wire the -48 VDC Communications Equipment Power Supplies and status panel in the telephone equipment rack. The -48 VDC power supplies shall be paralleled for load sharing operation.
   6. Install the appropriate wiring to distribute -48 VDC power from the power distribution center in the status panel to the following locations within the Communications Equipment Room:
      a. Fuse, Alarm and Distribution Panel(s) in the CTS equipment rack(s).
      b. Fuse, Alarm and Distribution Panel(s) in the FOS equipment rack(s).
      c. Fuse, Alarm and Distribution Panel in the TEL equipment rack.

C. Kiosk

1. Install the duplex receptacles, associated enclosures and cover plates within the Kiosk cabinetry of the passenger station Kiosk. Install the required mounting brackets and hardware to secure the enclosures of the duplex receptacles to the Kiosk structure and/or Kiosk cabinetry. The duplex receptacles shall be installed so that they do not create obstructions to mounted equipment within the Kiosk cabinetry and so that all receptacles are accessible.
2. Install branch circuit conductors (power phases, neutral and equipment ground) using appropriately sized, flexible, metallic conduit from the Kiosk Emergency Panelboard to the duplex receptacles within the Kiosk. Install the required conduit fittings, hardware, junction boxes, connectors and grounding hardware, and make the necessary connections.

D. Dispatcher's Room

1. Surface mount the Dispatcher's Facility ac power disconnect switch and panelboard in the vicinity of the Dispatcher's Facility. The Contractor shall install power feeders (power phases, neutral and equipment ground) from the Communications Equipment Room feeder disconnect switch to the Dispatcher's Facility ac power disconnect switch, and from the disconnect switch to the panelboard. Install appropriately sized rigid conduit, the required conduit fittings and hardware, and make the necessary connections. The power feeders to the Dispatcher's Facility ac power disconnect switch shall be connected to the Communications Equipment Room feeder disconnect switch at the input side.
2. Install branch circuit conductors (power phases and neutral) from the Dispatcher's ac power panelboard to the ac receptacles in the Dispatcher's Facility using appropriately sized rigid conduit. Install the required conduit fittings, hardware, junction boxes, terminals, connectors, grounding hardware, and make the necessary connections and cross-connections.

E. Grounding

1. Electrically insulate all conduits from equipment racks and equipment cabinets; power ground shall be separate and isolated from the communications ground. Conduit containing branch circuit conductors shall be insulated from the equipment racks and cabinets by means of short lengths of non-conducting conduits.
2. Provide short lengths of flexible metallic conduit in the equipment cabinets and on the equipment racks between the non-conducting conduit and the ac power receptacle strips. Each branch circuit shall contain a separate neutral conductor to the Communications Equipment Room Power Distribution Panelboard.

3.02 MANUFACTURER'S FIELD SERVICES

A. Prepare and start systems under provisions of Section 16707.

B. Supervise final wiring connections and system adjustments.

3.03 ADJUSTING

A. Adjust operating Products and equipment to ensure smooth and unhindered operation.

3.04 DEMONSTRATION

A. Demonstrate operation and maintenance of Products to designated WMATA personnel two weeks prior to date of Substantial Completion.

B. Demonstrate Project equipment by a qualified person who is knowledgeable about the Project.

C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with designated WMATA personnel in detail to explain all aspects of operation and maintenance.

D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at equipment location.

E. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.

F. Demonstrate system operation

G. Conduct walking tour of Project and briefly describe function, operation, and maintenance of each component.

END OF SECTION

SECTION 16732

FIRE ALARM, DETECTION AND NOTIFICATION SYSTEM

PART 1 – GENERAL

1.01 SUMMARY

A. The work covered by this Section of the Specification shall include all labor, equipment, materials and services to furnish and install a complete fire alarm system.

1. Fire Alarm Control Panel.
2. Remote Annunciator.
3. Manual pull stations.
4. Smoke detectors.
5. Heat detectors.
6. Fire Alarm System Interface Controls- Proprietary supervising station, magnetic door/card access release override, and air handling system.
7. Notification appliances.
8. Air handling systems shutdown control.
9. Magnetic door holder release.
10. Fire Suppression Supervision- Wet pipe, dry pipe, deluge valve, pre-action System, kitchen hood, clean agent and Halon system monitoring.

B. Related Sections:

1. Section 08331 – Overhead Coiling Doors.
2. Section 08710 – Finish Hardware.
3. Section 13905 – Fire Protection, Suppression and Alarm.
4. Section 14200 – Hydraulic Elevators.
5. Section 14240 – Traction Elevators.
6. Section 14300 – Heavy-Duty Escalator.
7. Section 16120 – Wire, Cable and Busways.
8. Section 16130 – Raceways, Boxes and Cabinets.
9. Section 16705 – Communications Standard Specifications – Equipment & Material.
10. Section 16706 – Communications Systems Submittals & Services.
11. Section 16707 – Communications Systems Quality Assurance & Testing.
12. Section 16710 – Communications Grounding.Section 16715 – Communications Electrical Power Distribution.
13. Section 16733 – Communications – Kiosk Systems.

14. Section 16925 – ATC – Data Transmission System.

1.02 REFERENCES

A. The system and all components shall be approved by insurance provider for use in fire protection systems and compliant with all insurance provider guidelines. If insurance provider approval is not available, insurance representatives must be consulted to ensure system is acceptable and components must at least be listed by Underwriters Laboratories, Inc. for use in fire protective signaling systems.

B. The installation shall comply with:

1. State and Local Building and Fire Codes.

2. Americans with Disabilities Act (ADA).

3. NFPA 70 – National Electrical Code.

4. NFPA 72 – National Fire Alarm and Signaling Code.

5. Local and State Authorities Having Jurisdiction.

6. NFPA 130 - Standard for Fixed Guideway Transit and Passenger Rail Systems

7. NFPA 70 - National Electrical Code

8. NFPA 101 - Life Safety Code

1.03 SUBMITTALS

A. Provide a list of all types of equipment and components provided. This shall be incorporated as part of a Table of Contents, which shall also indicate the manufacturer's part number, the description of the part, and the part number of the manufacturer's product data sheet on which the information can be found. See Division 1 for specific details about submissions.

B. Provide a Sequence of Operation matrix. The sequence of operation shall be building specific, and shall provide individual sequences for every type of alarm, supervisory or trouble condition which may occur as part of normal or off-normal system use.

C. Provide manufacturer's original printed product data, catalog cuts and description of any special installation procedures. Photocopied and/or illegible product data sheets shall not be acceptable. All product datasheets shall be highlighted or stamped with arrows to indicate the specific components being submitted for approval.

D. Provide manufacturer's installation instruction manual for specified system.

E. Provide samples of various items when requested.

F. Provide copy of state License to perform such work.

G. Provide copies of NICET Level IV Fire Alarm certifications for a minimum of two (2) technicians assigned to this project also responsible for Fire Alarm Control Panel (FACP) programming.

H. Provide shop drawings as follows:

1. Coversheet with project name, address and drawing index.

2. General notes drawing with peripheral device back-box size information, part numbers, device mounting height information, and the names, addresses, point of contact, and telephone numbers of all contact project team members.

3. Building specific device riser diagram, which individually depicts all control panels, annunciators, addressable devices, and notification appliances. Include a specific, proposed point descriptor above each addressable device. Include a specific discrete point address that shall correspond to address depicted on the device layout floor plans. Drawing shall provide wire specifications, and wire tags shown on all conductors depicted on the riser diagram. All circuits shall have designations that shall correspond with those required on the control panel and floor plan drawings. End-of-line resistors (and values) shall be depicted.

4. Control panel termination drawing(s). Include internal component placement and all internal and field termination points. Drawing shall provide a detail indicating where conduit penetrations shall be made, so as to avoid conflicts with internally mounted batteries. For each additional data gathering panel, a separate control panel drawing shall be provided, which clearly indicates the designation, service and location of the control enclosure. End-of-line resistors (and values) shall be depicted.

5. Building specific device wiring diagram drawing(s) shall be provided which depict all system components, and their respective field wiring termination points. Wire type, gauge, and jacket shall also be indicated. When an addressable module is used in multiple configurations for monitoring or controlling various types of equipment, different device typical diagrams shall be provided. End-of-line resistors (and values) shall be depicted.

6. See section 3.05 CLOSEOUT ACTIVITIES for other documents relating to this section.

I. Battery calculations shall be provided on a per power supply/charger basis. These calculations shall clearly indicate

1. The quantity of devices

2. The device part numbers

3. The supervisory current draw

4. The alarm current draw

5. Totals for all categories, and the calculated battery requirements (which reflect a 20% DEGRADE, for 24 hour supervisory, 5 minute alarm operation).

6. Battery calculations shall also reflect all control panel components, remote annunciator, and auxiliary relay current draws.

J. Scale drawing sets shall be submitted along with the submittal book. These drawings shall be 22” x 34” and of a sufficient resolution to be completely legible when reduced to 11” x 17” size.

K. Written proof of proper disposal by the installing contractor shall be required prior to release of outstanding retainage.

L. Turnover of all software database hard/soft copies to WMATA prior to the end of the one (1) year warranty period (or period as amended earlier in this specification). This shall include all possible programming software logs, exported project files, hard copies of all device maps, the revision number of the version of programming utility used, and all required passwords. This information shall be provided to WMATA on a flash drive.

1.04 QUALITY ASSURANCE

A. Qualifications: Company specializing in installation of work in this Section with minimum of three years documented experience, approved by manufacturer.

B. System Standards:

1. NFPA 72.

2. CEC, Article 760.

C. Design criteria:

1. Comply with all system standards.

2. Meet all requirements of fire authorities having jurisdictions.

3. The Building Electronics contractor shall provide complete fire detection and alarm system design, wiring diagrams, interphase wiring diagrams, and operational details.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Protect equipment delivered and placed in storage from the weather, humidity and temperature variation, dirt, dust and any other contaminants.

B. Project staging may be provided at stakeholders' convenience. A staging area is not guaranteed.

1.06 RELATED WORK

A. The fire alarm and detection system provides controls to and/or interfaces with the following systems and equipment:

1. Ventilation fans.

2. Fire suppression systems.

3. Elevators and escalators.

4. Data Transmission Systems (DTS).

5. Automatic Fare Collection (AFC).

6. Automatic public address.

7. Fire standpipe systems.

8. Clean agent systems.

9. Combustible gas detection.

10. Carbon monoxide detection.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Manufacturers capable of meeting the system requirements of Part 2 of this specification.

B. New fire alarm equipment shall be compatible with the existing WMATA fire alarm equipment. New equipment shall be able to provide two-way command and control communication between an EST Fireworks® head end and all protected premise fire alarm control panels and field devices.

2.02 EQUIPMENT

A. Fire Alarm Control Panel (FACP)

1. The fire alarm control panel(s) shall be an Edwards EST-3 or equivalent. System devices (notification appliances, pull stations, smoke and heat detectors, etc.) shall be compatible with one another. All components will be labeled "FM approved" for the use of fire alarm systems in this area of the United States of America.

2. Fire alarm control panel cabinet shall be 3-CAB series or equivalent. Cabinet shall be manufactured from #14 AWG cold rolled steel with a gray baked enamel finish. Operating controls shall be located behind a locked door with a viewing window.

3. Fire alarm control panel enclosures shall have engraved labels indicating, “FIRE ALARM SYSTEM”, and the areas of the building served by that panel.

4. All control modules shall be labeled, and all zone locations shall be identified.

5. Conventional fire alarm panel supporting 1/3/5/10 initiating device circuits and 1 through 4 notification appliance, Class B circuits as required in the space. If the panel is not a slave provide Digital Alarm Communicator Transmitter (DACT) for off premises communication.

6. The system shall store all basic system functionality and job specific data in non-volatile memory. All site specific and operating data shall survive a complete power failure intact. Passwords shall protect any changes to system operations.

7. The system shall have built-in automatic system programming to automatically address and map all system devices attached to the main controller. A minimum default single stage alarm system operation shall be supported with alarm silence, event silence, drill, lamp test, and reset common controls.

8. The system shall support distributed processor intelligent detectors with the following operational attributes: integral multiple differential sensors, automatic device mapping, electronic addressing, environmental compensation, pre-alarm, dirty detector identification, automatic day/night sensitivity adjustment, normal/alarm LEDs, relay bases, sounder bases and isolator bases.

9. The system shall use full digital communications to supervise all addressable loop devices for placement, *correct location*, and operation. It shall allow swapping of “same type” devices without the need of addressing and impose the “location” parameters on replacement device. It shall initiate and maintain a trouble if a device is added to a loop and clear the trouble when the new device is mapped and defined into the system.

10. The fire alarm panel shall provide integral security system interfaces.

B. User Interface

1. The display module shall be of membrane style construction with a 24 line by 40-character (960 total characters) Liquid Crystal Display (LCD). The LCD shall use super-twist technology and backlighting for high contrast visual clarity and a colored grey/black and white display.

    1.1 In the normal mode the LCD shall display the time, a customer facility name, and the number of history events.

    1.2 In the alarm mode the LCD shall display the total number of events and the type of event. The LCD shall display the first event of the highest priority as well as the previous seven (7) alarm events “hands free” in chronological order so that the arriving firefighter may track the fire progression. The LCD shall reserve 42 characters of display space for each user custom message by addressable device.

2. There shall be common control keys and visual indicators for reset, alarm silence, panel silence and drill.

    2.1 Provide four pairs of display control keys for selection of event display by type (alarm, supervisory, monitor and trouble) and forward/backward scrolling through event listings.

2.2 The operation of these keys shall be integrated with the related common control indicators to flash the indicators when un-displayed events are available for display and turn on steady when all events have been displayed.

3. Provide system function keys for status, reports, enable, disable, activate, restore, program and test. The module shall have a numeric keypad, zero through nine with delete and enter keys.

4. Provide field programmable 12 switch 12 LEDs control display module.

   As an alternate if the above cannot be provided, provide UL 864, 9th edition PC graphics display.

C. Software

1. Windows-based System Utility with Program Version Reporting to document any and all changes made during system start-up or system commissioning shall be used to maintain site specific programming. Time and Date Stamps of all modifications made to the program must be included to allow full retention of all previous program version data. Software will be Edwards EST-3 or equivalent and capable of coordination with EST fireworks head end. It shall support programming of any input point to any output point. The system shall support the use of Bar Code readers to assist custom programming functions. It shall allow authorized customization of fundamental system operations using initiating events to start actions, timers, sequences and logical algorithms. The system program shall meet the requirements of this project, current codes and standards, and satisfy the local Authority Having Jurisdiction.

D. Digital Alarm Communicator Transmitter (DACT)

1. The FACP shall have a DACT module to transmit alarm, supervisory and trouble signals to a central monitoring or proprietary supervising station.

2. The DACT shall support dual telephone lines, Contact I.D. communications, and configured for dual tone multi-frequency (DTMF) or pulse modes.

