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US DEPARTMENT
OF TRANSPORTATION
Federal Aviation
Administration

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U. S. Department of Transportation
Federal Aviation Administration
Specification

Library Use Only

ELECTRICAL WORK, INTERIOR

DOCUMENT CONTROL CENTER

FORWARD

This document has been revised to reflect current technology changes and to incorporate the latest commercial standards.

1. SCOPE

1.1 Scope.- This specification covers the ***minimum requirements*** for electrical work at FAA facilities. Where the phrase "unless otherwise indicated" or similar wording appears, it refers exclusively to other documents that are specific parts of the contract. Where there are requirements peculiar to specific FAA facility types, e.g., air route traffic control centers (ARTCCs), metroplex control facilities (MCFs), terminal radar control (TRACONs), etc., these requirements will be added following the appropriate paragraph.

2. APPLICABLE DOCUMENTS.- The current issues of the following documents in effect on the date of the invitation-for-bids or request-for-proposals form a part of this specification, and are applicable to the extent specified herein.

2.1 Federal specifications

J-C-30	Cable and Wire, Electrical (Power, Fixed Installation)
W-C-375	Circuit Breakers, Molded Case; Branch Circuit and Service
W-F-414	Fixture, Lighting (Fluorescent, Alternating Current, Pedant Mounting)
W-L-305	Light Set, General Illumination (Emergency or Auxiliary)
W-P-115	Panel, Power Distribution
WW-C-566	Conduit, Metal, Flexible
QQ-W-343	Wire, Electrical, (uninsulated)

(To obtain copies of federal specifications, contact General Services Administration offices in Washington DC, Atlanta, Boston, Chicago, Dallas, Denver, Kansas City MO, Los Angeles, New York, San Francisco, or Seattle.)

2.2 Steel Structures Painting Council standards

SSPC-PS 10.01	Hot-Applied Coal Tar Enamel Painting System

(Single copies of SSPC Standards can be obtained from the Steel Structures Painting Council, 4400 Fifth Avenue, Pittsburgh, Pa 15213, 412/578-3327)

2.3 Federal Aviation Administration specification/standards/orders

FAA specification:

FAA-C-1391	Installation and Splicing of Underground Cables

FAA standards:

FAA-STD-019	Lightning Protection, Grounding, Bonding and Shielding Requirements for Facilities
FAA-STD-020	Transient Protection, Grounding, Bonding and Shielding Requirements for Electronic Equipment

FAA orders:

3900.49	Control of Hazardous Energy During Maintenance, Servicing and Repair
6950.19	Practices and Procedures for Lightning Protection, Grounding, Bonding and Shielding Implementation
6950.20	Fundamental Consideration of Lightning, Protection, Grounding, Bonding and Shielding
6950.22	Maintenance of Electrical Power and Control Cables
6950.27	Short Circuit Analysis and Protective Device Coordination Study

(Copies of FAA specifications may be obtained from the Contracting Officer in the office issuing the

invitation-for-bids or request-for-proposals. Requests should fully identify material desired, i.e., specifications, standard, amendment, and drawing numbers and dates. Requests should cite the invitation-for-bids, request-for-proposals, or the contract involved or other use to be made of the requested material.)

2.4 National Fire Protection Association (NFPA) publications

NFPA 70	National Electrical Code (NEC)

(Requests for copies of NFPA publications should be addressed to the National Fire Protection Association, Batterymarch Park, Quincy MA 02269.)

2.5 National Electrical Manufacturers Association (NEMA) standards

OS-1	Sheet Steel Outlet Boxes, Device Boxes, covers and Box Supports
MG-1	Standard for Motors and Generators
ST 20	Dry Type Transformers for General Applications
VE 1	Cable Tray Systems
WC 5	Thermoplastic Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
WD 1	General Requirements for Wiring Devices

(For copies of NEMA standards, contact the National Electrical Manufacturers Association, 2101 L Street N.W. Washington DC 20057, 202/457-8400.)

2.6 Underwriters' Laboratories (UL) Inc. standards

UL 5	Surface Metal Raceways and Fittings
UL 6	Rigid Metal Conduit

UL 50	Enclosures for Electrical Equipment
UL 486A	Wire Connectors and Soldering Lugs for Use with Copper Conductors
UL 486C	Splicing Wire Connectors
UL 486E	Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors
UL 514A	Metallic Outlet Boxes
~~UL 514B~~	~~Fittings~~ for Conduit and Outlet Boxes
UL 542	Lampholders, Starters, and Starter Holders for Fluorescent Lamps
UL 651	Schedule 40 and 80 Rigid PVC
UL 797	Electrical Metallic Tubing
UL 870	Wireways, Auxiliary Gutters and Associated Fittings
UL 935	Fluorescent-Lamp Ballasts
UL 1242	Intermediate Metal Conduit

(For copies of UL standards, contact Underwriters' Laboratories Inc., Publication Department, 333 Pfingsten Rd., Northbrook IL 60062.)

2.7 Institute of Electrical and Electronics Engineers (IEEE) Inc. standards

STD C57.12.80	Standard Terminology for Power and Distribution Transformers
STD 141	Recommended Practice for Electric Power Distribution for Industrial Plants
STD 519	Recommended Practices and Requirements for Harmonic Control and Electrical Power Systems

STD 1100 Recommended Practice for Powering and Grounding Sensitive Electronic Equipment

For copies of this standard, contact the IEEE Inc., Service Department, 445 Hoes Lane, PO Box 1331, Piscataway NJ 08855-1331.)

2.8 Other documents

2.8.1 Local utility companies.- The rules and regulations of the local utility companies providing service.

2.8.2 Local governing bodies.- The rules, regulations, and codes of local governing bodies.

3. MATERIALS

3.1 General.- The contractor shall furnish all materials not specifically identified as Government Furnished Materials in the invitation-for-bids or contract. Materials and equipment shall comply with all requirements of the contract documents. Materials furnished by the contractor shall be new, the standard products of manufacturers regularly engaged in the production of such materials, and of the manufacturer's latest designs that comply with the specification requirements. If materials and equipment requirements conflict, the order of precedence for selection shall be as follows: special contract provision, the contract drawings, this specification, and then continuing order of precedence, referenced FAA documents, Military documents, Federal specifications, NFPA publications, IEEE standards; UL standards and NEMA standards. Wherever standards have been established by Underwriters' Laboratories, Inc., the material shall bear the UL label.

4. INSTALLATION

NOTE: Unscheduled interruptions of the electrical service to FAA facilities may cause aircraft accidents and loss of life. Work requiring a temporary or permanent deenergization of equipment shall be scheduled in writing with the onsite FAA maintenance personnel. Only onsite FAA maintenance personnel are authorized to energize, deenergize equipment or to operate a circuit breaker, switch, or fuse in an FAA facility. Work procedures shall include lock-out/tag-out procedures in accordance with FAA Order 3900.49.

4.1 General.- The rules, regulations and reference specifications enumerated herein shall be considered as minimum requirements. FAA requirements often exceed those of other standards organizations such as the NEC. Adherence to other standards shall not relieve the contractor from furnishing and installing higher grades of materials and workmanship when so required by this specification. Adherence to this specification shall not relieve the contractor from furnishing and installing higher grades of materials and workmanship when so required by the contract drawings or special contract provisions. This specification shall govern when conflicts occur between it and the documents referenced in paragraph 2, Applicable documents, and ~~in the order of precedence~~ established in paragraph 3, Materials.

4.1.1 Short circuit analysis and protective device coordination (SCA/PDC). - The distribution system and all component parts, when installed or as modified, shall be in accordance with IEEE Standard 519, Recommended Practices and Requirements for Harmonic Control and Electrical Systems, and shall include a short circuit analysis and protective device coordination study in accordance with FAA Order 6950.27.

