

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.
- 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.

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-1. 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 14-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