3. It shall be possible to delay AC power failure reports, auto test call, and be site programmable.

4. The dialer shall be capable of transmitting every individual alarm condition to the central station or proprietary supervising station.

E. Network Communications Card

1. A network communication card shall be provided for each building to allow building to building, peer to peer networking.

F. Fiber Optics Communications Interface

1. Fiber optics communications interface shall be provided for buildings, where available, to allow building to building networking in a Class A configuration.

G. System Controllers

1. The main controller shall be supervised, site programmable, and of modular design supporting at least 125 detectors and 125 remote modules per addressable Signaling Line Circuit (SLC).

2. The controllers shall support up to 10 SLC's per panel for a total system capacity of 2,500 intelligent addressable points.

3. The system shall be designed with peer-to-peer networking capability for enhanced survivability, with support for up to 64 nodes, each with up to 2,500 points and an overall capacity of 160,000 points.

4. The cabinets shall be steel, with a red finish.

5. The main controller module shall control and monitor all local or remote peripherals. It shall support at least a large 960 character LCD, power supply, remote LCD and zone display annunciators, printers, and support standard communication interface protocol devices such as color computer annunciators and color graphic displays. If configured as a network, each system shall display every point in the system and shall support up to 64 remote LCD display annunciators. Remote LCD annunciators shall also display every point in the system and be sized with the same number of characters as in the main FACP display.

6. Each controller shall contain a communication card which contains two RS232 ports. A computer for programming locally and a printer shall be provided and connected to the RS232 ports, a RS232 printer/programming port for programming locally via PC. When operational, each controller shall support a printer through the RS232 port and be capable of message routing.

7. Single stage operations shall be provided.

8. The system shall have a listed Detector Sensitivity test feature, which will be a function of the smoke detectors and performed automatically every 4 hours.

9. The system shall support 100% of all remote devices in alarm and provide support for a 100% compliment of detector isolator bases.

H. Power Supplies

1. Provide a power supply with power input of 120 VAC, 3.0A, 50/60 Hz and power output of Internal DC 24 Vdc @ 7.0A Max, Auxiliary DC Two 24 Vdc @ 3.5A Max. The battery charger shall be included in the power supply.

2. The power supply shall be a high efficiency switch mode type with line monitoring to automatically switch to batteries for power failure or brown out conditions. The automatic battery charger shall have low battery discharge protection.

3. The power supply shall provide internal power and 24VDC at 7.0A continuous for notification appliance circuits.

4. The power supply shall be capable of providing 7.0A to output circuits for a maximum period of 100 milliseconds. All outputs shall be power limited.

5. The battery shall be sized to support the system for 24 hours of supervisory and trouble signal current plus general alarm for 5 minutes.

I. Auxiliary Power Supplies

1. The power supply shall be a high efficiency switch mode type with line monitoring to automatically switch to batteries for power failure or brown out conditions. The automatic battery charger shall have low battery discharge protection.

2. The power supply shall provide internal power and 24VDC at 7.0A continuous for notification appliance circuits.

3. The power supply shall be capable of providing 7.0A to output circuits for a maximum period of 100 milliseconds. All outputs shall be power limited.

4. The battery shall be sized to support the system for 24 hours of supervisory and trouble signal current plus general alarm for 5 minutes.

J. Annunciators

1. The graphic remote annunciators shall be mounted in stand-alone enclosures or integrated into the network panels. The annunciator graphical diagram shall be 1/16 inch per foot scale minimum and operating on normal 24 Vdc. All annunciator switches shall be system input points and shall be capable of controlling any system output or function. The graphic annunciator shall be UL and ULC listed. The graphic shall be back-lit using high intensity LEDs. The unit shall be semi-flush or surface mounted. The main graphic door shall be tamper resistant and equipped with a key lock. It shall be possible to update the graphic image in the field without replacing the entire graphic.

2. Network alpha-numeric annunciators shall be located throughout the facility as indicated on the design drawings. The system shall have the capacity to support 64 network annunciators or network panel nodes. Each annunciator shall contain a supervised, back lit LCD with a minimum of 8 lines with 21 characters per line. Where required, the annunciator shall include additional zonal annunciation and manual control without additional enclosures.

3. The annunciator shall support full ability to serve as the operating interface to the system and shall include the following features:

    a. Matched appearance with other system displays.

    b. Each LCD on each node (cabinet) in the system shall be configurable to show the status of any or all of the following functions anywhere in the system: Alarm, Supervisory, Trouble and Monitor.

4. Each annunciator shall be capable of supporting custom messages as well as system event annunciation. It shall be possible to filter unwanted annunciation of trouble, alarm or supervisory functions by point or by geographic area.

K. Intelligent Devices

1. Each remote device shall have a microprocessor with non-volatile memory to support its functionality and serviceability. Each device shall store as required for its functionality the device serial number, device address, device type, personality code, date of manufacture, hours in use, time and date of last alarm, amount of environmental compensation left/used, last maintenance date, job/project number, current detector sensitivity values, diagnostic information (trouble codes) and algorithms required to process sensor data and perform communications with the loop controller. Each device shall be capable of electronic addressing, either automatically or application programmed assigned, to support physical/electrical mapping and supervision by location. Setting a device's address by physical means shall not be necessary.

L. Intelligent Detectors

1. The system intelligent detectors shall be capable of full digital communications using both broadcast and polling protocol. Each detector shall be capable of performing independent fire detection algorithms. The fire detection algorithm shall measure sensor signal dimensions, time patterns and combine different fire parameters to increase reliability and distinguish real fire conditions from unwanted deceptive nuisance alarms. Signal patterns that are not typical of fires shall be eliminated by digital filters. Devices not capable of combining different fire parameters or employing digital filters shall not be acceptable.

2. Each detector shall have an integral microprocessor capable of making alarm decisions based on fire parameter information stored in the detector head. Distributed intelligence shall improve response time by decreasing the data flow between detector and analog loop controller. Maximum total analog loop response time for detectors changing state shall be 0.5 seconds.

3. Each detector shall have a separate means of displaying communication and alarm status. A green LED shall flash to confirm communication with the analog loop controller. A red LED shall flash to display alarm status.

4. The detector shall be capable of identifying up to 32 diagnostic codes. This information shall be available for system maintenance. The diagnostic code shall be stored at the detector. Each smoke detector shall be capable of transmitting pre-alarm and alarm signals in addition to the normal, trouble and need cleaning information. It shall be possible to program control panel activity to each level.

5. Each smoke detector may be individually programmed to operate at any one of five (5) sensitivity settings. Each detector microprocessor shall contain an environmental compensation algorithm that identifies and sets ambient "Environmental Thresholds" approximately six times an hour. The microprocessor shall continually monitor the environmental impact of temperature, humidity, other contaminates as well as detector aging. The process shall employ digital compensation to adapt the detector to both 24-hour long term and 4-hour short-term environmental changes. The microprocessor shall monitor the environmental compensation value and alert the system operator when the detector approaches 80% and 100% of the allowable environmental compensation value. Differential sensing algorithms shall maintain a constant differential between selected detector sensitivity and the "learned" base line sensitivity. The base line sensitivity information shall be updated and permanently stored at the detector approximately once every hour.

6. The intelligent analog detectors shall be suitable for mounting on a variety of orientation/condition-specific detector mounting bases.

M. Fixed Temperature/Rate of Rise Detector

1. Heat detectors shall have a low mass thermistor heat sensor and operate at a fixed temperature and at a temperature rate-of-rise. It shall continually monitor the temperature of the air in its surroundings to minimize thermal lag to the time required to process an alarm. The integral microprocessor shall determine if an alarm condition exists and initiate an alarm based on the analysis of the data. The intelligent heat detector shall have a nominal fixed temperature alarm point rating of 135^0F and a rate-of-rise alarm point of 15^0F per minute. The heat detector shall be rated for ceiling installation at a minimum of 70 ft centers and be suitable for wall mount applications.

N. Photoelectric Smoke Detector

1. Analog photoelectric detectors shall utilize a light scattering type photoelectric smoke sensor to sense changes in air samples from its surroundings. The integral microprocessor shall dynamically examine values from the sensor and initiate an alarm based on the analysis of data. Systems using central intelligence for alarm decisions shall not be acceptable. The detector shall continually monitor any changes in sensitivity due to the environmental effects of dirt, smoke, temperature, aging and humidity. The information shall be stored in the integral processor and transferred to the analog loop controller for retrieval using a laptop PC or other equivalent program/service tool. The photo detector shall be rated for ceiling installation at a minimum of 30 ft centers and be suitable for wall mount applications. The photoelectric smoke detector shall be suitable for direct insertion into air ducts up to 3 ft high and 3 ft wide with air velocities up to 4,000 ft/min. without requiring specific duct detector housings or supply tubes. The percent smoke obscuration per foot alarm set point shall be field selectable to any of five sensitivity settings ranging from 1.0% to 3.5%. The photo detector shall be suitable for operation in the following environment: Temperature: 32^0F to 120^0F, Humidity: 0-93% RH, non-condensing, Elevation: no limit.

O. Multi-sensor Detector

1. Provide intelligent multi-sensor smoke detectors. The multi-sensor analog detector shall use a light scattering type photoelectric smoke sensor, a unipolar ionization smoke sensor and an

ambient temperature sensor to sense changes in air samples from its surroundings. The integral microprocessor shall employ time based algorithms to dynamically examine values from the three sensors simultaneously and initiate an alarm based on that data. The multi-sensor detector shall be capable of adapting to ambient environmental conditions. The temperature sensor shall self-adjust to the ambient temperature of the surrounding air and input an alarm when there is a change of 65^0F in ambient temperature. Systems using central intelligence for alarm decisions shall not be acceptable. The detector shall continually monitor any changes in sensitivity due to the environmental effects of dirt, smoke, temperature, age and humidity. The information shall be stored in the integral processor and transferred to the analog loop controller for retrieval using a laptop PC. Separately mounted photoelectric detectors, ionization detectors and heat detectors in the same location are not acceptable alternatives. The multi-sensor smoke detector shall be rated for ceiling installation at a minimum of 30 ft centers and suitable for wall mount applications.

P. Detector Mounting Base

1. Detector mounting bases shall be suitable for mounting on North American 1-gang, 3½" or 4" octagon box and 4" square box. The base shall contain no electronics, support all detector types and have the following minimum requirements: Removal of the respective detector shall not affect communications with other detectors, Terminal connections shall be made on the room side of the base; bases that must be removed to gain access to the terminals shall not be acceptable. The base shall be capable of supporting one (1) remote alarm LED Indicator. Provide remote LED alarm indicators where shown on the plans.

Q. Duct Detector Housing

1. Provide low profile intelligent addressable duct smoke detector as indicated on the project plans. Provide for variations in duct air velocity between 100 and 4,000 feet per minute and include a wide sensitivity range of .79 to 2.46%/ft. Obscuration. Include one shut down relay rated 2.0 amps @ 30 Vdc and also include slave high contact relays if required. Provide an air exhaust tube and an air sampling inlet tube that extends into the duct air stream up to ten feet. The addressable duct housing shall be suitable for extreme environments, including a temperature range of –20 to 158 degrees F and offer a harsh environment gasket option. Provide remote alarm LED Indicators and/or remote test station as indicated on the project plans.

R. Intelligent Modules

1. It shall be possible to address each module without the use of DIP or rotary switches. Devices using DIP switches for addressing shall not be acceptable. The personality of multifunction modules shall be programmable at site to suit conditions and may be changed at any time using a code downloaded from the Analog Loop Controller. Modules requiring EPROM, PROM, ROM changes or DIP switch and/or jumper changes shall not be acceptable. The modules shall have a minimum of 2 diagnostic LEDs mounted behind a finished cover plate. A green LED shall flash to confirm communication with the loop controller. A red LED shall flash to display alarm status. The module shall be capable of storing up to 24 diagnostic codes which can be retrieved for troubleshooting assistance. Input and output circuit wiring shall be supervised for open and ground faults. The module shall be suitable for operation in the following environment: Temperature: 32°F to 120°F, Humidity: 0-93% RH, non- condensing.

S. Single Input Module

1. Provide intelligent single input modules. The Single Input Module shall provide one (1) supervised Class B input circuit capable of a minimum of 4 "personalities", each with a distinct operation. The module shall be suitable for mounting on North American 2 ½"deep 1-gang boxes and 1 ½" (38mm) deep 4" square boxes with 1-gang covers. The single input module shall support the following circuit types: Normally- Open Alarm Latching (Manual Stations, Heat Detectors, etc.), Normally-Open Alarm Delayed Latching (Waterflow Switches), Normally-

Open Active Non-Latching (Monitor, Fans, Dampers, Doors, etc.), Normally-Open Active Latching (Supervisory, Tamper Switches.

T. Dual Input Module

1. Provide intelligent dual input modules. The Dual Input Module shall provide two (2) supervised Class B input circuits each capable of a minimum of 4 "personalities", each with a distinct operation. The module shall be suitable for mounting on North American 2 ½" deep 1-gang boxes and 1 ½" deep 4" square boxes with 1-gang covers. The dual input module shall support the following circuit types: Normally-Open Alarm Latching (Manual Stations, Heat Detectors, etc.), Normally-Open Alarm Delayed Latching (Waterflow Switches), Normally-Open Active Non-Latching (Monitor, Fans, Dampers, Doors, etc.), Normally-Open Active Latching (Supervisory, Tamper Switches).

U. Monitor Module

1. Provide intelligent monitor modules. The Monitor Module shall be factory set to support one (1) supervised Class B Normally-Open Active Non-Latching Monitor circuit. The monitor module shall be suitable for mounting on North American 2 ½" deep 1-gang boxes and 1½" deep 4" square boxes with 1-gang covers.

V. Universal I/O

1. Provide motherboards that provide mounting and wire terminations for modules. The motherboard shall support up to six modules. Locations: Communication Equipment Room, and Ancillary locations.

W. Waterflow/Tamper Module

1. Provide intelligent waterflow/tamper modules. The Waterflow/Tamper Module shall be factory set to support two (2) supervised Class B input circuits. Channel A shall support a Normally-Open Alarm Delayed Latching Waterflow Switch circuit. Channel B shall support a Normally-Open Active Latching Tamper Switch. The waterflow/tamper module shall be suitable for mounting on North American 2 ½" deep 1-gang boxes and 1 ½" deep 4" square boxes with 1-gang covers.

X. Single Input Signal Module

1. Provide intelligent single input signal modules. The Single Input (Single Riser Select) Signal Module shall provide one (1) supervised Class B output circuit capable of a minimum of 2 "personalities", each with a distinct operation. When selected as a telephone power selector, the module shall be capable of generating its own "ring tone". The module shall be suitable for mounting on North American 2 ½" deep 2-gang boxes and 1 ½" deep 4" square boxes with 2-gang covers. The single input signal module shall support the following operations: Audible/Visible Signal Power Selector (Polarized 24 Vdc @ 2A).