4.2 Workmanship.- All materials and equipment shall be installed in accordance with the contract drawings. When manufacturers recommended installation methods conflict with contract requirements, differences shall be resolved by the Contracting Officer. The installation shall be accomplished by qualified workers regularly engaged in this type of work. Where required by local regulations, the workers shall be properly licensed.

4.3 Contract drawings.- Where the electrical drawings indicate (by diagram or otherwise) the work intended and the functions to be performed, even though some details are not shown, the contractor shall furnish all equipment, material (other than the Government-furnished items, see paragraph 3.1) and labor to complete the installation work and to accomplish all the indicated functions of the electrical installation. Further, the contractor shall be responsible for taking the necessary actions to ensure that all electrical work is coordinated and compatible with architectural, mechanical, and structural plans, and the layout of any special electronic equipment.

4.3.1 Minor departures.- Minor departures from exact dimensions shown on the electrical plans may be permitted when required to avoid conflict or unnecessary difficulty in

placement of a dimensioned item, provided all contract requirements are met. The contractor shall promptly obtain approval from the Contracting Officer prior to undertaking any such departure and shall provide appropriate documentation of the departure.

4.4 Grounding

4.4.1 General.- FAA grounding requirements often exceed those of the NEC. Grounding systems shall be as indicated on the contract drawings and as specified herein. Reference IEEE Standard 1100-1992, Recommended Practice for Powering and Grounding Sensitive Electronic Equipment, when installing all NAS equipment. In no case, however, shall the NEC be violated.

4.4.2 Grounding electrode conductor.- The grounding electrode conduct shall be bare or insulated copper and shall be sized as shown in the contract documents. When not indicated in the contract documents, the conductor shall be copper and sized in accordance with Table 250-94, "Grounding Electrode Conductor for AC Systems", of the NEC, except that the conductor shall not be smaller than No. 6 AWG. Where the grounding electrode conductor is routed through a metal raceway, the raceway shall be electrically continuous and bonded to the conductor at each end. The grounding electrode conductor shall be bonded to the earth electrode system with an exothermic welded joint.
For a separately derived system such as an isolation transformer, the grounding electrode conductor shall be connected in accordance with the NEC. This conductor shall be permitted to terminate by exothermic welding to an equipment room's perimeter ground cable under a raised floor.

4.4.3 – Earth electrode system.- The earth electrode system shall be installed as shown in the contract documents. Unless otherwise indicated in these documents, the earth electrode system shall consist of a minimum of four (4) ground rods located at the corners of a structure. Rods shall be spaced apart a distance equal to or greater than the length of the rods. Ground rods shall be 3/4 inch by 10 feet, copper or copper-clad steel. Sectionalized type or exothermic butt welded rods shall be used when deeper earth penetration is required. Rods shall be interconnected by a bare copper cable forming a closed loop around a structure. The cable shall be a minimum No. 4/0 AWG and shall be buried at least 2 feet below grade. The top of the vertically-driven ground rods shall be a minimum of 12 inches below grade. All underground metal

pipes (excluding gas piping systems), tanks, and the telephone ground, if present, shall be connected to the earth electrode system by a copper cable no smaller than No. 2 AWG. All underground connections shall be made by exothermic welding process unless otherwise indicated.

4.4.4 Earth electrode system resistance.- The resistance of the earth electrode system shall not exceed 10 ohms, as tested per paragraph 5.3.6, unless otherwise indicated. If the measured resistance exceeds 10 ohms, the Contracting Officer shall be notified immediately for further guidance.

4.4.5 Equipment grounding conductor

4.4.5.1 General.- All metallic non-current carrying parts of electrical equipment shall be grounded with equipment grounding conductors whether or not shown on the drawings. Equipment grounding conductors shall always be green insulated copper conductors unless otherwise indicated. Non-insulated equipment grounding conductors are not allowed. When these conductors are not sized, or shown on the contract drawings, they shall be sized in accordance with Table 250-95, "Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment", of the NEC.

4.4.5.2 Connections.- There shall be no interconnection between equipment grounding conductors and neutral conductors except at the main service and separately derived sources. All connections to equipment to be grounded shall be made with a grounding connector specifically intended for that purpose. Bare wire, wrapped around mounting bolts and screws, is not acceptable as a grounding connection. All ground lugs shall be of a noncorrosive material suitable for use as a grounding connection, and must be compatible with the type of metal being grounded. All mating surfaces and connections shall be between cleaned bare metal to bare metal surfaces.

4.4.5.3 Installation.- Each overcurrent device shall have its own equipment grounding conductor, i.e., a single-pole single-phase overcurrent device shall be supplied with an equipment grounding conductor; a two-pole, single-phase overcurrent device shall be supplied with its own equipment grounding conductor; a three-pole, three-phase overcurrent device shall be supplied with its own equipment grounding conductor. The equipment grounding conductor shall be installed in the same conduit as its related branch and feeder conductors and shall be connected to the ground bus in the branch or distribution panelboard. Metal conduit housing the equipment grounding conductor shall be

electrically continuous, forming a parallel path to the equipment grounding conductor, except as allowed by the NEC. Where parallel feeders are installed in more than one raceway, a full sized equipment grounding conductor shall be installed in each raceway.

4.4.6 Raceway grounding.- Surface metal raceways, wireways, or cable rack systems shall be installed in a manner that assures electrical continuity. Insulated copper bonding jumpers shall be installed between adjacent raceway sections to assure proper bonding. Uninsulated conductors shall not be used. Unless otherwise indicated, the minimum size for these bonding jumpers shall be No. 6 AWG. Where aluminum raceways are used, the jumpers shall be bonded with approved connectors for the dissimilar metals. All metallic raceway penetrations into a facility structure shall be bonded to the earth electrode system in accordance with FAA-STD-019.

4.4.7 Other grounding systems.- Any additional grounding systems used for electronic equipment shall be connected directly to the exterior earth electrode system or the perimeter ground cable under a raised floor in an equipment room. Other grounding systems shall not be used in place or the equipment grounding conductor system. The conductor used for other grounding (i.e., NEC 250-74, exception #4) systems shall be color coded green with a yellow stripe for single point isolated signal ground, green with an orange stripe for multipoint signal ground, green with a red stripe for high energy ground, green with a violet stripe for isolated equipment grounding connections.

4.5 Electrical surge protection

4.5.1 General.- All electrical surge protection systems shall be installed in accordance with FAA-STD-019.

4.5.2 Supply transformer.- For utility owned transformers, protective devices shall be at the discretion of the utility. For FAA-owned transformers, proper protection shall be provided on the primary side of the transformer.

4.5.3 Service entrance surge arrester.- A fused surge arrester provided with disconnect capability shall be installed on the line, (supply-side) of the service as close as possible to the service terminals. Separate terminating lugs shall be provided for the surge arrester. This arrester shall be compatible with the service voltage, and shall be wired to avoid loops, sharp bends and kinks, and to minimize the number of bends. There shall be no

interconnection between neutral and ground within the arrester. Arrester conductors shall be No. 4 AWG insulated copper or larger, unless a smaller size is recommended by the arrester manufacturer.

4.5.4 Transient suppression installations.- Where transient suppression devices are installed in the electrical power distribution system they shall be installed in accordance with manufacturers instructions unless otherwise specified.

4.5.5 Land line/cable penetration installations.- Suppression systems shall be provided for land line and cable penetration systems in accordance with FAA-STD-019. High energy grounding conductors shall be bonded directly to the earth electrode system or to the perimeter ground cable under raised floors in equipment rooms.

4.6 Wiring methods

4.6.1 General.- All wiring shall consist of insulated copper conductors installed in metallic raceways, unless otherwise specified.

4.6.1.1 Conductor routing.- Panelboards, surge arresters, disconnect switches, etc., shall not be used as raceway for conductor routing other than conductors that originate or terminate in these enclosures. Isolated ground conductors will be allowed to traverse these enclosures.

