

## 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 pigtailed 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 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.)

TABLE 3.22-1

INSTALLED CABLE AND WIRE CONTINUITY  
INSTALLATION RESISTANCE AND MISCELLANEOUS TEST REQUIREMENTS

<u>Application</u>	<u>Type(s)/ Characteristics</u>	<u>Continuity</u> Conductor loop resistance, each pair: Shield resistance, each: Armor resistance, each: <u>Insulation Resistance</u> Conductor to Conductor (all): Conductor (all) to core separator and shield: Shield to armor: Armor to ground:	<u>Required Minimum Reading</u> <u>Calculated Value</u> <u>+7%</u> <u>+15%</u> <u>+20%</u> <u>Megohms</u> 500 500 50 100 <u>Calculated Value</u> <u>+10%</u> <u>+20%</u> <u>Megohms</u> 100 30 <u>Calculated Value</u> <u>+10%</u> <u>Megohms</u> 10 10
(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)).	With Compartmentalized Core	Shield resistance, each: Armor to ground: <u>Continuity</u>	
	Without Compartmentalized Core	Conductor loop resistance, each pair: Shield resistance, each: <u>Continuity</u> Conductor resistance, each: Shield resistance, each: <u>Insulation Resistance</u> Conductor to shield: Shield to shield(s) - if applicable: Outer shield to ground:	
	Jacketed, shielded, filled or nonfilled, twisted multipair cable	Conductor resistance, each: Shield resistance, each: <u>Insulation Resistance</u> Conductor to shield: Shield to shield(s) - if applicable: Outer shield to ground:	
	Jacketed coaxial cable, single center conductor plus shield(s)	Conductor resistance, each: Shield resistance, each: <u>Insulation Resistance</u> Conductor to shield: Shield to shield(s) - if applicable: Outer shield to ground:	
	Insulated wire, 600 volt or less rating	<u>Continuity</u> Conductor resistance: <u>Insulation Resistance</u> Conductor to Conductors (all) - if applicable: Conductor (each) to ground:	

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**