Y. Control Relay Module

1. Provide intelligent control relay modules. The Control Relay Module shall provide one form "R" dry relay contact rated at 2 amps @ 24 Vdc to control external appliances or equipment shutdown. The control relay shall be rated for pilot duty and releasing systems. The position of the relay contact shall be confirmed by the system firmware. The control relay module shall be suitable for mounting on 2 ½" deep 1-gang boxes and 1 ½" deep 4" square boxes with 1-gang covers.

Z. Conventional Manual Pull Stations

1. It shall be double action model with single pole contact used for pre-signal or general alarm initiation. The model shall have terminals for field connection of wire. The manual stations

shall be provided with a key lock matching the FACP. The manual pull station shall not be provided with a glass break operation. Surface mount the manual pull station unless flush mount is possible. The fire alarm pull station shall be suitable for operation in the following environment: Temperature: 32°F to 120°F, Humidity: 0-93% RH, non- condensing. Provide accessories as required for the installation.

AA. Intelligent Manual Pull Stations

1. It shall be possible to address each fire alarm pull station without the use of DIP or rotary switches. Devices using DIP switches for addressing shall not be acceptable. The manual stations shall have a minimum of 2 diagnostic LEDs mounted on their integral, factory assembled single or two stage input module. A green LED shall flash to confirm communication with the loop controller. A red LED shall flash to display alarm status. The station shall be capable of storing up to 24 diagnostic codes that can be retrieved for troubleshooting assistance. Input circuit wiring shall be supervised for open and ground faults. The fire alarm pull station shall be suitable for operation in the following environment: Temperature: 32°F to 120°F, Humidity: 0-93% RH, non-condensing.

BB. Manual Pull Station

1. Provide intelligent double action, single stage fire alarm stations. The fire alarm station shall be of metal construction with an internal toggle switch. Provide a locked test feature. Finish the station in red with silver “PULL IN CASE OF FIRE” English lettering. The manual station shall be suitable for mounting on North American 2 ½” deep 1-gang boxes and 1½” deep 4” square boxes with 1-gang covers.

CC. Notification Appliances

1. All appliances shall be FM Approved for Fire Protective Service. All strobe appliances or combination appliances with strobes shall be capable of providing the “Equivalent Facilitation” which is allowed under the Americans with Disabilities Act accessibly guidelines (ADA (AG)), and shall be UL 1971. All appliances shall be of the same manufacturer as the Fire Alarm Control Panel (NO EXCEPTIONS) specified to insure absolute compatibility between the appliances and the control panels, and to insure that the application of the appliances are done in accordance with the single manufacturers’ instructions. Any appliances that do not meet the above requirements, and are submitted for use must show written proof of their compatibility for the purpose intended. Such proof shall be in the form of documentation from THE CONTROL PANEL MANUFACTURER clearly stating that the control equipment (as submitted) is 100% compatible with the submitted Notification Appliances.

DD. Strobes

1. Provide low profile wall mounted strobes at the locations shown on the drawings. Strobes shall provide synchronized flash outputs. Strobe output shall be field selectable as indicated on the drawings in one of the following intensity levels; 15/75, 15cd, 30cd, 75cd or 110cd*. Low profile strobes shall mount in a North American 1-gang box or surface mounted on a matching back box provided by the manufacturer, as directed in the field. Provide weatherproof type and associated components when strobe is located outside or in areas requiring weather proofing.

EE. Temporal Horn/Strobes

1. Provide low profile wall mount horn/strobes at the locations shown on the drawings. The horn/strobe shall provide an audible output of 84.4 dBA at 10 ft at the high setting and for smaller room size locations (as indicated on the plans) a low dB setting (field selectable) of 79.4 dB at 10 ft. when measured in reverberation room per UL-464. Strobes shall provide synchronized flash outputs. The strobe output shall be as indicated on the drawings in one of the following field selectable intensity levels*; 15/75, 15cd, 30cd, 75cd & 110cd devices. The horn shall have a selectable steady or synchronized temporal 3-3-3 output. Low profile

horn/strobes shall mount in a North American 1-gang box or surface mounted on a matching back box provided by the manufacturer, as directed in the field.

FF. Temporal Horn

1. Provide low profile wall mount horn at the locations shown on the drawings. The horn shall provide an audible output of 84.4 dBA at 10 ft at the high setting and for smaller room size locations (as indicated on the plans) a low dB setting (field selectable) of 79.4 dB at 10 ft. when measured in reverberation room per UL-464. The horn shall have a selectable steady or synchronized temporal 3-3-3 output. Low profile horn shall mount in a North American 1-gang box or surface mounted on a matching back box provided by the manufacturer, as directed in the field.

GG. Speaker/Strobe

1. Provide low profile wall mount speaker/strobes at the locations shown on the drawings. The strobe output shall be as indicated on the drawings in one of the following field selectable intensity levels; 15cd, 30cd, 75cd & 110cd devices. Speakers shall operate between ¼ Watt and 2 Watts and shall provide an audible output between 80 dBA and 89 dBA.

HH. Speaker

1. Provide low profile wall mount speakers at the locations shown on the drawings. Speakers shall operate between ¼ Watt to 2 Watts and shall provide an audible output between 80 dBA and 89 dBA.

II. Multi-Voltage Control Relays

1. Provide remote control relays connected to supervised ancillary circuits for control of fans, dampers, door releases, etc. Relay contact ratings shall be DPDT and rated for 10 amperes at 115 Vac. A single relay may be energized from a voltage source of 24 Vdc, 24 Vac, 115 Vac, or 230 Vac. A red LED shall indicate the relay is energized. A metal enclosure shall be provided.

JJ. Electromagnetic Door Holders

1. Electromagnetic door holders submitted for use must have written proof of their compatibility for the purposes intended. Such proof shall be in the form of documentation from all manufacturers that clearly states that their equipment (as submitted) is 100% compatible with each other for the purposes intended.

2. Wall mounted, provide flush, semi-flush or surface wall mounted electromagnetic door holder/releases rated at 24 Vac/dc. Finish shall be brushed zinc.

KK. Surge Suppressor

1. Surge suppressors shall be multi-stage, hardwired base, field replaceable, with multiple voltage settings. 2 pairs shall be protected per module. UL497B listed with 10AWG max screw terminals. 0-75 service voltage, 6.6-108V list through voltage.

LL. Manual Pull Station Guards

1. Manual pull stations shall be provided with guards as required on the plans. They shall be surface or flush mounting, as required for each individual device.

MM. Voice Evacuation

1. The audio system must provide simultaneous page, alert, and evacuation signals. Systems that cause signaling devices to go silent while performing signaling functions will not be acceptable. The system must provide operation to 25Vrms or 70.7Vrms speakers. The system

must provide as a minimum the following paging common controls and indicators: Ready to page LED, VU display of paging output level, single switch function for paging to all — Alert zones, Evacuation zones, and areas not programmed for signaling. The system must provide high quality analog to digital conversion of paging sources. Digital transmission of paging must be provided between system nodes. The analog sources must be sampled and converted to digital with a sampling rate no less than 9600 samples per second. It must be possible to transmit signal sources (Alert, Alarm, Page, etc.) together over a single pair of wires between nodes. System amplifiers must be distributed zoned type. Centrally banked systems are not acceptable. An integral circuit for operating traditional Network Access Control (NAC) devices must be provided with each system amplifier. The circuit must carry a minimum rating of 3.5 Amps for operating 24 VDC signals. The system shall provide fully integrated fire fighters' telephone system that shall provide 2-way communication between the fire alarm control panel and any fire fighters' telephone station. The system shall include an alphanumeric user display and controls. When a telephone is activated, a call-in buzzer shall sound, and the location of the phone shall be shown on the alphanumeric display. The display shall be capable of bilingual operation, displaying English, Dutch, Finnish, French, German, Italian, Portuguese or Spanish messages. The incoming call shall be selected by activating a single button. All subsequent telephone call locations shall be displayed in full text. The system shall display all incoming calls, all connected phone(s) on the alphanumeric display. The system shall be configured so that page messages may be issued from any firefighter's telephone connected to the system, as directed by the emergency operator.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Shop drawings must be submitted and approved prior to execution of any installation or demolition activity.

B. Circuiting

1. Addressable analog signaling line circuit, initiating device circuit and notification appliance circuit loops shall be Class B. Conventional signaling line circuit, initiating device circuit and notification appliance circuit loops shall be Class B. Network communication and annunciator communication loops shall be Class A. Tee tapping is not permitted for any circuit.

2. Device loading shall not exceed 80% of loop capacity for each addressable or conventional analog loop to accommodate the installation of future devices.

3. Provide intelligent input modules to supervise Class B zone wiring where required to interface conventional initiating devices.

4. Sprinkler systems shall be supervised as follows:

a. Provide one (1) supervisory module for each sprinkler valve supervisory switch.

b. Provide one (1) dual input addressable module where water flow and tamper switches exist at the same location.

c. Provide one (1) additional single input addressable module where odd numbers of devices exist at a single location.

5. Notification appliance circuits:

a. Audible Signals: Provide sufficient spare capacity to assure that an increase of 20% of the audible devices can be supported without the need for additional components (power supplies, signal circuit modules, batteries, etc.).

b. Visual Signals: Provide sufficient spare capacity to assure that an increase of 20% of the visual devices can be supported without the need for additional components (power supplies, signal circuit modules, batteries, etc.).

6. Each of the following types of remote equipment associated with the fire alarm system shall be provided with a form 'C' control relay contact as follows, unless otherwise noted on the drawings:

   a. HVAC Fan Systems: Provide one (1) shutdown control relay contact for each HVAC fan system.

   b. HVAC Supply Fans: Provide one (1) shutdown control relay contact for each HVAC supply fan.

   c. HVAC Return Fans: Provide one (1) shutdown control relay contact for each HVAC return fan.

7. Provide a dedicated 24VDC circuit to feed all auxiliary relays required for inductive loads. Circuits shall be supervised via an end-of-line relay and addressable input module. Auxiliary relays shall not derive their power from the starter or load being controlled.

8. Each control or data gathering panel shall have a dedicated 20 Amp, 120VAC feed. This feed shall come from an emergency circuit breaker panel where available, and shall have a locked circuit breaker. Earth grounds shall also terminate to the same circuit breaker panel from each respective control panel.

9. The system shall have a CPU "watchdog" circuit to initiate trouble should the CPU fail.

10. All low voltage wiring terminated to the fire alarm system shall be plenum rated with no exceptions and no less than No. 18 AWG in size, and solid copper.

11. All line voltage (120VAC) wiring shall be no less than No. 12 AWG in size, and solid copper. This shall include all system grounding. FACP must have a dedicated 20 Amp circuit marked back at the power panel no exceptions.

12. All wiring shall be color-coded throughout, to National Electrical Code standards.

13. Power-limited/non-power-limited NEC wiring standards shall be observed.

14. All junction box covers shall be painted federal safety red and labeled FIRE ALARM SYSTEM ONLY in black letters.

15. Fire alarm system wiring shall not co-mingle with any other system wiring in the facility. Conduits shall not be shared under any circumstance. Only when fire alarm wiring enters the enclosure of a monitored or controlled system will co-habitation be permitted (i.e. at fan starters or elevator controllers).

16. Auxiliary relays shall be appropriately labeled to indicate "FIRE ALARM SYSTEM" and their specific function (i.e. FAN S-1 SHUTDOWN).

17. All fire alarm wiring shall be continuous and without splices. Terminations shall only occur at fire alarm devices or control panel enclosures under terminal screws. All other splicing methods are specifically disallowed (i.e. plastic wire nuts).

18. All fire alarm wiring shall be installed in conduit. See Specification Section 16120.

19. All fire alarm wiring shall be sleeved when passing through any wall, using conduit sleeves (1"min.) with bushings, and fire stopped in accordance with Code.

20. The fire alarm system shall be arranged to receive power from one three wire 120 Vac, 20 A supply. All low voltage operation shall be provided from the fire alarm control panel.

21. End of Line Resistors shall be furnished as required for mounting as directed by the manufacturer. Devices containing end-of-line resistors shall be appropriately labeled. Devices should be labeled so removal of the device is not required to identify the EOL device.

22. New door holders shall derive their 24VAC/VDC power from a separate power supply housed in a dedicated, metal enclosure. The power supply shall have a 120VAC feed, and is to be centrally located to serve door holders on a per floor or area basis. All existing door holders shall be connected to new FACP. E.C. shall extend all existing wiring in order to make this work.

23. All WMATA protected premises report to two proprietary supervising station locations. The supervising station locations are located at the Jackson Graham Building and at the Carmen Turner Facility.

C. Fire Alarm System Sequence of Operation

1. The system shall identify any off normal condition and log each condition into the system database as an event.

    a. The system shall automatically display on the control panel Liquid Crystal Display the first event of the highest priority by type. The priorities and types shall be alarm, supervisory, trouble and monitor.

    b. The system shall have a Queue operation, and shall not require event acknowledgement by the system operator. The system shall have a labeled color coded indicator for each type of event; alarm shall be red, supervisory shall be yellow, trouble shall be yellow, monitor shall be yellow. When an unseen event exists for a given type, the indicator shall be lit.

    c. For each event, the display shall include the current time, the total number of events, the type of event, the time the event occurred and up to a 42 character custom user description.

    d. The user shall be able to review each event by scrolling keys (up-down) for each event type.

    e. New alarm, supervisory or trouble events shall sound an audible signal at the control panel; the operator shall be able to silence this audible signal.

2. Operation of any alarm initiating device shall automatically:

    a. Update the control/display as described in this Section.

    b. Sound all audible appliances in a Temporal-3 pattern. All audible appliances shall be synchronized with each other when two or more horns can be heard. Audible devices shall have the ability to be silenced.

    c. Activate all strobe appliances throughout the facility. All strobe appliances shall be synchronized with each other in any location with two or more devices in a common field of view. Visual devices shall be non-silenced unless the system is successfully reset.

    d. Operate control relay contacts to shutdown HVAC units in accordance with IMC requirements.

e. Operate control relay contacts to return all elevators that serve the floor of alarm initiation to the ground floor. If the alarm originates from the ground floor, operate control circuits contacts to return all elevators to the floor above or to a level as directed by the local fire department.

f. Operate control relay contacts to release all magnetically held smoke doors throughout the building.

g. Visually annunciate the individual point of alarm on all remote annunciator panels. The visual indication shall remain activated until the alarm condition is reset to normal.

h. Transmit an alarm condition to central station/local fire department and/or proprietary supervising station (as required by the AHJ/WMATA).

3. Elevator smoke and heat detector sequences shall comply with ANSI A17.1 Safety Code for Elevators and Escalators requirements and local code requirements for main/alternate floor recalls, and shunt trip activations.

4. Activation of a sprinkler supervisory initiating device shall:

   a. Update the control/display as described in this Section.

   b. Transmit a supervisory condition to central station/local fire department and/or proprietary supervising station (as required by the AHJ/WMATA).

   c. Visually annunciate the individual point of alarm on all remote annunciator panels. The visual indication shall remain on until the alarm condition is reset to normal.