4.6.1.2 Conductor separation - Power conductors shall be routed separately from all other conductor types. This may be accomplished by routing power conductors and other conductors in separate raceways, or by a metallic divider between the power conductors and the other conductors in the same raceway.

4.6.2 Neutral conductor.- Shared/common neutrals shall not be permitted, i.e., each overcurrent device shall have its' own separate neutral conductor. Neutral conductor sizes shall not be less than the respective feeder or phase conductor sizes.

4.6.3 Raceway systems

4.6.3.1 General.- Each run shall be complete, and shall be fished and swabbed before conductors are installed. Ends of raceway systems not terminated in boxes or cabinets shall be capped. Exposed raceways shall be installed parallel to or at right angles with the lines of the structure. Crushed or

deformed raceways shall not be installed. A pull wire shall be installed in all empty tubing and conduit systems in which wiring is to be installed by others. The pull wire shall be No. 14 AWG zinc-coated steel, or plastic with a minimum 200-pound tensile strength. Ten inches of slack shall be left at each end of the pull wire. Sections of raceways which pass through to damp, concealed, or underground locations shall be of a type allowed for such locations by NEC Article 300-5, and shall extend a minimum of 12 inches beyond the damp, concealed, or underground area. Where raceway has to be cut in the field, it shall be cut square and burrs and sharp edges removed. Where conduits penetrate walls or floors separating the building interior from the exterior, they shall be sealed to prevent moisture and rodent entry and to deter air transfer. In addition, where conduits penetrate walls separating individually controlled temperature or humidity controlled areas, they shall be sealed to prevent air circulation. Sealing methods and sealants shall be accordance with NEC Article 300-7. Openings around penetrations through fire-resistant-rated walls, partitions, floors, or ceilings shall be fire stopped using approved methods to maintain the fire resistance rating.

4.6.3.2 Conduit. — Minimum conduit size shall be 3/4 inch unless otherwise specified. Conduit for telephone and signal systems shall be allowed to be 1/2 inch. Where threads have to be cut on conduit, the threads shall have the same effective length and shall have the same thread dimensions and taper as specified for factory cut threads on conduit.

NOTE:

For ARTCCs, MCFs, and Large TRACONs, rigid steel conduit (RSC)or intermediate metal conduit (IMC) shall be used for all distribution panel feeders, transformer feeders, motor control center feeders and distribution switchboards. Electrical metallic tubing (EMT) maybe used for communication, lighting and branch circuits.

4.6.3.2.1 Zinc coated rigid steel conduit (RSC).- Zinc coated rigid steel conduit (RSC) shall conform to UL 6. RSC, may be used in all locations and shall be used for all underground service conductors. For installation below slab, on-grade, or underground, the conduit shall conform to Steel Structures Painting Council Standard, SSPC-PS 10.01, or shall be field wrapped with 0.01-inch thick pipe wrapping plastic tape applied with 50% overlap. Fittings used underground shall be protected by field wrapping as

specified herein for conduit. All fittings used with rigid steel conduit shall be the threaded type, of the same material as the conduit. Where conduits enter enclosures without threaded hubs, double locknuts (one on each side of the enclosure wall) shall be used to securely bond the conduit to the enclosure. In addition, a bushing shall be installed on the interior threaded end of the conduit to protect conductor insulation.

4.6.3.2.2 Intermediate metal conduit (IMC). IMC shall be zinc coated steel, shall conform to UL Standard 1242, and shall bear the UL label. For installation below slab on grade or underground, the conduit shall conform to Steel Structures Painting Council Standard, SSPC-PS 10.01, or shall be field wrapped with 0.01-inch thick pipe wrapping plastic tape applied with 50% overlay. Fittings used underground shall be protected by field wrapping as specified herein for conduit. Where it is necessary to fabricate IMC bends in the field, the tooling required to fabricate those bends shall be specifically designed for IMC. All fittings shall be of the threaded type, of the same material as the conduit. Where conduits enter enclosures without threaded hubs, double locknuts (one on each side of the enclosure wall) shall be used to securely bond the conduit to the enclosure. In addition, a bushing shall be installed on the interior threaded end of the conduit to protect conductor insulation.

4.6.3.2.3 Electrical metallic tubing (EMT).- EMT shall conform to UL 797. EMT may be used only in dry interior locations, and where not subject to physical damage. EMT shall not be used on circuits above 600 volts nor in sizes greater than 34 inches in diameter. Fittings used with EMT shall be standard compression-type fittings designed for this type of EMT, unless otherwise indicated. Screw-type fittings are not acceptable. Where EMT enters enclosures without threaded hubs, an appropriate connector with threads and cast or machined (not sheet metal) locknut shall be used to securely bond the conduit to the enclosure. The connector body and locknut shall be installed so that firm contact is made on each side of the enclosure. In addition the connectors shall have an insulated-throat, smooth bell shaped end, or a bushing.

4.6.3.2.4 Rigid aluminum conduit.- Aluminum raceways shall not be used for any installation.

4.6.3.2.5 Rigid nonmetallic conduit.- Rigid nonmetallic conduit shall be heavywall PVC conforming to UL 651. Rigid nonmetallic conduit used to protect electrical power

conductors may only be used underground, or in concrete, or as a vertical riser to 6 inches above grade or floor surface for connection to metal conduit; and only when required by the contract drawings or specific job specifications. PVC fittings shall be used with PVC conduit and shall be assembled in accordance with manufacturer's instructions. A PVC threaded fitting with locknut and plastic bushing shall be used to connect PVC conduit to boxes or cabinets without threaded hubs. Rigid nonmetallic conduit may be used to protect lightning protection system conductors and, in interior locations, to protect signal grounding conductors.

4.6.3.2.6 Flexible metal conduit.- Flexible metal conduit shall conform to Federal Specification, WW-C-566. Flexible metal conduit shall be used for terminal connections to motors or motor driven equipment, and in lengths only up to 6 feet for other applications permitted by the NEC. Liquid-tight flexible metal conduit shall be used outdoors and in wet locations. All flexible metal conduit shall be of a type where both the conduit and fittings are listed for grounding. This last requirement shall not apply to factory assembled equipment.

NOTE: Flexible metal conduit may be used under raised floor for branch circuits in lengths longer than 6 feet in computer room locations that meet all the requirements of Article 645 of the NEC. All fittings and junction boxes shall be liquid tight types under the raised floor.

4.6.3.2.7 Flexible nonmetallic conduit.- Flexible nonmetallic conduit shall not be used.

4.6.3.3 Surface raceways.- Nonmetallic surface raceways shall not be used. Surface metal raceways shall conform to UL 5. Surface metal raceways shall be installed only in exposed, dry locations not subject to physical damage. Surface metal raceways shall meet NEC requirements, however, they shall not be used for circuits above 600 volts.

4.6.3.4 Wireways.- Wireways shall conform to UL 870. Wireways shall only be installed in accessible locations. Wireways installed in wet or outdoor locations shall be rated for these locations.

4.6.3.5 Cable rack systems

4.6.3.5.1 General.- Cable rack systems shall be of the ladder or ventilated trough type conforming to NEMA Standard VE 1, unless otherwise indicated. All components for each

cable rack system shall be the product of a single manufacturer. Cable rack support spacing shall be as recommended by the manufacturer except that in no case shall spacing of supports exceed 6 feet. Cable racks shall be supported from structural members only.

4.6.3.5.2 Dimensions.- Straight sections, bends, tees, offsets, reducers, etc., for ladder-type cable rack systems shall consist of 3 inch minimum side channels with suitable cross channels (rungs) installed on 6 inch centers unless otherwise indicated. Straight sections, fittings, etc., for ventilated-type cable rack systems, shall have 3 inch minimum high sides and a ventilated bottom with cross pieces 2 inches (maximum) wide on 3 inch (maximum) centers and openings 2 inches (maximum) wide. Cable rack widths shall be as shown on the drawings.