5. All fire alarm system wiring shall be electrically supervised to automatically detect and report trouble conditions to the fire alarm control panel. Any opens, grounds or disarrangement of system wiring and shorts across alarm signaling wiring shall automatically:

   a. Update the control/display as described in this Section.

   b. Transmit a trouble condition, via the integral central station communicator, to the central station/local fire department and proprietary supervising station (as required by the AHJ).

   c. Visually and audibly annunciate a general trouble condition on the remote annunciator panels. The visual indication shall remain on until the trouble condition is repaired.

6. Purge/Smoke Control

   a. Smoke control panels shall be UUKL listed specifically for smoke control operation to allow the smoke purge control to be housed in the FACP cabinet. The smoke control switches shall be located behind a locked glass door.

   b. Where required, each floor shall have a dedicated switch for fan shutdown via a listed addressable control module. Each damper shall also be monitored at the panel for open/close position via control module. This module shall illuminate the associated green LED when the damper is open and the red LED when the damper is closed. The dampers shall be interlocked with the fans to prevent the fan from activating while the damper is closed.

7. All panel modules shall be supervised for placement and return trouble if damaged or removed.

8. All WMATA protected premises report to two proprietary supervising station locations, and to the WMATA contracted third party monitoring location. The supervising station locations are located at the Jackson Graham Building and at the Carmen Turner Facility.

D. Device Mounting

1. The entire system shall be installed with aesthetics in mind as approved by WMATA. All control panels and remote annunciators installed in public spaces shall be semi-flush mounted with no exposed conduit or cable trays unless approved by WMATA.

2. All manual pull stations shall be mounted 48 inches above the finished floor, as measured to the handle.

3. Wall-mounted appliances shall be mounted such that the entire lens is not less than 80 in. and not greater than 96 in. above the finished floor. Where low ceiling heights do not permit mounting at a minimum of 80 in., appliances shall be mounted within 6 in. of the ceiling. All audiovisual devices shall have lexan covers in all areas.

4. No area smoke detectors shall be mounted within 36 inches of any HVAC supply, return air register or lighting fixture.

5. No area smoke or heat detector shall be mounted within 12 inches of any wall. All detectors shall be installed in strict accordance with NFPA 72 guidelines for such devices.

6. All addressable modules shall be mounted within 36 inches of the monitored or controlled point of termination. This shall include, but is not necessarily limited to, fan shutdown, elevator recall, shunt trip, sprinkler status points, or door release. Label all addressable modules as to their function.

7. All fire alarm devices shall be accessible for periodic maintenance. Should a device location indicated on the Contract Drawings not meet this requirement, it shall be the responsibility of the installing contractor to bring it, in writing, to the attention of WMATA. Failure to bring such issues to the attention of WMATA shall be the exclusive liability of the installing Contractor.

3.02 CONSTRUCTION

A. System cable and devices shall be installed and inspected based on Fire Marshal approved drawings. Original contract drawings are for bidding purposes only. The entire system shall be installed in accordance with approved manufacturer's wiring diagram. The contractor shall furnish all conduit, wiring, outlet boxes, junction boxes, cabinets and similar devices necessary for the complete installation. All wiring shall be of the type recommended by the manufacturer, approved by the local Fire Department and specified herein.

B. All penetration of floor slabs and firewalls shall be sleeved (1" conduit minimum) fire stopped in accordance with all local fire codes.

C. The existing fire alarm system shall remain in operation until such time that approval has been granted for its removal.

D. After acceptance of the new building fire alarm system, the installing Contractor shall be responsible for the removal of entire existing fire alarm system components and controls, upon approval of the AHJ and WMATA. WMATA reserves the right to retain any existing fire alarm system components, upon their request. All existing fire alarm system components requiring special handling for disposal (due to radioactivity) shall be the responsibility of the installing contractor.

E. Prior to commencement and after completion of work notify Authorities Having Jurisdiction

3.03 FIELD/SITE QUALITY CONTROL

A. The system shall be installed and fully tested under the supervision of a trained manufacturer's representative. The system shall be demonstrated to perform all of the function as specified.

B. The installing contractor or fire alarm equipment vendor shall have no less than two (2) NICET Level III fire alarm technicians dedicated to this project.

C. The Installing Contractor and the Fire Alarm System Vendor shall, upon the request of the Consulting Engineer or WMATA attend any and all project meetings for the purpose of accurately determining progress.

D. It shall be the responsibility of the installing contractor to assure that construction debris does not adversely affect any sensing devices installed as part of this project. Should it be deemed necessary by the WMATA construction manager, the installing contractor shall be responsible for the cleaning of all smoke detectors prior to final acceptance.

3.04 SYSTEM STARTUP

A. Tests

1. The fire alarm system vendor shall test the system in accordance with the manufacturer's requirements and NFPA 72. The vendor shall provide final acceptance test reports to WMATA for review and approval prior to final acceptance.

2. Each individual system operation on a circuit by circuit basis shall be tested for its complete operation in accordance with NFPA 72 (2010ed.), Table 14.4.2.2 (see appropriate section from other editions). The procedure for testing the entire fire alarm system shall be set forth with the consent of the code enforcement official, the Engineer and the manufacturer.

3. Provide a NFPA 72 System Record of Completion Form for each part of the fire alarm system as required.

3.05 CLOSEOUT ACTIVITIES

A. Documentation and Training

1. The contractor shall compile and provide to WMATA a complete manual on the completed system to include site specific operating and maintenance instruction, catalog cuts of all equipment and components, as-built wiring diagrams and a manufacturer's suggested spare parts list. An operational Video, on DVD media, shall also be included.

2. The Contractor shall provide the onsite services of a manufacturer's trained representative for two (2) separate calendar days for a period of eight (8) hours per day to instruct the WMATA's designated personnel on the operation and maintenance of the entire system.

3. Submit letter of approval for installation before requesting acceptance of system.

B. As-built Drawings

1. Revise existing drawings to incorporate contract work.

2. Point-to-point depiction of all device wiring on the device layout floor plans.

3. Full size, as-built drawings.

4. All drawings should be readable and printable in 11 x 17.

5. Provide electronic copies in AutoCAD and PDF.

6. Provide one copy inside PVC pipe next to FACP.

3.06 MAINTENANCE

A. Provide a coded one-man walk test feature. Allow audible or silent testing. Signal alarms and troubles during test. Ensure receipt of alarms and programmed operations for alarms from areas not under test.

B. Provide internal system diagnostics and maintenance user interface controls to display/report the power, communication, and general status of specific panel components, detectors, and modules.

C. Provide loop controller diagnostics to identify common alarm, trouble, ground fault, NFPA 72 Class A fault, and map faults. Map faults include wire changes, device type changes by location, device additions/deletions and conventional open, short, and ground conditions. Ground faults on the circuit wiring of remote module shall be identified by device address.

D. Allow the user to display/report the condition of addressable analog detectors. Include device address, device type, percent obscuration, and maintenance indicator. The maintenance indicator shall provide the user with a measure of contamination of a device upon which cleaning decisions can confidently be made.

E. Allow the user to report history for alarm, supervisory, monitor, trouble, smoke verification, watchdog, and restore activity. Include Facility Name, Licensee, Project Program Compilation date, Compiler Version, Project Revision Number, and the time and date of the History Report.

F. Allow the user to disable/enable devices, zones, actions, timers and sequences. Protect the disable function with a password.

G. Allow the user to activate/restore outputs, actions, sequences, and simulate detector smoke levels.

H. Allow the service user to enter time and date, reconfigure an external port for download programming, initiate auto programming and change passwords. Protect these functions with a password.

I. WMATA shall retain complete rights and ownership to all software running in the system. The fire alarm equipment vendor shall provide useable hard and soft copies of the software database to WMATA at the end of the warranty period. The database provided shall be useable by any authorized and certified distributor of the product line, and shall include all applicable passwords necessary for total and unrestricted use and modification of the database.

END OF SECTION

SECTION 16866

INTERFACE CRITERIA AND RESPONSIBILITIES

PART 1 - GENERAL DESCRIPTION

1.01 SECTION DESCRIPTION AND BASIC REQUIREMENTS

A. The Contractor shall identify all electrical, mechanical and physical interfaces associated with these Specifications. These shall include, but not be limited to, the following interfaces:
   1. Between the various communications systems, subsystems, equipment and materials included in these Specifications.
   2. Between the communications systems, subsystems, equipment and materials included in these Specifications, and existing WMATA systems, subsystems, and equipment.
   3. Between the Contractor-provided systems, subsystems, equipment and materials and those furnished by the Authority or other contractors (including structures, equipment, etc.).

B. The Contractor-provided systems, subsystems, equipment and materials shall be designed to have the characteristics required to ensure that electrical, mechanical and physical interfaces achieve the specified grade of service and performance levels on a non-interfering basis with existing system and equipment functions (except as otherwise specified).

C. The Contractor shall be fully responsible for the correct interfacing of the systems, facilities and equipment that are provided under this Contract with the existing WMATA communications systems, subsystems, facilities, and with the facilities and equipment furnished by the Authority. If any incompatibility is discovered, the Contractor shall correct the incompatibility by modifying the equipment provided and/or by providing additional required equipment and material at no additional cost to the Authority. Unless otherwise specified, modifications to the equipment of existing WMATA systems, subsystems and facilities and to equipment provided by the Authority will not be permitted.

D. The Contractor shall be responsible for verifying product compatibility and system performance of all equipment, including equipment specified under the Major Items sections of this Contract.

E. The Contractor shall ensure that continuing coordination is accomplished as defined.The Contractor shall submit an interface procedure which shall include the following:
   1. A detailed list specifically identifying each interface associated with this Contract.
   2. A description of the work involving interfaces to be performed by the Contractor under this Contract.
   3. Sketches or drawings showing details of interface points, where applicable.

1.02 DEFINITION

A. Interface Point
   1. An interface point is defined as the line(s) of demarcation between the various Contractor-furnished and/or installed systems, subsystems, equipment and materials, and those existing facilities including WMATA communications systems and equipment.

B. Electrical/Mechanical Interface Compatibility

1. Electrical and mechanical interface compatibility is defined as the electrical and mechanical characteristics required to: Ensure that separate systems, subsystems, equipment and materials, and existing systems, subsystems, equipment and materials are compatible, retain their specified function, and perform a specified service in the specified manner, in conjunction with facilities to which they are connected; and that they do not impair, or have any adverse effect on, the specified operation of any system, subsystem or equipment to which they are directly or indirectly connected, or that may be influenced by them or their electromagnetic field(s).

C. Physical Interface Compatibility
1. Physical interface compatibility is defined as the physical form and fit required to ensure that all items of equipment and materials are fully compatible with all other equipment, materials, facilities and structures with which they interface, including: Those furnished in accordance with these Specifications; and those owned or occupied by the Authority.

D. Schedule Compatibility
1. Schedule compatibility is defined as the scheduling of contract work on the essentially non-interfering basis to WMATA. The Engineer's determination of what constitutes an "essentially non-interfering basis" shall be required whenever any degree of interference to WMATA is anticipated.

1.03 COMMUNICATIONS SYSTEMS/SUBSYSTEMS/FACILITIES INTERFACE

A. General
1. Some of the communications systems, subsystems and facilities to be furnished and installed in accordance with these Specifications are expansions and extensions of systems, subsystems and facilities furnished and installed by WMATA or local jurisdiction contracts.
2. All systems, subsystems, equipment and materials furnished in accordance with the provisions of this Contract shall be fully compatible and operable to full specifications on an essentially non-interfering basis with all systems, subsystems, equipment and materials that are to be utilized by WMATA (including the electromagnetic compatibility of electrical, magnetic and radio frequency emissions of all types). The existing systems and facilities, and the extensions and expansions furnished in accordance with these Specifications, shall be fully compatible with each other, and each shall function as a single integrated system/facility.

1.04 PUBLIC ADDRESS SYSTEM

A. Passenger Station Public Address System interfaces shall include, but are not limited to, the Carrier Transmission System, the Technical Control Facility, the Automatic Public Address Announcement System, the Electrical Power Distribution System, the passenger station Kiosk, and the existing Public Address System equipment in the Jackson Graham Building. Points of interface include the passenger station's Communications Equipment Room, the Jackson Graham Building, the Kiosk, and locations within the passenger stations where loudspeakers are required.

1.05 CLOSED CIRCUIT TELEVISION SYSTEM

A. The Closed Circuit Television System interfaces include, but are not limited to, the passenger station's Kiosk and the Electrical Power Distribution System. Points of interface

include the passenger station's Communications Equipment Room, the Kiosk, and locations within the passenger stations where CCTV cameras are required.

1.06 FIRE AND INTRUSION ALARM SYSTEM

A. Passenger Station Fire and Intrusion Alarm System interfaces include, but are not limited to, the existing partial Station Fire and Intrusion System, the Technical Control Facility, the passenger station Public Address System, the Data Transmission System, the Automatic Fare Collection equipment, the elevators, and the Electrical Power Distribution System.

B. Points of interface in the passenger stations and ancillary buildings associated with this Contract include the Communications Equipment Room, the Kiosk, elevators and the Elevator Machine Room, selected air handling equipment, escalators and areas that contain deluge valves and water flow valves, and all locations where detectors are required.

1.07 CARRIER TRANSMISSION SYSTEM

A. .Carrier Transmission System interfaces include, but are not limited to, the Fiber Optics System, the Telephone System, the Public Address System, the Passenger Emergency Reporting System, the Data Transmission System, the Technical Control Facility, the Mobile Radio System, and the Electrical Power Distribution System. Each system/facility shall be compatible with the channel(s) of the Carrier Transmission System which it utilizes.

B. Points of interface exist in the Communications Equipment Rooms in the passenger stations, the Jackson Graham Building, and in the Communications Equipment Rooms and designated intermediate locations along the right-of-way.

C. Carrier Transmission Systems, in addition to interfacing with each of the systems/facilities that use it as a transmission means, shall be compatible and operable with Carrier Transmission System equipment located at the Jackson Graham Building, in Communications Equipment Rooms along the right-of-way, and/or other specified locations. Space has been allocated in the Jackson Graham Building for Carrier Transmission System equipment to be furnished and installed in accordance with these Specifications.

1.08 FIBER OPTICS SYSTEM

A. The Fiber Optics System interfaces include, but are not limited to, the Carrier Transmission System and the Electrical Power Distribution System for the passenger stations.

B. Points of interface exist at the passenger station Communications Equipment Room, the Jackson Graham Building, and along the right-of-way.

1.09 TELEPHONE SYSTEM

A. Passenger Station Telephone System interfaces include, but are not limited to, the Carrier Transmission System, the existing Computerized Branch Exchange (CBX) in the Jackson Graham Building, and the Electrical Power Distribution System. Points of interface include the passenger station's Communications Equipment Room, the Jackson Graham Building, the Kiosk; and in the passenger stations, ancillary buildings, and at Emergency Trip Station (ETS) enclosures along the right-of-way where telephone instruments are required.