4.6.4 Raceway support systems

4.6.4.1 General.- Raceways shall be securely supported at intervals specified in the NEC Article 300-11, "Securing and Supporting", and fastened in place with pipe straps, wall brackets, hangers, or ceiling trapezes. Fastenings shall be by wood screws, nails or screw-type nails to wood; by toggle bolts on hollow masonry units; by expansion-bolts on concrete or brick; by machine screws, welded threaded studs, or spring tension clamps on steel work. Nail type nylon anchors or threaded studs driven by a power charge and provided with lock washers and nuts may be used in lieu of expansion bolts, machine screws, or wood screws. Threaded C clamps with retainers may be used. Raceways or pipe straps depth of more than 1-1/2 inch in reinforced concrete beams, or to a depth of more than 3/4 inch in reinforced concrete joists, shall not cut the main reinforcing bars. Holes not used shall be filled. In partitions of light steel construction, sheet-metal screws may be used. Raceways shall not be supported from sheet-metal roof decks. In suspended-ceiling construction, raceways shall not be fastened to the suspended-ceiling supports.

4.6.4.2 Telephone and signal raceways.- Telephone and signal system raceways shall be installed in accordance with the previous requirements for conduit and tubing, with the additional requirements that no length of run shall exceed 50 feet for 1/2-inch and 3/4-inch sizes, and 100 feet for-1-inch or larger sizes; and shall not contain more than two 90-degree bends or the equivalent. Pull or junction boxes shall be installed to comply with these limitations, whether or not indicated on the drawings. Bends in

conduit, 1 inch and larger, shall have minimum inside radii of 12 times the nominal conduit diameter.

4.6.5 Conductors

4.6.5.1 Uninsulated conductors.- Uninsulated conductors shall be copper and in accordance with Federal Specification QQ-W-343.

4.6.5.2 Insulated conductors.- Unless otherwise indicated, insulated conductors shall be copper with thermoplastic or thermosetting insulation, type THW, THWN, and XHHW for general use, or type THHN for use in dry locations only, all insulated for 600 volts in accordance with Federal Specification J-C-30. Unless otherwise indicated, conductors No. 10 AWG and smaller shall be solid. Conductors No. 8 AWG and larger shall be stranded. Minimum branch circuit conductor size shall be No. 12 AWG. Stranded conductors may be used with wire compression connectors or a pressure washer type lug; lugs with screw only compression are not allowed. Minimum control wire size shall be No. 14 AWG unless noted otherwise. Stranded conductors smaller than 10 AWG is allowed in applications where vibration and flexing may be encountered.

4.6.5.2.1 Fixture wiring.- Fixture wiring shall be thermoplastic insulated copper, rated for 600 volts, in accordance with Federal Specification J-C-30 and the NEC.

4.6.5.2.2. Color coding.- All feeder and branch circuits, including neutral conductors, shall be identified at both ends of the conductor with panel and circuit number indicated. This shall be accomplished using shrink embossed labels only. The color coding shall be continuous throughout the facility on each phase conductor to its point of utilization so that the conductor phase connection is readily identifiable. Equipment grounding conductors shall be color coded green. Conductors covered with green insulation with yellow, orange, violet or red tracers shall be used for other grounding systems. Neutral conductors shall be white insulated for 120/208/240 volt systems and gray insulated for 277/480 volt systems. For conductors, No. 4 AWG and larger, where appropriate insulation color is not available, color coded tape, half lapped for a minimum length of 3 inches shall be used. Switch leg conductors shall be violet insulated. Green, white, and gray insulated conductors shall not be reidentified. All conductor color codes including reidentified conductors shall be visible at all junction boxes, pullboxes, panelboards, outlets, switches, at access locations in closed raceways, every

three (3) feet in open raceways, under all raised floors and at all terminations. Phase conductors shall be color coded as follows:

Single Phase

120 Volts	120/208/240 Volts
Line 1 - Black	Line 1 - Black
	Line 2 - Red
Neutral - White	Neutral - White

Three Phase

120/208/240 Volts	277/480 Volts
Phase A - Black	Phase A - Yellow
Phase B - Red	Phase B - Brown
Phase C - Blue	Phase C - Orange
Neutral - White	Neutral - Gray

Color coding for conductors in control cables shall be in accordance with NEMA Standard WC 5. DC power conductors. shall be color coded as follows: positive conductor, red with brown tracer; negative conductor, brown with red tracer; neutral conductors, if used, shall be white.

4.6.5.3 Splices.- Splices shall be made only at outlets , junction boxes or accessible raceways. Splicing of ungrounded conductors in panelboards is not permitted. Splices shall be made with solderless connectors conforming to UL 486A, UL 486C, AND UL 486E. Insulated wire nuts may only be used to splice conductors sized No. 10 AWG and smaller. Compression connectors shall be used to splice conductors No. 8 AWG and larger. All splices, including those made with insulated wire nuts, shall be insulated with electrical tape or shrink tubing to a level equal to that of the factory insulated conductors. All underground splicing shall be accomplished in accordance with FAA-C-1391.

NOTE:

Conductors in critical power systems shall not be spliced.

4.7 Boxes.- Boxes shall be either the cast-metal threaded-hub type conforming to UL 514A and UL514B, galvanized steel type conforming to UL 514A and UL 514B, or metal outlet boxes conforming to NEMA-OS 1. All enclosures shall conform to NEMA standards.

4.7.1 Applications.- Boxes shall be provided in the wiring or raceway system for pulling wires, making connections, and mounting devices or fixtures. All outdoor boxes shall be rated minimum NEMA 3R. In hazardous areas, boxes shall be explosion proof. Each electrical outlet box shall have a machine screw which fits into a tapped hole in the box for the ground connection. Boxes shall be sized in accordance with the NEC Article 370. Boxes for mounting lighting fixtures shall not be less than 4 inches square. Boxes installed for concealed wiring shall be provided with extension rings or plaster covers. The front edge of the box shall be flush or recessed not more than 1/4-inch from the finished wall surface. Boxes for use in masonry-block or tile walls shall be square-cornered tile-type, or standard boxes having square-cornered tile-type covers. Cast-metal boxes installed in wet locations and boxes installed flush with exterior surfaces shall be gasketed. Separate boxes shall be provided for flush or recessed fixtures where required by the fixture terminal operating temperature, and fixtures shall be readily removable for access to the boxes unless ceiling access panels are provided. Boxes for fixtures on suspended ceilings shall be supported independently of the ceiling supports. Boxes shall not be supported from sheet-metal roof decks. Non-metallic boxes may be used only with non-metallic raceway systems.

4.7.2 Supports.- Boxes and supports shall be securely fastened to wood with wood screws, nails, screw-type nails, carriage bolts, or lag screws of equal holding strength, with bolts and expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws or welded studs on steel work. Support systems shall be capable of carrying the weight of the box and its contents. Threaded studs driven by powder charge and provided with lockwashers and nuts, or nail-type nylon anchors may be used in lieu of expansion shields, or machine screws. In open overhead spaces, cast-metal boxes threaded to raceways need not be separately supported except where used for fixture support; cast-metal boxes having threadless connectors and sheet-metal boxes shall be supported directly from the building structure or by bar hangers. Where bar hangers are used, the bar shall be attached to raceways on opposite sides of the box and the raceway shall be supported

with an approved fastener not more than 24 inches from the box. Penetration shall be no more than 1-1/2 inches into reinforced concrete beams nor more than 3/4-inch into reinforced concrete joists. Main reinforcing steel shall not be cut.