1.10 PASSENGER EMERGENCY REPORTING SYSTEM

A. Passenger Emergency Reporting System interfaces include, but are not limited to, the

passenger station Kiosk, the Electrical Power Distribution System and on the passenger station's platform. Points of interface exist in the Communications Equipment Room of the passenger stations, the Kiosk, and at locations within the passenger stations where Call Station Panels are required.

1.11 AUTOMATIC PUBLIC ADDRESS ANNOUNCEMENT SYSTEM

A. Automatic Public Address Announcement System interfaces include, but are not limited to, the Public Address System, the Fire and Intrusion Alarm System, the passenger station Kiosk, and the Electrical Power Distribution System. Points of interface exist in the Communications Equipment Room of the passenger stations and the Kiosk within the passenger stations.

1.12 PASSENGER STATION KIOSKS

A. Passenger Station Kiosk interfaces include, but are not limited to, the passenger station Public Address System, the passenger station Telephone System, the passenger station Closed Circuit Television System, the Passenger Station Fire and Intrusion Alarm System, the Technical Control Facility, the Passenger Emergency Reporting System, the Automatic Public Address Announcement System, the Electrical Power Distribution System, the Kiosk structures, the Data Transmission System, and the escalators and elevators. Points of interface exist within the Kiosk, in the passenger station Communications Equipment Room, in the AC Switchboard Room, and at the elevators and escalators.

1.13 ELECTRICAL POWER DISTRIBUTION SYSTEM

A. Electrical Power Distribution System interfaces for the provision of uninterruptible 120 Vac power include, but are not limited to, the passenger station Public Address System, the passenger station Closed Circuit Television System, the passenger station Fire and Intrusion Alarm System, the Carrier Transmission System, the passenger station Telephone System, the Passenger Emergency Reporting System, the Automatic Public Address Announcement System, the passenger station Kiosk and the passenger station Mobile Radio System. Points of interface include the passenger station Communications Equipment Room, the Kiosk, and the AC Switchboard Room.

B. For the provision of -48 Vdc power, Electrical Power Distribution System interfaces include, but are not limited to, the Carrier Transmission System, the Fiber Optics System and the passenger station Telephone System. Points of interface include the passenger station Communications Equipment Room.

1.14 MOBILE RADIO SYSTEM

A. Mobile Radio System interfaces include, but are not limited to, the existing slotted coaxial cable antenna along the right-of-way and in other areas. Points of interface may exist within the tunnel areas where the existing slotted coaxial cable antenna is terminated, at the remote ancillary building(s) and passenger station(s) where UHF Two-Way Line Driver Units may be installed, and the passenger station Communications Equipment Room where a base station shall be installed.

1.15 FARE COLLECTION SYSTEM

A. The Contractor shall interface with the Fare Collection System to determine the availability of the Kiosk fare collection console and fare collection equipment, and to coordinate work schedules and related details.

1.16 INTERFACE WITH THE AUTHORITY

A. WMATA is an operating rapid transit system. The Contractor shall interface with the Authority to coordinate schedules and access to areas of the system where work is to be performed. Coordination is required for physical access to Communications Equipment Rooms, tunnel areas, the Jackson Graham Building, operations rooms, Kiosks, and platform areas (other than areas within the passenger stations in this Contract).

B. Equipment installed in the Communications Equipment Rooms and Kiosks in operational passenger stations and in the Jackson Graham Building, contain working circuits supporting transit operations. Certain work in those areas may require special coordination, in accordance with instructions furnished by the Engineer, to ensure that work can be performed on an essentially non-interfering basis.

C. Within Communications Equipment Rooms and Kiosks in operational passenger stations and yards, Contractors' work shall be performed with a representative of the Authority present. Connections to working circuits shall be made only by the Authority or with the permission of the Authority. The Contractor shall coordinate with the Authority all other work in operational passenger stations and yards to be performed in Communications Equipment Rooms and Kiosks. The Contractor shall advise the Authority of the work to be accomplished, including wiring and cross-connections, and the scheduled beginning and completion of each task.

1.17 LOCAL FIRE AUTHORITY

A. The Contractor shall interface with the local fire authority having jurisdiction over the various areas within the limits of the Contract work area to obtain advisory opinions concerning compliance with proprietary "Fire Protection Equipment and Life Safety Agreements" and applicable provisions of the local fire codes, and to coordinate related details when so directed by the Engineer.

PART 2 PRODUCTS (SECTION NOT USED)

PART 3 EXECUTION (SECTION NOT USED)

END OF SECTION

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

DEPARTMENT OF
INFORMATION TECHNOLOGY
NETWORK & COMMUNICATIONS SERVICES

INFRASTRUCTURE DESIGN & WIRING STANDARDS

Table of Contents

PART 1 - GENERAL SPECIFICATIONS

1.1 SCOPE

This document describes the standards, products and execution requirements relating to furnishing and installing Telecommunications Cabling at new or remodeled buildings for the Washington Metropolitan Area Transit Authority, herein after called WMATA. These standards are provided for use in planning spaces, budgeting for communications infrastructure, and as a technical description suitable for use in Requests for Proposals.

These standards, used in conjunction with published current ANSI/TIA standards represent a structured communications wiring system which will accommodate technological developments over the next several years. As technology changes this document will be amended to provide the most current and effective information available. Any aspects of communications wiring or design, which are not sufficiently addressed in this document, shall be brought to the attention of Network Technology Operations & Infrastructure Design (IT-NCSInfrastructure@wmata.com) in the department of Information Technology, Network and Communications Services.

1. Backbone and horizontal cabling comprised of copper and fiber cabling, and support systems are covered under this document.
2. The Horizontal (workstation) Cabling System shall consist of a minimum of two (2) 4-pair category 6 Unshielded Twisted Pair (UTP) Copper Cables to each work area outlet unless otherwise noted for specific locations. The cables shall be installed from the Work Area Outlet to the Telecommunications Room (TR) located on the same floor, and routed to the appropriate rack serving that area and terminated as specified in this document.
3. All cables and related terminations, support and grounding hardware shall be furnished, installed, wired, tested, labeled, and documented by the Telecommunications contractor/installer as detailed in this document unless otherwise noted.
4. Product specifications, general design considerations, and installation guidelines are provided in this document. Typical installation details, cable routing and outlet types will be provided as an attachment to this document. If bid documents are in conflict, this specification shall take precedence. The contractor/installer shall meet or exceed all requirements for the cable system described in this document.

1.2 REGULATORY REFERENCES:

All work and materials shall conform in every detail to the rules and requirements of the National Fire Protection Association, the local Electrical Code and present manufacturing standards.

All materials shall be UL Listed and shall be marked as such. If UL has no published standards for a particular item, then other national independent testing standards shall apply and such items shall bear those labels. Where UL has an applicable system listing and label, the entire system shall be so labeled.

The cabling system described in this document is derived from the recommendations made in recognized telecommunications industry standards. The following documents are incorporated by reference:

1. ANSI/TIA-568-C.0, Generic Communications Cabling for Customer Premises, February 2009
2. ANSI/TIA - 568-C.1, Commercial Building Telecommunications Cabling Standard Part 1: General Requirements
3. ANSI/TIA - 568-C.2, Commercial Building Telecommunications Cabling Standard Part 2: Balanced Twisted-Pair Cabling Components
4. ANSI/TIA - 568-C.3, Commercial Building Telecommunications Cabling Standard Part 3: Optical Fiber Cabling Components
5. 5. ANSI/TIA – 569-C, Commercial Building Standard for Telecommunications Pathways and Spaces,
6. TIA-527, Measurement of Optical Power Loss of Installed Single-mode Fiber Cable Plant – OFSTP-7

7. TIA-526-14-A, Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant - OFSTP-14A
8. TIA-598-C, Optical Fiber Cable color Coding, January, 2005
9. ANSI/TIA – 570-B, Residential Telecommunications Infrastructure Standard, April 2004
10. ANSI/TIA – 606 - B, Administration Standard for Commercial Telecommunications Infrastructure April 2012
11. ANSI/TIA- 607-B - Commercial Building Bonding and Grounding (Earthing) Requirements for Telecommunications, August 2011
12. TIA– 758-A, Customer-Owned Outside Plant Telecommunications Infrastructure Standard, August 2004
13. BICSI - TDMM, Building Industries Consulting Services International, Telecommunications Distribution Methods Manual (TDMM) – 13th Edition, 2014
14. National Fire Protection Agency (NFPA – 70),
15. National Electrical Code (NEC) -2014
16. National Fire Protection Agency (NFPA-130) Standard for Fixed Guideway Transit and Passenger Rail Systems, 2010

If this document or any of the documents listed above are in conflict, then the more stringent requirement shall apply. All documents listed are believed to be the most current releases of the documents. The contractor/installer has the responsibility to determine and adhere to the most recent release when installing or designing for installation.
This document does not replace any code, either partially or wholly. The contractor/installer must be aware of local codes which may have an impact on the design or installation of any cabling.

1.3 APPROVED CONTRACTOR

The Telecommunications contractor must be an approved Legrand/Ortronics Certified Installer at a CIP or CIP-ESP level. A copy of certification documents must be submitted initially to this office (IT-NCSInfrastructure@wmata.com). The Telecommunications contractor/installer is responsible for workmanship and installation practices in accordance with the Legrand/Ortronics Certification Program. Legrand/Ortronics/Superior Essex will extend an nCompass Limited Lifetime warranty to the end user once the Telecommunications contractor/installer fulfills all requirements under Legrand/Ortronics Certification Program. The contractor must be in good standing with a minimum of 30 percent of the technicians on site and at least one manager current with the required training. **See Appendix A, Legrand/Ortronics Certified Installation Contractors.**

1.4 APPROVED PRODUCTS

Superior Essex and Legrand/Ortronics have been listed here as a WMATA preferred solution; however any other manufacture's solution meeting or exceeding the listed criteria may be submitted for review and approval. Any solution submitted must also be capable of providing a manufacturers warranty equal to, or greater than the preferred Superior Essex-Legrand/Ortronics nCompass solution. **See Appendix B, Approved Material List. This is not an all-inclusive list and represents our most commonly used products.**

1.5 WORK INCLUDED

The work included under this design standard consists of furnishing all labor, equipment, materials, and supplies and performing all operations necessary to complete the installation of this structured cabling system in compliance with the specifications and drawings. The Telecommunications contractor/installer will provide and install all of the required material to form a complete system whether specifically addressed in the technical specifications or not.
The work shall include, but not be limited to the following:

- Furnish and install a complete telecommunications wiring infrastructure
- Furnish, install, and terminate all UTP and Optical Fiber cable
- Furnish and install all wall plates, jacks, patch panels, and patch cords

- Furnish and install all required cabinets and/or racks as required and as indicated
- Furnish any other material required to form a complete system
- Perform link or channel testing (100% of horizontal and/or backbone links/channels) and certification of all components
- Furnish test results of all cabling to the owner on compact disk and paper format, listed by each closet, then by workstation ID
- Adhere and comply with all requirements of Legrand/Ortronics Certification program
- Provide owner training and documentation. (Testing documentation and As-built drawings

1.6 SUBMITTALS

Under the provisions of this design and wiring standard, prior to the start of work the telecommunications contractor/installer shall:

- Submit copies of the certification of the company and names of staff that will be performing the installation and termination of the installation to provide proof of compliance of this design and installation standard.
- Submit proof from manufacturer of contractor's good standing in manufacturer's program. This certification must be completed annually and submitted to this office (IT-NCSInfrastructure@wmata.com).
- Submit appropriate cut sheets and samples for all products, hardware and cabling.
- Work shall not proceed without the Owner's approval of the submitted items.
- The telecommunications contractor/installer shall receive approval from the Owners on all substitutions of material. No substituted materials shall be installed except by written approval from the Owner and this office.

1.7 QUALITY ASSURANCE

The Legrand/Ortronics CIP / CIP-ESP telecommunications contractor/installer shall be a company specializing in communication cabling installation. The contractor must be in good standing with a minimum of 30% of the technicians on site and at least one manager current with the required training.

IT/NCS Cable Installation Quality Control Process

1. QA Phase 1
    - IT/NCS Cable Installation Practices. Inspections will ensure the following conform to TIA/EIA, WMATA Design & Wiring Standards, and all Local codes
    - Cable bend radius
    - Cable support in ceiling (Hangers/J hooks/ladder racks)
    - Cable slack at the work area and the TR
    - TR Configuration (Proper cable placement based on scope of work)
2. QA Phase 2
    - IT/NCS Cable Termination Practices. Inspections will ensure the following conform to TIA/EIA, WMATA Design & Wiring Standards, and all Local codes
    - Correct type, style and color of work area outlet
    - Correct jack pin out configuration
    - Correct TR termination: Pin out, Hardware and placement
    - Correct backbone termination
3. QA Phase 3
    - IT/NCS Cable Installation Practices. Inspections will ensure the following conform to TIA/EIA, WMATA Design & Wiring Standards, and all Local codes
    - Final check of horizontal / Backbone cable route
    - Correct racks/enclosure installation. Type and placement
    - Overall progress
4. QA Phase 4 (Final)
    - IT/NCS Final Testing and Inspection. Inspections will ensure the following conform to

TIA/EIA, WMATA Design &Wiring Standards, and all Local codes
- Complete work area installation, including work area outlets, face plates and label
- Complete TR installation. Hardware installation, correct labeling, installation, type and the complete installation of all wire management
- Complete Backbone cable installation, termination and labeling
- View a percentage of the actual field testing to ensure correct procedures are being adhered to and the proper test equipment is being used

Final sign off: IT/NCS will sign a document provided by the telecommunications contractor/installer approving the installation process and materials demonstrated in this project.

1.8 DELIVERY, STORAGE AND HANDLING

- Delivery and receipt of products shall be at the contractor's main place of business/office.
- WMATA will not be responsible for the acceptance or delivery of any materials.
- Cable shall be stored according to manufacturer's recommendations as a minimum. In addition, cable must be stored in a location protected from vandalism and weather. If cable is stored outside, it must be covered with opaque plastic or canvas with provision for ventilation to prevent condensation and for protection from weather. If air temperature at cable storage location will be below 40 degrees F., the cable shall be moved to a heated (50 degrees F. minimum) location. If necessary, cable shall be stored off site at the contractor's expense.
- If the telecommunications contractor/installer wishes to have a trailer on site for storage of materials, arrangements shall be made with the Owner.

1.9 DRAWINGS

- It shall be understood that the electrical details and drawings provided with the specification package are diagrammatic. They are included to show the intent of the specifications and to aid the telecommunications contractor/installer in bidding the job. The telecommunications contractor/installer shall make allowance in the bid proposal to cover whatever work is required to comply with the intent of the plans and specifications.
- The telecommunications contractor/installer shall verify all dimensions at the site and be responsible for their accuracy.
- Prior to submission of any bid package, the telecommunications contractor/installer shall call to the attention of the Engineer of any materials or apparatus the telecommunications contractor/installer believes to be inadequate and to any necessary items of work omitted.

PART 2 – PRODUCTS

2.1 EQUIVALENT PRODUCTS

Due to the nature and type of communications, all products including but not limited to faceplates, jacks, patch panels, racks, 110 blocks, and patch cords, for the purpose of this document, shall be manufactured by Legrand/Ortronics. All copper and optical fiber cable products shall be manufactured by Superior Essex. Substitutions meeting or exceeding the listed criteria may be submitted for review and approval. Any solution submitted must also be capable of providing a manufacturer's warranty equal to, or greater than the preferred Superior Essex-Legrand/Ortronics nCompass solution.

2.2 WORK AREA OUTLETS

Work area cables shall each be terminated at their designated work area location in the connector types described in section 1.4, Approved Products.

The Telecommunications Outlet Assembly shall accommodate:

- A minimum of two (2) modular jacks
- Additional accommodations for specific locations as noted in the plans for optical fiber and/or additional copper cables as necessary.
- A blank filler will be installed when extra ports are not used.
- A dust cap shall be provided on all modular jacks with the circuit number on the identifier strip.
- Multiple jacks that are identified in close proximity on the drawings (but not separated by a physical barrier) may not be combined in a single assembly unless pre-approved through the use of a Request for Information (ROI). The telecommunications contractor/installer shall be responsible for determining the optimum compliant configuration based on the products proposed.
- The same orientation and positioning of jacks and connectors shall be utilized throughout the installation. Prior to installation, the telecommunications contractor shall submit the proposed configuration for each outlet assembly for review by the Owner.
- The modular jack shall incorporate printed label strip on the dust cap module for the purpose of identifying the outlet. Printed labels shall be permanent and compliant with ANSI/TIA–606-B standard specifications. Labels shall be printed using Legrand/Ortronics label template or using a printer such as a Dymo or Brady hand held printer. Hand printed labels shall not be accepted.

Faceplates: The faceplates shall:

- Be as described in section 1.4, Approved Products
- Be UL listed and CSA certified
- Be constructed of high impact, ABS plastic UL 94V-0 construction (except where noted otherwise)
- Shall match the faceplate color used for other utilities in the building or match the color of the raceway if installed in surface raceway
- Be compliant with the above requirements along with the following when incorporating optical fiber
- Be a low profile assembly
- Incorporate a mechanism for storage of cable and fiber slack needed for termination
- Position the fiber optic couplings to face downward or at a downward angle to prevent contamination
- Incorporate a shroud that protects the optical couplings from impact damage
- Be available as single-gang or dual-gang
- Shall provide easy access for adds, moves, and changes by front removal of jack modules
- Possess recessed designation windows to facilitate labeling and identification
- Shall include a clear plastic cover to protect labels in the designation window
- Have mounting screws located under recessed designation windows
- Comply with ANSI/TIA-606-B work area labeling standard
- Allow for the UTP modules to be inverted in place for termination purposes

Voice / Data Jacks/Outlets

- Voice/Data jacks shall be 8-position modular jacks and shall be Category 6 performance as defined by the references in this document including ANSI/TIA-568-C.2. All pair combinations must be considered, with the worst-case measurement being the basis for compliance
- Be as described in section 1.4, Approved Products
- The modular jack shall be backwards compatible to Category 3, 5, and 5e
- All horizontal category 6 user end outlet cable will be terminated on a category 6 rated patch panel
- User end outlets are utilized for both voice and/or data connectivity
- 568B pin out configuration to be used

2.3 110 COPPER TERMINATION BLOCK

The copper cross connect shall be a passive connection between the horizontal termination patch panels and the backbone termination blocks. The wall mount frames shall be field terminated kits including all blocks, connecting blocks, and designation strips. Management rings shall be mounted between vertical columns of blocks to provide management of cross-connect wire. Backbone blocks shall use 5-pair connecting blocks.

110 Block Kits shall

- Include both the wiring block in a 50, 100 and 300 pair footprint
- Be OR-110ABC6050, OR-110ABC6100 AND OR-110ABC6300
- Be as described in section 1.4, Approved Products
- Support termination of 22-24 AWG solid conductor
- Wiring block shall contain back openings for the feed through of cable
- Have color-coded tips on the wiring block and color coding on the connector blocks for installation identification
- Shall use standard termination practice requiring a single conductor 110 impact tool
- Termination hardware shall maintain the paired construction of the cable to facilitate minimum untwisting of the wires
- Be labeled in compliance with ANSI/TIA-606-B labeling specifications using permanent labels and Ortronics 110 block template (or other labeling software/printer)

110 Cross-Connect System Backboard Channels Shall

- Be available in 300 and 900 pair sizes
- Allow the mounting of 110 100-pair blocks without legs
- Include bottom trough and grounding bar
- Be wall mountable

110 Wall Mount Vertical Trough Shall

- Be available in single channel or dual channel configurations
- Be in dual channel configuration shall be used to provide separation for different wiring media
- Be available in 300 pair and 900 pair sizes
- Be wall mountable
- Be used with wall mountable backboard channels. Acceptable configurations include a 300 pair and a 900 pair

2.4 MODULAR PATCH PANELS

The Modular Patch Panels shall

- Meet category 6 component compliance
- Be as described in section 1.4, Approved Products
- Require standard termination practices using a 110 impact tool
- Use a single piece IDC housing designed to accept larger Category 6 conductors
- Support both T568B and T568A wiring
- Include easy to follow wiring labels
- Include label fields

- Allow for the use of icons
- Include full length metal rear cable management
- Be available in standard or high density
- Be backward compatible to category 3, 5 and 5e

2.5 RACKS

All racks and wire management shall be Legrand/Ortronics specific. The equipment rack shall provide vertical cable management and support for the patch cords at the front of the rack and wire management, support, and protection for the horizontal cables inside the legs of the rack. Waterfall cable management shall be provided at the top of the rack for patch cords and for horizontal cables entering the rack channels for protection and to maintain proper bend radius and cable support. Wire management shall also be mounted above each patch panel and/or piece of equipment on the rack. The rack shall include mounting brackets for cable tray ladder rack to mount to the top of the rack. Velcro cable ties shall be provided inside the rack channels to support the horizontal cable. Rack shall be black in color to match the patch panels and cable management.

Free-Standing Rack

Free-standing rack shall:

- Provide the necessary strain relief, bend radius and cable routing for proper installation of high performance cross connect products, meeting all specifications of ANSI/TIA-568-C
- Have top cable trough with waterfall and built in patch/horizontal cable distribution separator
- Have EIA hole pattern on front and rear
- Be available with a 6.5" (165 mm) channel depth
- Be available with hook and loop straps for securing bulk cables inside the vertical U-channels
- Assemble as 19" (483 mm) or 23" (584 mm) with no additional hardware
- Be available with three styles of vertical patch cord management: interbay with latches, cable management rings, or finger duct with covers
- Provide floor and ceiling access for cable management and distribution
- Provide pre-drilled base for floor attachment of rack
- Rack height shall be specified as 7 ft / 2.13 m (44 rack units) or 4.0 ft/1.22 m (22 rack units)
- Be available with vertical cable management rings for cord routing organization and strain relief

Wall Mounted Rack

Wall mount rack shall:

- Provide the necessary strain relief, bend radius and cable routing for proper installation of high performance cross connect products, meeting all specifications of ANSI/TIA-568-C
- Have EIA hole pattern
- Be available with hook and loop straps for securing cables inside the vertical U-channels
- Be available with vertical U-channels to protect and conceal distribution cables
- Provide floor and ceiling access for cable management and distribution
- Have wall mount braces with locator posts for easy wall mounting
- Have side access points that allow for access to manage/install distribution cables in the vertical channels

2.6 HORIZONTAL DISTRIBUTION CABLE

All horizontal distribution cable shall be Superior Essex specific. All horizontal station cable shall terminate on modular patch panels (copper or fiber), or patch/splice cabinets (fiber) in their respective Telecommunications Room or Equipment Room as specified on the drawings. In all instances, unless otherwise specified, all horizontal user end outlet cables will be category 6 and terminate on an appropriate category 6 patch panel.

100 OHM Category 6 UNSHIELDED TWISTED PAIR CABLE (UTP)

Physical Characteristics:

- (For Plenum) shall be plenum rated and meet applicable requirements of ANSI/ICEA S-116-732-2013.
- UL listed and UL Verified Cat 6.
- All 4 pairs must be insulated with FEP.
- Be as described in section 1.4, Approved Products
- The outer jacket shall be flame retardant, low smoke PVC.
- Shall be suitable for the environment in which they are to be installed.

Transmission Characteristics:

- Electrical transmission performance testing of a cabling configuration to the requirements of ANSI/TIA-568-C.2 Balanced Twisted-Pair Telecommunications Cabling and Component Standards for Category 6 Channel.
- Channel Margin Guarantees: Improved channel performance that exceeds the ANSI/TIA-568-C.2 standard. Margins supported over standard compliant channels from 7 to 100 meters.

Parameter	Margin vs. TIA-568-C.2
Insertion Loss	3%
NEXT	5 dB
PSNEXT	5 dB
Return Loss	3 dB
ACRF	5 dB
PSACRF	5 dB
ACR	5 dB
PSACR	5 dB

2.7 HORIZONTAL AND BACKBONE CABLE

Premise Optical Fiber Plenum (OFNP) Tight Buffered With Laser Optimized OM3 50/125 Optical Fibers

Each Multimode Fiber shall be:

- Graded-index Multi-mode optical fiber wave-guide with TeraFlex Bend Resistant Laser Optimized 50/125nm-core/cladding.
- Be as described in section 1.4, Approved Products
- Shall comply with the requirements of the latest revision of ICEA S-83-596.
- Attenuation shall be measured in accordance with the latest revision of TIA-455-78-B.
- Information transmission capacity shall be measured in accordance with the latest revision of TIA-455-220-A.
- Maximum attenuation dB/Km @ 850/1300 nm: Per manufacturer's specifications

Physical Characteristics:

- Shall be suitable for use in intra-building backbone, conduit pathways and service entrance to communication closet applications.
- Shall be suitable for use in risers, plenums and horizontal applications.
- Shall be available with a fiber strand count range from 6 to 144.
- Shall have and be marked with an UL-OFNP (OFCP if armored) and OFN (OFC if armored) FT6 Flame Rating.
- Strength members shall be dielectric aramid yarn.
- Subunits shall be numbered and color-coded in accordance with the latest TIA-598-C with an

overall aqua jacket.
- Subunits shall be manufactured with a reverse oscillating lay (ROL) stranded around a flexible high-strength glass reinforced rod.
- Suitable for operation between -20°C to +75°C for riser and 0°C to +75°C for plenum
- Shall be available in Aluminum Interlock Armor construction as needed

Premise Optical Fiber Plenum (OFNP) Tight Buffered With Enhanced (Low Water Peak) Single-mode Optical Fibers

Each Single-mode Fiber shall be:
- Class IVa dispersion - unshifted single mode optical fibers with TeraFlex Bend Resistant G657.A1 complying with the latest revision of ANSI/ICEA S-83-596.
- Be as described in section 1.4, Approved Products
- The zero dispersion wavelengths shall be between 1300 nm and 1324 nm. The ANSI/TIA-455-175-B maximum value of the dispersion slope shall be no greater than 0.090 ps/km-nm2. Dispersion measurements shall be made in accordance with the latest revision of ANSI/TIA-455-175.

Transmission Characteristics:
- Maximum cabled attenuation dB/km @ 1310/1550 nm: 0.5/0.4
- The cabled cutoff wavelength shall be ≤1260 nm when measured in accordance with the latest revision of ANSI/TIA-455-80.

Physical Characteristics:
- Shall be suitable for use in intra-building backbone, conduit pathways and service entrance to communication closet applications.
- Shall be suitable for use in risers, plenums and horizontal applications.
- Shall be available with a fiber strand count range from 6 to 144.
- Shall have and be marked with an UL-OFNP and OFN FT6 Flame Rating.
- Shall comply with the requirements of the latest revision of ANSI/ICEA S-83-596.
- Strength members shall be dielectric aramid yarn.
- Subunits shall be numbered and color-coded in accordance with TIA-598-C with an overall aqua jacket.
- Subunits shall be manufactured with a reverse oscillating lay (ROL) stranded around a flexible high-strength glass reinforced rod.
- Suitable for operation between -20°C to +75°C for riser and 0°C to +75°C for plenum
- Shall be available in Aluminum Interlock Armor construction as needed

Indoor/Outdoor Optical Fiber Plenum (OFNP) With Laser Optimized 50/125 Optical Fibers

Each Multimode Fiber shall be:
- Graded-index Multi-mode optical fiber wave-guide with TeraFlex Bend Resistant Laser Optimized 50/125nm-core/cladding.
- Be as described in section 1.4, Approved Products
- Shall comply with the latest revision of ANSI/TIA-492AAAB.
- Shall comply with the latest revision of ANSI/ICEA S-104-696.
- Attenuation shall be measured in accordance with the latest revision of ANSI/TIA-455-78.
- Information transmission capacity shall be measured in accordance with the latest revision of ANSI/TIA-455-220.
- Maximum attenuation dB/km @ 850/1300 nm: Per manufacturer's specifications

Physical Characteristics:
- Shall be available in either tight buffered or loose tube construction for use in both outdoor and

indoor applications without the use of a transition at the building entrance.
- Shall be suitable for use in risers, plenums and horizontal applications.
- Shall have a dry water blocking system for cable core and buffer tubes.
- Shall be available with a fiber strand count range from 6 to 144.
- Shall have and be marked with an UL-OFNP (OFCP for armored) and OFN (OFC for armored) FT6 Flame Rating.
- Shall comply with the requirements of the latest revision of ANSI/ICEA S-104-696.
- Strength members shall be dielectric.
- Suitable for underground or above ground conduits.
- Cable shall be color coded in accordance with the latest revision of ANSI/TIA-598 with an overall black jacket.
- Suitable for operation between -40°C to +70°C
- Shall be UV resistant
- Shall be available in either aluminum interlock or steel construction armor.

Indoor/Outdoor Optical Fiber Plenum (OFNP) With Enhanced (Low Water Peak) Single-mode Optical Fibers

Each Single-mode Fiber shall be:
- Class IVa dispersion - unshifted single mode optical fibers with TeraFlex Bend Resistant G657.A1 complying with the latest revision of ANSI/ICEA S-104-696.
- Be as described in section 1.4, Approved Products
- The zero dispersion wavelengths shall be between 1300 nm and 1320 nm. The ANS/TIA-455-168 maximum value of the dispersion slope shall be no greater than 0.090 ps/km-nm2. Dispersion measurements shall be made in accordance with the latest revision of ANSI/TIA-455-175.

Transmission Characteristics:
- Maximum cabled attenuation dB/km @ 1310/1550 nm: 0.5/0.4
- The cabled cutoff wavelength shall be ≤1260 nm when measured in accordance with the latest revision of ANSI/TIA-455-80.