4.8 Wiring devices

4.8.1 Receptacles.- All receptacles shall be specification grade in accordance with NEMA STD WD-1. Unless otherwise indicated, general purpose duplex receptacles shall be specification grade, 20 ampere rating, 125 volt, grounding type NEMA 5-20R. Receptacles with push-in connections or a combination of screw-type and push-in connectors are not acceptable. Unless noted otherwise, receptacles shall be installed 12 inches above finished floor. All receptacles, unless they are of the isolated-ground type, shall be grounded by the installation of a green grounding pigtail from the receptacle grounding screw directly to the grounding screw on the outlet box where the green equipment grounding conductor is terminated.

NOTE: For all critical power circuits, the receptacles shall be twist lock type except where the receptacles are not subject to be kicked or bumped (e.g., receptacles mounted inside an equipment rack).

4.8.1.1 General.

4.8.1.2 Ground fault circuit-interrupter (GFCI) receptacles.- GFCI receptacles shall be installed in all locations required by the NEC and in other locations as indicated on the drawings. GFCI receptacles shall be 125-volt, duplex, UL Group I, Class A, rated for 20 amperes minimum. All exterior GFCI receptacles shall be mounted in weatherproof boxes with weatherproof covers.

4.8.1.3 Reserved

4.8.1.4. Isolated ground terminal receptacles.- When isolated ground terminal receptacles are shown in the contract documents, they shall be installed in accordance with Article 250-74 exception #4, of the NEC. Isolated ground terminal receptacles shall only be used where shown on the drawings. All isolated ground terminal receptacles shall be colored orange.

4.8.1.5 Plug-in strip outlets

4.8.1.5.1 General.- Fixed multi-outlet assemblies shall consist of a surface metal raceway with grounding type receptacles. Phase and neutral conductors shall not be smaller than No. 12 AWG and shall have the type of insulation specified for branch circuit conductors. In addition, a No. 12 AWG or larger green insulated equipment grounding conductor having the same insulation as the phase conductors shall be installed. This grounding conductor shall connect all receptacle ground terminals and each section of the surface metal raceway, and shall be securely connected to the equipment grounding conductor from the branch power panel. Where more than one circuit is indicated as serving a group of similar receptacles in a common raceway, adjacent receptacles shall not be connected to the same circuit.

4.8.1.5.2 Associated hardware.- Surface metal raceways shall be provided with snap-on blank covers and/or snap-on receptacle covers for the receptacles furnished, all manufactured by the raceway manufacturer. They shall be installed to prevent open cracks. Where industry standard device plates are to be installed on raceways, snap-on blank covers shall be accurately cut to avoid open cracks. Fittings, elbows, clips, mounting straps, connection blocks, and insulators, shall be provided as required for a complete installation.

4.8.1.6 Emergency light receptacles.- Emergency light receptacles shall be grounding type single receptacles in accordance with NEMA standard WD 1.

4.8.2 Wall switches.- Single-pole and three-way wall switches shall be specification grade, rated 120/277 volts, and shall be fully rated 20 amperes, AC only. Wiring terminals shall be of the screw type. Switches with push-in connections or a combination of screw-type and push-in connections are not acceptable. Switches shall be equipped with grounding terminals and shall be grounded with a green grounding pigtail connected from the switch grounding screw directly to the grounding lug or screw on the outlet box where the green equipment grounding conductor is terminated. Switches shall be the quiet-operating type. Not more than one switch shall be installed in a single gang position.

4.8.3 Device plates.- Plates of the one-piece type shall be provided for all outlets and fittings to suit the devices installed. Plate screws shall be of metal with countersunk heads, in a color to match the finish of the plate.

Telephone and communication outlets shall be provided with a blank cover plate unless otherwise indicated. Plates shall be installed with all four edges in continuous contact with finished wall surfaces with the use of mats or similar devices. Plaster fillings will not be permitted. Plates shall be installed with an alignment tolerance of 1/16 inch. The use of sectional type device plates will not be permitted. Plates installed in wet locations shall be gasketed. Device plates for telephone and intercommunication outlets shall have a 3/8-inch bushed opening in the center or a dome-shaped grommet on the side.

4.8.4 Photoelectric control.- Unless otherwise indicated, photoelectric controls for floodlighting or obstruction lighting shall be 120 volt, 3000 watt, single-pole, single-throw, double-break type. Photoelectric controls shall be mounted in an appropriate weatherproof housings installed on the building exterior. The housing should be vented if possible, faced in a northerly direction. At no time shall the controllers be mounted in the same enclosure with thre batteries.

4.9 Service equipment

4.9.1 Power.- Service entrance equipment and installation for power shall be in accordance with the regulations of the local utility providing service and NEC Article 230.

4.9.1.1 Service entrance conduits.- Service entrance conduits shall be installed as shown on the drawings and shall be heavywall zinc coated rigid steel unless otherwise indicated. Grounding bushings shall be installed on both ends of the service entrance conduit.

4.9.1.1.1 Underground service.- Underground service entrance conduits shall be installed a minimum of 2 feet below finished grade. Service entrance conduit shall be electrically continuous between the service disconnecting means and the facility transformer housing. The conduit shall be bonded to the counterpoise.

4.9.1.1.2 Aerial service.- A minimum of 4 feet of slack in all service entrance conductors shall be extended from an appropriate weatherproof entrance fitting to permit connection to the service drop. Conduit shall be concealed within the building where possible and conduit penetrations into the building shall be caulked with sealing compound.

4.9.1.2 Service disconnecting means.- Service equipment shall be a fused disconnect switch, separately mounted circuit breaker, or main circuit breaker in the main distribution panel. All switches and circuit breakers used as service entrance disconnecting means shall be UL rated for service equipment.

4.10 Panelboards

4.10.1 General.- Panelboards shall be dead-front type, shall conform to Federal Specification W-P-115, Type I, Class 1, and shall be listed by UL except for installations which require special panelboards to incorporate items not available as UL listed. Panelboards shall be mounted so that the height to the top of the panelboard shall not exceed 81 inches above the finished floor level. Unless otherwise specified, panelboards shall have a full hinged front cover with a hinged door in that cover for access to circuit breaker switches. Doors shall have flush type cylinder locks and catches. Doors over 48 inches in height shall have auxiliary fasteners on top and bottom. All locks in a project shall be keyed alike, and two keys shall be furnished with each lock. Directories shall be type written to indicate the load served by each circuit and shall be mounted on the inside of the door in a holder with a protective covering. Circuits shall be connected as indicated on the drawing. The directory shall be arranged so that the typed entries simulate circuit breaker positions in the panelboard.

4.10.2 Wiring gutters.- The minimum size of side wiring gutters shall be 4 inches for power feeders up to and including 100 amperes, 6 inches for power feeders over 100 amperes and up to 225 amperes, and 8 inches for power feeders over 225 amperes and up to 600 amperes.

4.10.3 Circuit breakers.- Circuit breaker ratings shall be in accordance with the SCA/PDC study, FAA Order 6950.27. All circuit breakers shall be UL listed thermal magnetic type or electronic solid state type, as described herein, and with a minimum rating of 10,000 AIC. Circuit breakers shall also have trip ratings, voltage ratings, and number of poles as defined on the drawings. All circuit breakers shall have a trip indicating feature. Single-pole breakers shall be full-size modules. Two-pole and three-pole breakers shall be physically sized in even multiples of a single-pole breaker. Breakers shall be sized so that two single-pole breakers can not fit in a single housing. Multipole circuit breakers shall have an internal common trip mechanism. All circuit breakers and the panelboards in

which the breakers are installed shall be products of the same manufacturer. Plug in type load centers and/or plug in type branch or feeder circuit breakers shall not be used. Positive integral locking plug-in circuit breakers, and associated panelboards, may be used.

4.10.3.1 Thermal magnetic.- All thermal magnetic breakers shall be quick make, quick break type conforming to Federal specification W-C-375. Adjustable breakers shall have setting adjustments readily accessible and visible from the front of the panel board, after installation.

4.10.3.2 Solid state.- Adjustable, solid-state or microprocessor-controlled circuit breakers shall have adjustments readily accessible and visible from the front of the panelboard, after installation. Individual circuit breaker frame size shall not exceed the panelboard bus rating.

4.10.3.3 Self enclosed circuit breakers

4.10.3.3.1 General.- Circuit breakers shall be UL listed thermal magnetic type or electronic solid state type, as described herein. Multiple circuit breakers shall have an internal common trip mechanism. Circuit breakers shall comply with Federal Specification W-C-375.

4.10.3.3.2 Thermal magnetic.- These circuit breakers shall be of the molded-case type, shall have a quick-make and quick-break toggle mechanism, inverse-time trip characteristics and shall be trip-free on overload or short-circuit. Automatic release shall be secured by a BI-metallic thermal element releasing the mechanism latch. In addition, a magnetic armature shall be provided to trip the breaker instantaneously for short-circuit currents above the overload range. Automatic tripping shall be indicated by a handle position between the manual OFF and ON positions.

4.10.3.3.3 Solid state/microprocessor.- These circuit breakers may be used providing they meet or exceed the performance characteristics given by paragraph 4.10.3.3.2 above.

4.10.4 Bus bars.- All phase bus bars shall be copper or plated copper. Neutral and ground bus bars shall be copper or plated copper. Bus capacity shall be as indicated on the drawings. Where bus capacity is not indicated on the drawings, the capacity shall be equal to or greater than the

panelboard feeder overcurrent protective device. Except as indicated paragraph 4.10.3, circuit breaker current-carrying connections shall be bolted. Bus bar connections to branch circuit breakers shall be of the sequence phase type. The neutral bus shall be insulated from all panelboards except where the panelboard is used as the service disconnecting means. Where "provisions for," "future," or "space" is noted on the drawings, the panelboard shall be equipped with bus connections for the future installation of circuit breakers.

4.10.4.1 Ground bus.- All panelboards shall have an uninsulated ground bus that is separate from the neutral bus. The ground bus shall be securely bonded to the cabinet and adequately sized for the panelboard capacity and with the number of terminations equal to the number of poles in the panelboard. The ground bus shall only be bonded to the neutral bus at the service disconnecting means. The ground bus bar shall be structurally integral to the panelboard or attached to the panelboard with a bolt, nut and lock washer. If the ground bus bar is mounted to the enclosures with screw threads only (i.e., tapped blind hole) a separate, bolted ground lug shall be installed on the panelboard and bonded to the ground bus bar. The bond conductor shall have the same current carrying capacity as the largest equipment grounding conductor terminated to the ground bus bar.

4.11 Reserved.

4.12 Safety switches.- Safety switches shall be type "HD," heavy duty, locking type unless otherwise indicated. Switches mounted in dry locations shall be NEMA type 1 enclosures. Switches installed outdoors, or in damp locations shall be mounted in NEMA type 3R enclosures. Switches shall be of the voltage and current ratings indicated on the drawings. Switches shall be the quick-make, quick-break type. Except for ground lugs which shall be bonded to the housing, all parts shall be mounted on insulating bases to permit replacement of any part from the front of the switch. All current-carrying parts shall be of high-conductivity copper unless otherwise specified. Switch contacts shall be silver-tungsten or plated to minimize corrosion, pitting and oxidation. When used for motors a safety switch shall be sized in accordance with NEC Article 380. Switches shall disconnect all ungrounded conductors.

4.13 Cabinets.- Telephone and signal systems cabinets shall be constructed of zinc coated sheet steel in accordance with NEC Article 373-10, and shall meet the requirements of

UL 50. Cabinets shall be constructed with interior dimensions not less than those indicated on the drawings. Cabinets shall be mounted so that the height to the top of the cabinet does not exceed 81 inches above the finished floor level. A locking catch and two keys shall be provided with each cabinet unless otherwise indicated. All locks in a project shall be keyed alike. Cabinets shall also be provided with a 5/8-inch plywood backboard unless otherwise indicated.

4.14 Motors and controls

4.14.1 Motors.- Motors furnished under this specification shall be of sufficient size for the duty to be performed, and shall not exceed the full-load rating when the driven equipment is operating at specified capacity. Motors shall be rated for the voltage of the system to which they are to be connected. Unless otherwise indicated, all motors shall have open frames, and continuous-duty classifications. Polyphase motors shall conform to NEMA Standard MG-1, and shall be type II, class 3, minimum insulation class B, squirrel-cage type, having normal starting-torque and low-starting-current characteristics, unless otherwise specified. When motor horsepower ratings are indicated on electrical drawings, these ratings are only approximate. Higher ratings may be required to adequately power driven equipment selected by the contractor for the duty to be performed.

4.14.2 Motor controls.- Each motor, 1/8 horsepower or larger, shall have overload protection in each phase, or other equally rated method in accordance with the NEC. The overload-protection device shall be provided either integral with the motor, or with the control, or shall be mounted in a separate enclosure. In any case the reset button shall be in an accessible location. Unless otherwise indicated, the protective device shall be of the manual reset type. Single or double-pole tumbler switches specifically designed for AC operation may be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating. Automatic control devices such as thermostats and float or pressure switches may control the starting and stopping of motors directly, provided the devices used are designed for that purpose and have an adequate horsepower rating. When the automatic control device operates the motor directly, a double-throw, three-position tumbler or rotary switch shall be provided for manual control.

4.14.2.1 Reduced-voltage controllers.- Reduced voltage starting methods when required shall be as indicated on the drawings.

4.14.3 Motor disconnecting means.- Each motor shall be provided with a disconnecting means and a manually operated switch as shown on the drawings or when required by the NEC. For single-phase motors, a single-pole or double-pole toggle switch, rated only for AC, will be acceptable for capacities less than 30 amperes, provided the ampere rating of the switch is at least 125 percent of the motor full load amperages (FLA). Enclosed safety switches shall conform with paragraph 4.12 above.

4.15 Dry-type transformers

4.15.1 General.- Dry-type transformers shall be of the sizes and characteristics shown on drawings. Unless otherwise indicated, the design, manufacture, and testing of dry-type transformers, and the methods of conducting tests and preparing reports shall be in accordance with NEMA ST 20, and UL standards. These transformers shall be dry-type self-cooled (Class AA) as defined by ANSI/IEEE C57.12.80. Unless otherwise indicated, minimum Basic Insulation Levels (BIL) shall be in accordance with IEEE STD 141.

4.15.2 Windings and taps.- Dry-type transformers shall be provided with separate primary and separate secondary windings for each phase. The transformers shall be provided with copper windings. Unless otherwise indicated, each primary winding of each transformer rated 15 KVA and greater shall be provided with four taps, two of which shall provide 2-1/2 percent increments above full rated voltage and two of which shall provide 2-1/2 percent increments below full rated voltage. Each primary winding of each transformer rated below 15 KVA shall, be provided with not less than two taps, each providing a 5 percent increment above and below full rated voltage.

4.15.3 Insulation.- Insulation provided in transformers having ratings not exceeding 25 KVA shall have 185°C rise rating. Insulation provided in transformers having ratings exceeding 25 KVA shall have 220°C rise rating.

4.15.4 Terminal compartments.- Each dry-type transformer shall be provided with a suitable terminal compartment to accommodate the required primary and secondary wiring connections, and side or bottom conduit entrance.

Transformers having ratings not exceeding 25 KVA shall be provided with terminal leads equipped with factory installed and supported connectors. Transformers rated greater than 25 KVA shall have terminal boards equipped with factory installed clamp-type connectors. The terminal compartment temperature shall not exceed 75°C when the transformer is operating continuously at rated load with an ambient temperature of 40°C.