Physical Characteristics:
- Shall be available in either tight buffered or loose tube construction for use in both outdoor and indoor applications without the use of a transition at the building entrance.
- Shall be suitable for use in risers, plenums and horizontal applications.
- Shall have a dry water blocking system for cable core and buffer tubes.
- Shall be available with a fiber strand count range from 6 to 144.
- Shall have and be marked with an OFNP (OFCP for armored) and OFN (OFC for armored) FT-6 Flame Rating.
- Shall comply with the latest revision of ANSI/ICEA S-104-696.
- Strength members shall be dielectric.
- Suitable for underground or above ground conduits.
- Cable shall be color coded in accordance with the latest revision of ANSI/TIA-598 with an overall black jacket.
- Shall have a ripcord for overall jacket.
- Suitable for operation between -40^{o}C to +70^{o} C
- Shall be UV resistant
- Shall be available in either aluminum interlock or steel construction armor.

Indoor/Outdoor Optical Fiber Low Smoke Zero Halogen (LSZH) Loose Tube With Laser Optimized OM3 50/125 Optical Fibers - use in NFPA-130 required environments

Each Multimode Fiber shall be:
- Graded-index Multi-mode optical fiber wave-guide with TeraFlex Bend Resistant Laser

Optimized 50/125nm-core/cladding.
- Be as described in section 1.4, Approved Products
- Shall comply with the latest revision of ANSI/ICEA S-104-696-2013.
- Attenuation shall be measured in accordance with the latest revision of ANSI/TIA-455-78.
- Information transmission capacity shall be measured in accordance with the latest revision of ANSI/TIA-455-220.
- Maximum attenuation dB/Km @ 850/1300 nm: Per manufacturer's specifications

Physical Characteristics:
- Shall be suitable for use in NFPA-130 tunnel, subway passages and passage station environments both outdoor and indoor applications without the use of a transition at the building entrance.
- Shall be suitable for use in low smoke zero halogen applications.
- Shall have a dry, fully water blocked core and buffer tubes water blocked with PFM.
- Shall be available with a fiber strand count range from 6 to 288.
- Shall have and be marked with an UL-1666 and OFNG-LS (OFCG-LS for armored) Flame Rating.
- Shall comply with the requirements of the latest revision of ANSI/ICEA S-104-696.
- Strength members shall be dielectric and may be aramid yarn.
- Suitable for underground or above ground conduits.
- Loose Tube fibers shall be color coded in accordance with TIA-598-C with an overall black jacket.
- Suitable for operation between -40°C to +70°C
- Shall be flame and sunlight resistant
- Shall be available in Corrugated Steel Armor construction as needed.

Indoor/Outdoor Optical Fiber Plenum (OFNP) Loose Tube With Enhanced (Low Water Peak) Single-mode Optical Fibers - use in NFPA-130 required environments

Each Single-mode Fiber shall be:
- Class IVa dispersion - unshifted single mode optical fibers with TeraFlex Bend Resistant G657.A1 complying with the latest revision of ANSI/ICEA S-104-696.
- Be as described in section 1.4, Approved Products
- The zero dispersion wavelengths shall be between 1300 nm and 1320 nm. The ANSI/TIA-455-168 maximum value of the dispersion slope shall be no greater than 0.090 ps/km-nm2. Dispersion measurements shall be made in accordance with the latest revision of ANSI/TIA-455-169 or ANSI/TIA-455-175.

Transmission Characteristics:
- Maximum cabled attenuation dB/km @ 1310/1550 nm: 0.5/0.4
- The cabled cutoff wavelength shall be ≤1260 nm when measured in accordance with the latest revision of ANSI/TIA-455-80.

Physical Characteristics:
- Shall be suitable for use in NFPA-130 tunnel, subway passages and passage station environments both outdoor and indoor applications without the use of a transition at the building entrance
- Shall be suitable for use in low smoke zero halogen applications.
- Shall have a dry, fully water blocked core and buffer tubes water blocked with PFM.
- Shall be available with a fiber strand count range from 6 to 288.
- Shall have and be marked with an UL-1666 and OFNG-LS (OFCG-LS for armored) Flame Rating.
- Shall comply with the latest revision of ANSI/ICEA S-104-696.
- Strength members shall be aramid/yarn.
- Suitable for underground or above ground conduits.
- Loose Tube fibers shall be color coded in accordance with TIA-598-C with an overall black

jacket.
- Suitable for operation between -40°C to +70°C
- Shall be flame and sunlight resistant
- Shall be available in Corrugated Steel Armor construction as needed.

2.8 FIBER OPTIC CONNECTORS

Each Fiber Connector shall:

- WMATA's standard multimode and singlemode fiber optic connector is the SC style connector
- Be available in singlemode and multimode versions
- Be as described in section 1.4, Approved Products
- Accept a nominal fiber diameter of 125 micrometers
- Have a typical insertion loss of 0.3 dB for multimode and 0.2 dB for singlemode
- Be stable over an operating range of –40C to +75 degrees C.

2.9 COPPER CABLE PROTECTION UNITS

All copper circuits shall be provided with protection between each building with an entrance cable protector panel. See section 2.11 for additional requirements. All building-to-building circuits shall be routed through this protector. The protector shall be connected with a #6 AWG copper bonding conductor between the protector ground lug and the TC ground point. Approved manufacturer of protection units is Porta Systems.

2.10 PATCH CORDS

The contractor shall provide factory terminated and tested UTP and optical fiber patch cords and equipment cords for the complete cabling system. The UTP patch cables shall meet the requirements of ANSI/TIA/ -568-C for patch cord testing.

Copper (UTP) patch cords shall:

- Be as described in section 1.4, Approved Products
- Be an Ortronics category 6 Clarity patch cord with Paralign 2 Plug Design.
- Use 8 position connector with impedance matched contacts and designed using dual reactance.
- Be constructed of 100 ohm, 4 pair, 24 AWG, stranded conductor, unshielded twisted pair copper per the requirements of the ANSI/TIA-568-C.2 and ANSI/TIA-568-C.2–1 standard.
- Meet TIA category 6 component specifications in ANSI/TIA-568-C.2-1
- 100% factory tested to meet category 6 performance
- Be capable of universal T568A or T568B wiring schemes.
- Modular connector shall maintain the paired construction of the cable to facilitate minimum untwisting of the wires.
- Have a performance marking indelibly labeled on the jacket (by the manufacturer).
- Have the ability to accept color-coded labels and icons to comply with ANSI/TIA-606-B labeling specifications.
- Have "snagless" protection for the locking tab to prevent snagging and to protect locking tab in tight locations and provide bend relief
- Be backwards compatible to Category 3, 5 and 5e

Optical Fiber patch cords shall:

- Contain two (2) optical fibers.
- Be as described in section 1.4, Approved Products
- Include listing of actual loss of patch cord when packaged

2.11 BONDING AND GROUNDING

The facility shall be equipped with a Telecommunications Bonding Backbone (TBB). This backbone shall be used to ground all telecommunications cable shields, equipment, racks, cabinets, raceways, and other associated hardware that has the potential to act as a current carrying conductor. The TBB shall be installed independent of the building's electrical and building ground and shall be designed in accordance with the recommendations contained in the ANSI/TIA-607 Telecommunications Bonding and Grounding Standard.

- The main entrance facility/equipment room in each building shall be equipped with a telecommunications main grounding bus bar (TMGB).
- Each telecommunications room shall be provided with a telecommunications ground bus bar (TGB).
- The TMGB shall be connected to the building electrical entrance grounding facility. The intent of this system is to provide a grounding system that is equal in potential to the building electrical ground system. Therefore, ground loop current potential is minimized between telecommunications equipment and the electrical system to which it is attached.
- All racks, metallic backboards, cable sheaths, metallic strength members, splice cases, cable trays, etc. entering or residing in the TR or ER shall be grounded to the respective TGB or TMGB using a minimum #6 AWG stranded copper bonding conductor and compression connectors.
- All wires used for telecommunications grounding purposes shall be identified with a green insulation. Non-insulated wires shall be identified at each termination point with a wrap of green tape.
- All cables and bus bars shall be identified and labeled in accordance with the System Documentation Section of this specification.

2.12 FIRESTOP

A fire stop system is comprised of the item or items penetrating the fire rated structure, the opening in the structure and the materials and assembly of the materials used to seal the penetrated structure. Fire stop systems comprise an effective block for fire, smoke, heat, vapor and pressurized water stream.

- All penetrations through fire-rated building structures (walls and floors) shall be sealed with an appropriate fire stop system. This requirement applies to through penetrations (complete penetration) and membrane penetrations (through one side of a hollow fire rated structure). Any penetrating item i.e., riser slots and sleeves, cables, conduit, cable tray, and raceways, etc. shall be properly fire stopped.
- Fire stop systems shall be UL Classified to ASTM E814 (UL 1479) and shall be approved by a qualified Professional Engineer (PE), licensed (actual or reciprocal) in the state where the work is to be performed.
- A drawing showing the proposed fire stop system, stamped/embossed by the PE shall be provided to the Owner's Technical Representative prior to installing the fire stop system(s).

PART 3- EXECUTION

3.1 WORK AREA OUTLETS

Cables shall be coiled in the in-wall or surface-mount boxes if adequate space is present to house the cable coil without exceeding the manufacturer's bend radius. In hollow wall installations where box-eliminators are used, excess wire can be stored in the wall. No more than 12" of UTP and 36" of fiber slack shall be stored in an in-wall box, modular furniture raceway, or insulated walls. Excess slack shall be loosely coiled and stored in the ceiling above each drop location when there is not enough space present in the outlet box to store slack cable.

- Cables shall be dressed and terminated in accordance with the recommendations made in the ANSI/TIA/EIA-568-C.1 document, manufacturer's recommendations and best industry practices.
- Pair untwist at the termination shall not exceed 12 mm (one-half inch).
- Bend radius of the horizontal cable shall not be less than 4 times the outside diameter of the cable.
- The cable jacket shall be maintained to within 25mm (one inch) of the termination point.

All Work Area design and installation practices should adhere to the BICSI TDMM 13th Edition Chapter 3.

3.2 TELECOMMUNICATIONS SPACES

Telecommunications spaces are defined as:

- Telecommunications enclosure (TE)
- Telecommunications room (TR)
- Equipment room (ER)
- Entrance facility (EF)

Conduit Pathways between any of these spaces must be at minimum 4in (EMT) in size. The amount of these conduits must be calculated using a 40% fill ratio and maintaining at least 50% vacancy after completion. All design and installation practices should adhere to the BICSI TDMM 13th Edition Chapter 6. This should include but is not limited to location, sizing, conditioning, fire protection, flood protection, floor loading, grounding, lighting, physical protection & EMI.

3.3 HORIZONTAL DISTRIBUTION SYSTEMS

The horizontal distribution system consists of two basic elements—the horizontal pathways and related spaces, and the horizontal cabling system.

Horizontal pathways include:

- Physical pathways (e.g., conduit and cable tray) used for containment of telecommunications cabling.
- Non-physical pathways (e.g., the space between open-top cable supports [J-hooks]) through which cable is placed between physical support or containment components.

Horizontal pathways consist of structures that conceal, protect, support, and provide access to horizontal cables between the telecommunications outlet/connector used to connect work area equipment at the work area and HC (FD) in the serving TR or TE.
All horizontal distribution systems design and installation practices should adhere to the BICSI TDMM 13th Edition Chapter 4.

3.4 HORIZONTAL DISTRIBUTION CABLE INSTALLATION

- Cable shall be installed in accordance with manufacturer's recommendations and best industry practices.
- A pull cord (nylon; 1/8" minimum) shall be co-installed with all cable installed in any conduit.
- Cable raceways shall not be filled greater than the ANSI/TIA/-569-C maximum fill for the particular raceway type or 40%.
- Cables shall be installed in continuous lengths from origin to destination (no splices) except for transition points, or consolidation points.
- Where transition points or consolidation points are allowed, they shall be located in accessible locations and housed in an enclosure intended and suitable for the purpose.
- The cable's minimum bend radius and maximum pulling tension shall not be exceeded.
- If a J-hook or trapeze system is used to support cable bundles all horizontal cables shall be supported at a maximum of 48 to 60 inch (1.2 to 1.5 meter) intervals. At no point shall cable(s) rest on acoustic ceiling grids or panels.
- Horizontal distribution cables shall be bundled in groups of no more than 50 cables. Cable bundle quantities in excess of 50 cables may cause deformation of the bottom cables within the bundle and degrade cable performance.
- Cable shall be installed above fire-sprinkler systems and shall not be attached to the system or any ancillary equipment or hardware. The cable system and support hardware shall be installed so that it does not obscure any valves, fire alarm conduit, boxes, or other control devices.
- Cables shall not be attached to ceiling grid or lighting fixture wires. Where support for horizontal cable is required, the contractor/installer shall install appropriate carriers to support the cabling.
- Any cable damaged or exceeding recommended installation parameters during installation shall be replaced by the contractor prior to final acceptance at no cost to the Owner.
- Cables shall be identified by a self-adhesive label in accordance with the System Documentation Section of this specification and ANSI/TIA-606-B. The cable label shall be applied to the cable behind the faceplate on a section of cable (within 6" of termination) that can be accessed by removing the cover plate.
- Unshielded twisted pair cable shall be installed so that there are no bends smaller than four times the cable outside diameter at any point in the run and at the termination field.
- Pulling tension on 4-pair UTP cables shall not exceed 25-lbf for a four-pair UTP cable.

All horizontal distribution systems design and installation practices should adhere to the BICSI TDMM 13th Edition Chapter 4 & BICSI ITISM Chapter 4.

3.5 HORIZONTAL CROSS CONNECT INSTALLATION

- Cables shall be dressed and terminated in accordance with the recommendations made in the ANSI/TIA-568-C standard, manufacturer's recommendations and best industry practices.
- Pair untwist at the termination shall not exceed 13 mm (0.5 inch). Untwist should be as close to zero as possible.
- Bend radius of the cable in the termination area shall not exceed 4 times the outside diameter of the cable.
- Cables shall be neatly bundled and dressed to their respective panels or blocks. Each panel or block shall be fed by an individual bundle separated and dressed back to the point of cable entrance into the rack or frame.
- The cable jacket shall be maintained as close as possible to the termination point.
- Each cable shall be clearly labeled on the cable jacket behind the patch panel at a location that can be viewed without removing the bundle support ties. Cables labeled within the bundle, where the label is obscured from view shall not be acceptable.

All horizontal distribution systems design and installation practices should adhere to the BICSI

TDMM 13th Edition Chapter 4.

3.6 OPTICAL FIBER TERMINATION HARDWARE

- Fiber slack shall be neatly coiled within the fiber splice tray or enclosure. No slack loops shall be allowed external to the fiber panel.
- Each cable shall be individually attached to the respective splice enclosure by mechanical means. The cables strength member shall be securely attached the cable strain relief bracket in the enclosure.
- Each fiber bundle shall be stripped upon entering the splice tray and the individual fibers routed in the splice tray.
- Each cable shall be clearly labeled at the entrance to the splice enclosure. Cables labeled within the bundle shall not be acceptable.
- A maximum of 12 strands of fiber shall be spliced in each tray
- All spare strands shall be installed into spare splice trays.
- All connectors shall be mechanically installed. No pigtail splices without prior approval.

All fiber optic termination practices should adhere to the BICSI ITSIM Chapter 6.

3.7 BACKBONE CABLE INSTALLATION

- Backbone cables shall be installed separately from horizontal distribution cables
- A pull cord (nylon; 1/8" minimum) shall be co-installed with all cable installed in any conduit.
- Where cables are housed in conduits, the backbone and horizontal cables shall be installed in separate conduits
- Where backbone cables are installed in an air return plenum, riser rated cable shall be installed in metallic conduit.
- Where backbone cables and distribution cables are installed in a cable tray or wire way, backbone cables shall be installed first and bundled separately from the horizontal distribution cables.
- All backbone cables shall be securely fastened to the sidewall of the TR on each floor.
- Backbone cables spanning more than three floors shall be securely attached at the top of the cable run with a wire mesh grip and on alternating floors or as required by local codes.
- Vertical runs of cable shall be supported to messenger strand, cable ladder, or other method to provide proper support for the weight of the cable.
- Large bundles of cables and/or heavy cables shall be attached using metal clamps and/or metal banding to support the cables.

All backbone distribution systems design and installation practices should adhere to the BICSI TDMM 13th Edition Chapter 5.

3.8 COPPER TERMINATION HARDWARE

- Cables shall be dressed and terminated in accordance with the recommendations made in the ANSI/TIA-568-C standard, manufacturer's recommendations and best industry practice.
- Pair untwist at the termination shall not exceed 12 mm (one-half inch). Keep untwist as close to zero as possible.
- Bend radius of the cable in the termination area shall not exceed 4 times the outside diameter of the cable.
- Cables shall be neatly bundled and dressed to their respective panels or blocks. Each panel or block shall be fed by an individual bundle separated and dressed back to the point of cable entrance into the rack or frame.
- The cable jacket shall be maintained to within 25 mm (one inch) of the termination point.
- Each cable shall be clearly labeled on the cable jacket behind the patch panel at a location that can be viewed without removing the bundle support ties. Cables labeled within the bundle, where the

label is obscured from view shall not be acceptable.

All copper cable termination practices should adhere to the BICSI ITSIM Chapter 6.

3.9 RACKS

- Racks shall be securely attached to the concrete floor using the provided hardware or as required by local codes.
- Isolation pads and/or isolation spacer shall be used in all railway stations, TPSS, and TBS locations.
- Nonmetallic hardware shall be used to secure racks to flooring in all railway stations, TPSS, and TBS locations.
- Racks shall be placed with a minimum of 36 inch clearance from the walls on all sides of the rack. When mounted in a row, maintain a minimum of 36 inches from the wall behind and in front of the row of racks and from the wall at each end of the row.
- All racks shall be grounded to the telecommunications ground bus bar in accordance with Section 2.11 of this document.
- Rack mount screws not used for installing patch panels and other hardware or accessories shall be bagged and left with the rack upon completion of the installation.
- Wall mounted termination block fields shall be mounted on 4’ x 8’ x .75” void free plywood. The plywood shall be mounted vertically 12” above the finished floor. The plywood shall be painted with two coats of white fire retardant paint.
- Wall mounted termination block fields shall be installed with the highest point not to exceed 5’6” above the finished floor and with the lowest edge of the mounting frame 18” from the finished floor.

3.10 FIRESTOP SYSTEM

- All fire stop systems shall be installed in accordance with the manufacturer’s recommendations and shall be completely installed and available for inspection by the local inspection authorities prior to cable system acceptance. UL Classified Fire stop Systems are to be included in the submittals.

All fire stopping practices should adhere to the BICSI TDMM 13th Edition Chapter 7 & BICSI ITSIM Chapter 5.

3.11 GROUNDING SYSTEM

- The TBB shall be designed and/or approved by a qualified PE, licensed in the state that the work is to be performed. The TBB shall adhere to the recommendations of the ANSI/TIA-607-B standard, and shall be installed in accordance with best industry practice.
- Installation and termination of the main bonding conductor to the building service entrance ground shall be performed by a licensed electrical contractor.

All Bonding and Grounding design and installation practices should adhere to the BICSI TDMM 13th Edition Chapter 8.

3.12 IDENDIFICAITON AND LABELING

- The contractor shall develop and submit for approval a labeling system for the cable installation. The Owner will negotiate an appropriate labeling scheme in conjunction with the installer/contractor.
- At a minimum, the labeling system shall clearly identify all components of the system: racks, cables, panels and outlets.
- The labeling system shall designate the cables origin and destination and a unique identifier for the cable within the system.
- Racks and patch panels shall be labeled to identify the location within the cable system

infrastructure.

- All labeling information shall be recorded on the as-built drawings and all test documents shall reflect the appropriate labeling scheme.
- Labeling shall follow the guidelines of ANSI/TIA-606-B.
- All label printing will be machine generated with Legrand/Ortronics templates using indelible ink ribbons or cartridges or equivalent.
- Self-laminating labels will be used on cable jackets, appropriately sized to the OD of the cable, and placed within view at the termination point on each end.
- Outlet, patch panel and wiring block labels shall be installed on or in the space provided on the device.

All identification and labeling practices should adhere to the BICSI TDMM 13th Edition Chapter 10.

3.13 TESTING AND ACCEPTANCE

General

- All cables and termination hardware shall be 100% tested for defects in installation and to verify cabling system performance under installed conditions according to the requirements of ANSI/TIA-568-C.
- All pairs of each installed cable shall be verified prior to system acceptance.
- Any defect in the cabling system installation including but not limited to cable, connectors, feed through couplers, patch panels, and connector blocks shall be repaired or replaced in order to ensure 100% useable conductors in all cables installed.
- All cables shall be tested in accordance with this document, the latest revision of the ANSI/TIA standards, the Legrand/Ortronics Certification Program Information Manual and best industry practice. If any of these are in conflict, the Contractor/Installer shall bring any discrepancies to the attention of this office for clarification and resolution.

Copper Channel Testing

- All twisted-pair copper cable links shall be tested for continuity, pair reversals, shorts, opens and performance as indicated below. Additional testing is required to verify Category performance.
- Horizontal cabling shall be tested using a Level III test unit for category 6 performance compliance.
- The basic tests required are:
    - Wire Map
    - Length
    - Attenuation
    - NEXT (Near end crosstalk)
    - Return Loss
    - ELFEXT Loss
    - Propagation Delay
    - Delay skew
    - PSNEXT (Power sum near-end crosstalk loss)
    - PSELFEXT (Power sum equal level far-end crosstalk loss)

Continuity

- Each pair of each installed cable shall be tested using a test unit that shows opens, shorts, polarity and pair-reversals, crossed pairs and split pairs.
- Shielded/screened cables shall be tested with a device that verifies shield continuity in addition to the above stated tests.
- The test shall be recorded as pass/fail as indicated by the test unit in accordance with the manufacturers' recommended procedures, and referenced to the appropriate cable identification number and circuit or pair number.

- Any faults in the wiring shall be corrected and the cable re-tested prior to final acceptance.

Length

- Each installed cable link shall be tested for installed length using a TDR type device.
- The cables shall be tested from patch panel to patch panel, block to block, patch panel to outlet or block to outlet as appropriate.
- The cable length shall conform to the maximum distances set forth in the ANSI/TIA-568-C Standard.
- Cable lengths shall be recorded, referencing the cable identification number and circuit or pair number.
- For multi-pair cables, the shortest pair length shall be recorded as the length for the cable.

Category 6 Performance

Shall meet the channel requirements outlined below for a 100-meter, 4-connector channel. Frequency (MHz)	Maximum Insertion Loss (dB)	Minimum NEXT (dB)	Minimum PSNEXT (dB)	Minimum ELFEXT (dB)	Minimum PSELFEXT (dB)	Minimum Return Loss (dB)
1.0	2.1	70.0	67.0	68.3	65.3	24.0
4.0	4.0	68.0	65.5	56.2	53.2	24.0
10.0	6.3	61.6	59.0	48.3	45.3	24.0
20.0	9.0	56.6	54.0	42.2	39.2	24.0
31.25	11.3	53.4	50.7	38.4	35.4	22.1
62.5	16.4	48.4	45.6	32.3	29.3	19.1
100.0	21.2	44.9	42.1	28.3	25.3	17.0
155.0	26.6	41.7	38.8	24.4	21.4	15.1
200.0	31.5	39.8	36.9	22.2	19.2	14.0
250.0	36.0	38.1	35.2	20.3	17.3	13.0

Fiber Testing

- All fiber testing shall be performed on all fibers in the completed end-to-end system.
- There shall be no splices unless clearly defined in an RFI.
- Testing shall be conducted in accordance with the latest revision of TIA-526-7, Method B for single-mode fibers.
- Test shall be conducted in accordance with the latest revision of ANSI/TIA-526-14 Standard for multimode fibers.
- System loss measurements shall be provided at 850 and1300 nanometers for multimode fibers and 1310 and1550 nanometers for single mode fibers.
- These tests also include continuity checking of each fiber.
- Backbone multimode fiber cabling shall be tested at both 850 nm and 1300 nm (or 1310 and 1550 nm for single-mode) in both directions.
- Where links are combined to complete a circuit between devices, the Contractor/Installer shall test each link from end to end to ensure the performance of the system. ONLY LINK TEST IS REQUIRED.
- The contractor/installer can optionally install patch cords to complete the circuit and then test the entire channel.
- The test method shall be the same used for the test described above. The values for calculating loss shall be those defined in the latest revision of the ANSI/TIA Standard.
- Attenuation testing shall be performed with an approved hand held tester from an industry recognized test equipment manufacturer.

All field testing practices should adhere to the BICSI, TDMM 13th Edition Chapter 11.

3.14 SYSTEM DOCUMENTATION

- Upon completion of the installation, the telecommunications contractor/installer shall provide three (3) full documentation sets to the Engineer for approval. Documentation shall include the items detailed in the sub-sections below.
- Manufacturer's original certificate of origin with each fiber's factory attenuation results must be submitted. In the event the "birth certificate" was destroyed or lost the contractor/installer is responsible for contacting the factory of origin for a certified duplicate copy.
- Documentation shall be submitted within ten (10) working days of the completion of each testing phase (e.g. subsystem, cable type, area, floor, etc.). This is inclusive of all test result and draft as-built drawings.
- Draft drawings may include annotations done by hand. Machine generated (final) copies of all drawings shall be submitted within 30 working days of the completion of each testing phase.
- At the request of the Engineer, the telecommunications contractor/installer shall provide copies of the original test results.
- The Engineer may request that a 10% random field re-test be conducted on the cable system, at no additional cost, to verify documented findings.
- Tests shall be a repeat of those defined above. If findings contradict the documentation submitted by the telecommunications contractor, additional testing can be requested to the extent determined necessary by the Engineer, including a 100% re-test. This re-test shall be at no additional cost to the Owner.

3.15 TEST RESULTS

- Test documentation shall be provided on compact disk within three weeks after the completion of the project.
- The disk shall be clearly marked on the outside front cover with the words "Project Test Documentation", the project name, and the date of completion (month and year).
- The results shall include a record of test frequencies, cable type, conductor pair and cable (or outlet) I.D., measurement direction, reference setup, and crew member name(s).
- The test equipment name, manufacturer, model number, serial number, software version and last calibration date will also be provided at the end of the document. Unless the manufacturer specifies a more frequent calibration cycle, an annual calibration cycle is anticipated on all test equipment used for this installation.
- The test document shall detail the test method used and the specific settings of the equipment during the test as well as the software version being used in the field test equipment.
- The field test equipment shall meet the requirements of latest revision of ANSI/TIA-568-C including applicable TSB's and amendments.
- The appropriate Level III tester shall be used to verify Category 6 cabling systems.
- Printouts generated for each cable by the wire (or fiber) test instrument shall be submitted as part of the documentation package.
- The telecommunications contractor/installer must furnish this information in electronic form (CD-ROM) or acceptable pre-approved media.
- When repairs and re-tests are performed, the problem found and corrective action taken shall be noted, and both the failed and passed test data shall be documented.
- When repairs and re-tests are performed, the problem found and corrective action taken shall be noted, and both the failed and passed test data shall be documented.

3.16 AS-BUILT DRAWINGS

- The drawings are to include cable routes and outlet locations.
- Outlet locations shall be identified by their sequential number as defined elsewhere in this document.
- Numbering, icons, and drawing conventions used shall be consistent throughout all documentation provided.

- The Owner will provide floor plans in paper and electronic (DWG, AutoCAD rel. 14) formats on which as-built construction information can be added.
- These documents will be modified accordingly by the telecommunications contractor/installer to denote as-built information as defined above and returned to the Owner.
- The Contractors shall annotate the base drawings and return a hard copy (same plot size as originals) and electronic (AutoCAD rel. 14) form.

PART 4-WARRANTY AND SERVICES

Warranty

- An Extended Product Warranty shall be provided which warrants functionality of all components used in the system for 25 years from the date of registration. The Extended Product Warranty shall warrant the installed horizontal and/or backbone copper, and both the horizontal and the backbone optical fiber portions of the cabling system.
- The Application Assurance Warranty shall cover the failure of the wiring system to support the applications that are designed for the link/channel specifications of ANSI/TIA–568-C.1. These applications include, but are not limited to, 10BASE-T, 100BASE-T, 1000BASE-T, and 155 Mb/s ATM.
- The contractor/installer shall provide a warranty on the physical installation.

Final Acceptance & System Certification

- Completion of the installation, in-progress and final inspections, receipt of the test and as-built documentation, and successful performance of the cabling system for a two week period will constitute acceptance of the system.
- Upon successful completion of the installation and subsequent inspection, the end user shall be provided with a numbered certificate, from Ortronics or Berk-Tek, registering the installation.

PART 5 - INSTALLATION AND DESIGN PRACTICES

All installation practices will adhere to the Building Industry Consulting Service International (BISCI) Telecommunications Distribution Methods Manual (TDMM) Thirteenth edition, as well as the Information Transport Systems Installation Manual (ITSIM) & Outside Plant Design Reference Manual (OPDRM). These BISCI manuals shall take precedence in any situation regarding design and installation practices.

PART 6 - SAFETY

It is the responsibility of the user of this document to determine the use of applicable safety and health practices (e.g., WMATA's MSRPH [Metrorail Safety Rules and Procedures Handbook], Occupational Safety and Health Administration [OSHA], *National Electrical Code*® [*NEC*®], *National Electrical Safety Code*® [*NESC*®] associated with telecommunications systems installation and design practices. No project is so important nor any completion deadline so critical as to justify nonconformance to industry safety standards.