4.15.5 Sound pressure levels and vibration isolation.- Sound pressure levels of dry-type transformers shall be determined in accordance with NEMA Standard ST 20. Levels shall not exceed 40 db for transformers rated at 9 KVA or less; 45 db for transformers rated over 9 KVA but not over 50 KVA; and 50 db for transformers rated over 50 KVA but not over 150 KVA. All dry-type transformers 45 KVA and greater shall have integral vibration isolation supports between the core and coil assembly and the transformer enclosure. Transformers of lesser rating shall have either integral or external vibration isolation supports. Conduit connections to transformers shall be made with flexible metal conduit, nominally 12 inches length but not more than 36 inches in length.

4.15.6 Enclosures.- Single-phase transformers larger than 25 KVA and three-phase transformers larger than 15 KVA shall be fully encased in steel enclosures. Transformers smaller than 15 KVA shall be fully encased in steel enclosures with or without compound fill, or shall have exposed cores, impregnated windings, and steel enclosures encircling all live parts. Enclosures shall be bonded to the grounding system. The surface temperature of the transformer shall not exceed 65°C when the transformer is operating continuously at rated load with an ambient temperature of 40°C.

4.15.7 Mounting.- Transformers shall be mounted to allow for adequate ventilation. Unless otherwise indicated on drawings, dry-type transformers having ratings not exceeding 25 KVA shall be suitable for wall mounting. Shop drawings of wall brackets and platforms for transformers shall be submitted for approval.

4.16 Identification.- Motor controllers, panelboards, safety switches and self-enclosed circuit breakers shall be identified with a name plate showing the functional name of the unit, voltage utilized, the number of phases, and other pertinent formation. Switches for local lighting need not be identified. Additional equipment shall be identified if called for on the drawings.

4.16.1 Name plates.- Name plates shall be non-ferrous metal or rigid plastic, stamped, embossed or engraved with 3/8-inch minimum height characters. The plates shall be secured to the equipment with a weather-proof bonding material or a minimum of two screws.

4.17 Fuses.- A complete set of fuses shall be installed and one set of spares shall be furnished for each fusible device. Time and current tripping characteristics of fuses serving motors or connected in series with circuit breakers shall be determined by the facility Protective Device Coordination Study (PDC). Fuses shall have a voltage rating not less than the circuit voltage. Required fuse interrupting ratings, determined by the Short Circuit Analysis (SCA) calculations, shall be as shown on the drawings, except that these interrupting ratings shall not be less than 100,000 amperes in branch and feeder circuits, and not less than 200,000 amperes in a service entrance switch.

4.18 Lamps and lighting fixtures

4.18.1 General.- Lamps and lighting fixtures shall be of the types indicated on the drawings. All lighting fixtures shall be UL approved and shall bear the UL label. All incandescent lamps shall be rated for 130 volts unless otherwise indicated. Flexible metal conduit, minimum 3/8 inch nominal trade size is permitted. External bonding jumpers are not required across the lighting fixture flexible conduit.

4.18.2 Fluorescent fixtures.- Unless otherwise indicated, fluorescent fixture lenses shall be the prismatic-type, made of virgin acrylic. Fluorescent lamps shall be rapid start, cool white unless otherwise indicated. Ballasts for fluorescent fixtures shall be class P, protected (including inherent automatic thermal reset and fuse) rapid start, high power factor type, conforming to UL Standard UL 935. Unless otherwise indicated, all ballasts shall be provided with factory installed choke-type radio frequency interference suppressers. Lampholders shall have silver plated contacts, and shall conform to standard UL 542.

4.18.2.1 Recessed fluorescent fixtures.- Recessed fluorescent fixtures shall conform to NEC Article 410-64 through 410-72, and shall be installed in suspended ceiling openings. These fixtures shall have adjustable fittings to permit alignment with ceiling panels.

4.18.2.2 Suspended fluorescent fixtures.- Pendant-mount fluorescent fixtures shall conform to Federal Specification W-F-414 and shall be of the types indicated on the drawings. Single-unit suspended fluorescent fixtures shall have twin-stem hangers. Multiple-unit or continuous row fluorescent units shall have tubing or a stem for wiring at one point, and tubing or a stem suspension provided for each unit length of chassis, including one at each end.

4.18.3 Suspended incandescent fixtures.- Pendant-mounted incandescent fixtures shall be provided with swivel hangers to insure a plumb installation.

4.18.4 Emergency lights.- Emergency lights shall conform to Federal Specification W-L-305, type I, class I, style D or E, with the number of heads as indicated on the drawings. Emergency light sets shall be connected to the wiring system by a cord no more than 3 feet in length to a single receptacle.

4.18.5. High intensity discharge (HID) lamps.- HID lamps including mercury vapor, metal halide, and high or low pressure sodium shall be as indicated on the drawings. High power factor, constant wattage ballasts shall be furnished with HID lamps. Mercury vapor lamps shall be the color improved type.

4.19 Signal and communications

4.19.1 Entrance conduits.- Conduit materials shall be RSC unless otherwise indicated. Except where otherwise indicated, underground conduits shall be a minimum of 2 feet below finished grade and extend at least 5 feet beyond the grounding electrode system. The conduits shall be bonded to the grounding electrode system with No. 2 AWG bare copper conductor by exothermic welds or FAA-approved pressure connectors. Conduits installed for future use by others, such as for telephone, communications, electronic signals, etc., shall have both ends capped.

4.19.2 Transient protection demarcation box for electronic landlines.- A metallic, appropriately rated NEMA junction box, shall be installed where electronic landlines or conduits enter the facility. This box will house terminal boards, cables, and circuit transient protectors as shown on the contract drawings.

4.19.3 Fiber optics.- The use of fiber optics is recommended to replace metallic, control cables. Using

fiber optics will eliminate outages and loss of service due to lightning strikes.

4.20 Painting and finishing.- Where factory finishes are not adequate to protect metal surfaces from corrosion, the contractor shall paint exposed surfaces prior to or after installation. All marred or damaged surfaces, except exposed metal for grounding purposes, shall be refinished to leave a smooth, uniform finish at final inspection.

4.21 Repair of existing work.- Electrical work shall be carefully planned. Where cutting, channeling, chasing, or drilling of floors, wall partitions, ceilings, or other surfaces is necessary for the proper installation, support, or anchorage of the conduit, raceways, or other electrical work, it shall be carefully done. The contractor shall repair, with equal material by skilled workers, any damage to facilities caused by the contractor's workers or equipment. Contracting Officer's prior approval must be obtained for the materials, workers, time of day or night, repair method, and for temporary or permanent repairs purposes. On completion, repair work shall be inspected and approved by the Contracting Officer with the concurrence of any other affected parties such as utility companies and airport authorities.

5. QUALITY ASSURANCE PROVISIONS

5.1 List of materials and equipment.- When required by the contract the contractor shall submit a list of materials and equipment to the Contracting Officer for approval.

5.1.1 Information required.- This list shall include manufacturer's style or catalog numbers. Partial lists submitted from time to time shall not be considered as fulfilling this requirement. Approval of materials will be based on manufacturer's published data. Approval of materials and equipment will be tentative, subject to submission of complete shop drawings, when required, indicating compliance with the contract documents.

5.1.2 Statement.- A manufacturer's statement indicating complete compliance with the applicable federal specification, military specification, or standards of ASTM, NEMA, or other commercial standard, is acceptable as indicating compliance with contract documents.

5.2 Shop drawings.- When required by the contract or by direction of the contracting officer, the contractor shall

submit shop drawings for materials and equipment not completely identified by information submitted in the materials and equipment lists. This information shall include, but is not limited to panelboards, lighting fixtures, cable trays, switchgear, transformers, busways, cabinets, and lightning protection systems. In addition, the contractor shall provide the completed Short Circuit Analysis/Protective Device (SCA/PDC) study, FAA Order 6950.27.

5.2.1 Coordination.- Drawings and submitted data shall be checked and coordinated with the work of other construction trades involved, before they are submitted for approval, and shall bear the contractor's stamp of approval as evidence of such checking and coordination.

5.2.2 Required data.- Drawings and submitted data shall be complete, assembled in sets and shall bear the date, drawing revision number, name of project or facility, name of contractor and subcontractor, and the clear identity of contents and location of work.

5.2.3 Approval.- The approval of drawings and submitted data shall not be construed as (1) permitting any departure from the contract requirements; (2) relieving the contractor of the responsibility for any errors, including details, dimensions, materials, etc.; or (3) approving departures from full size details furnished by the Contracting Officer.

5.2.4 Variations.- If drawings show variations from the contract requirements because of standard shop practice or for other reasons, the contractor shall describe such variations in a letter of transmittal to the Contracting Officer. If acceptable, the Contracting Officer may approve any or all such variations, subject to a proper adjustment in the contract. Contractors failing to describe such variations shall not be relieved of the responsibility for executing the work in accordance with the contract, even though such drawings have been approved.

5.2.5 Submission.- The contractor shall submit and obtain approval of shop drawings by the Contracting Officer before ordering materials or proceeding with any work associated with the shop drawings.

5.3 Tests

5.3.1 General.- Unless otherwise indicated, the contractor shall furnish all test instruments, materials and labor

necessary to perform the following tests. All tests shall be performed in the presence of the Contracting Officer or his designated representative. All instruments shall have been calibrated within a period of two years preceding testing. Calibrations shall be traceable to applicable industry recognized standards.

5.3.2 Cables.- All cables shall be tested in accordance with FAA Order 6950.22 prior to installation and again upon completion of the installation. All testing shall be accomplished before connection is made to any existing equipment.

5.3.3 Load balancing.- After the electrical installation has been completed, the contractor shall take current readings with a true RMS ammeter for the purpose of load balancing. These readings shall be taken at the service entrance, each feeder panelboard, each branch panelboard, and each separately derived source. The contractor shall redistribute single-phase loads where there is greater than a 20% difference between readings in any two phases. The contractor shall also be required to notify the Contracting Officer of current readings taken before and after installation, and any phase loaded above 80% of the rating of its overcurrent protective device.

5.3.4 Insulation resistance tests.- Feeder and branch circuit insulation tests shall be performed after installation, but before connection to fixtures or appliances. Motors shall be tested for grounds or short circuits after installation but before start-up. All conductors shall test free from short circuits and grounds, and have a minimum phase-to-phase and phase-to-ground insulation resistance of 30 megohms when measured with a 500-volt DC insulation resistance tester. Apply the test voltage for at least one minute after the meter reading has stabilized. The contractor shall submit a letter type test report to the Contracting Officer prior to final FAA inspection of the contractor's work. The report shall list the tests performed and results obtained.

5.3.5 Neutral isolation tests.- For all new installations, the neutral in the service entrance switch shall be tested for isolation from ground with an ohmmeter capable of reading greater than 20,000 ohms. This procedure to be used is detailed in the Appendix. This procedures can also be used to determine if there are any other neutral-ground connections on the load side of the service disconnecting means.

5.3.6 Earth resistance test.- To demonstrate compliance with paragraph 4.4.4, the contractor shall measure the resistance of the grounding electrode system. Tests shall not be conducted within 48 hours of a rainfall or in frozen soil. The contractor shall immediately notify the Contracting Officer if the specified resistance is not obtained. Upon project completion, the contractor shall also submit a written test report to the Contracting Officer, defining the test procedure and results obtained.

5.3.7 Operating test.- After the interior wiring system installation is completed, and at such time as the Contracting Offer may direct, the contractor shall conduct an operating test for approval. The equipment shall be demonstrated to operate in accordance with the requirements of this specification. The test shall be performed in the presence of the Contracting Officer or designated representative.

6. NOTES

6.1 General.- This specification is to be used as part of the contract documentation for construction and facility modification projects that do not require major design efforts. No waivers to contractors, other than those indicated as alternatives, are allowed. This specification is not to be used as a design guide. For design information, consult FAA-STD-019, Lightning Protection, Grounding, Bonding and Shielding Requirements for Facilities; FAA-STD-020, Transient Protection, Grounding, Bonding and Shielding Requirements for Equipment; FAA Order 6950.19, Practices and Procedures for Lightning Protection, Grounding, Bonding, and Shielding Implementation; FAA Order 6950.20, Fundamental Considerations for Lightning Protection, Grounding, Bonding and Shielding and other documentation as applicable.

6.2 Conflicts between documents.- In all but the smallest of modification or construction contracts, conflicts are unavoidable between the various documents cited in the contract or referenced in an included specification. Any proposal request using this document should contain the following provisions: "Prospective contractors shall, as part of their proposals, enumerate, identify, and list conflicts that exist with the contract documents, and between those documents and the rules, regulations, and codes of the local utility company and local, county or state governing bodies."

Appendix

FACILITY NEUTRAL/GROUND ISOLATION TESTING.

The following testing is to be utilized to verify required isolation between facility neutral and ground systems within the electrical distribution system and facility equipment. Neutral grounding at the service entrance disconnect means is still required by NFPA, NEC Article 250.

EQUIPMENT NEEDED: Volt-ohm meter, flash light, allen wrenches, screw drivers, socket wrenches, and wire markers.

NOTE 1: A resistance value of greater than 20,000 ohms is the minimum value for an acceptable neutral/ground isolation test. Any lesser value indicates an unacceptable isolation condition that must be investigated.

NOTE 2: Capacitors on the neutral line or capacitive effects of the distribution system will impact resistance readings. Always use the final, stabilized readings.

NOTE 3: High impedance meters are susceptible to acting as an antenna, picking up stray fields that would not be picked up by lower impedance meters. For this series of tests, it is highly recommended that low impedance meters be used, such as an analog meter the Simpson 260 or its equivalent, or use a digital meter the Fluke 8060a series or its equivalent.

STEPS:

1. Schedule a facility outage in order to conduct the tests.

2. Review one-line diagrams of the facility electrical distribution system.

3. Isolate and lock out all standby power sources.

4. Remove facility power by opening the service disconnect means.

CAUTION: Voltage is still present at the supply side (line side) of the service entrance disconnect.

5. Verify that no voltage is present at the load side of the service disconnect means with the voltmeter using progressively lower scales.

6. Open all circuit breakers in the facility distribution system.
7. Disconnect load side neutral conductor(s).

8. Measure resistance between disconnected load side neutral conductor(s) and the service entrance enclosure ground bus.

9. If resistance reading is acceptable, reconnect neutral conductor(s) and terminate testing.

10. If resistance reading is unacceptable, tag the grounded neutral conductor(s) and leave the conductor(s) disconnected.

11. Trace the tagged conductor(s) to the load and correct the unacceptable neutral/ground bond, or to the next downstream (towards the load) neutral termination.

12. At the next downstream location, remove each load side neutral conductor one at a time and measure resistance between the conductor and the enclosure. If the resistance reading is acceptable, re-terminate the conductor. If the resistance reading is unacceptable, tag the grounded neutral conductor and leave it disconnected. Measure resistance of the rest of the neutral bus immediately after identifying a grounded conductor, to possibly verify the rest of the bus as acceptable.

13. Continue downstream as described above until all unintentional neutral/ground bonds are found and corrected.

14. Reconnect all neutral conductor(s) except at the service entrance disconnect means. Measure resistance between the load side neutral conductor(s) and the service entrance enclosure to verify successful isolation of neutral/ground conductors.

15. Reconnect neutral conductor(s), close service entrance disconnect means.

16. Place standby power source on line.